Essays in Corporate Finance and Monetary Policy

by

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ABSTRACT

This dissertation consists of three essays studying the relationship between corporate finance and monetary policy and macroeconomics. In the first essay, I provide novel estimations of the monetary policy's working capital channel size by estimating a dynamic stochastic macro-finance model using firm-level data. In aggregate, I find a partial channel —about three-fourths of firms' labor bill is borrowed. But the strength of this channel varies across industries, reaching as low as one-half for retail firms and as high as one for agriculture and construction. These results provide evidence that monetary policy could have varying effects across industries through the working capital channel. In the second essay, I study the effects of the Unconventional Monetary Policy (UMP) of purchasing corporate bonds on firms' decisions in the COVID-19 crisis. Specifically, I develop a theoretical model which predicts that the firm's default probability plays a crucial role in transmitting the effects of COVID-19 shock and the UMP. Using the model to evaluate two kinds of heterogeneities (size and initial credit risk), I show that large firms and high-risk firms are more affected by COVID-19 shock and are more responsive to the UMP. I then run cross-sectional regressions, whose results support the theoretical predictions suggesting that the firm's characteristics, such as assets and operating income, are relevant to understanding the UMP effects. In the third essay, I document that capital utilization and short-term debt are procyclical. I show that a strong positive relationship exists at the aggregate and firm levels. It persists even when I control the regressions for firm size, profits, growth, and business cycle effects. In addition, the Dynamic Stochastic General Equilibrium (DSGE) model shows that in the presence of capital utilization, positive real and financial shocks cause the firm to change its financing of the equity payout policy from earnings to debt, increasing short-term debt.

DEDICATION

To Jesus Christ, my God, and Lord!

In Him, I have life, salvation, hope, and everything! There are not enough books, words, or deeds to express my thankfulness to Him!

This is for his glory!

by Him for Him.

ACKNOWLEDGMENTS

I want to express my profound gratitude to Jesus Christ. I know that eternity is not sufficient to thank him for his unconditional and great love, patience, mercy, forgiveness, and grace. He has been my cornerstone in the PhD program and every stage of my life. He has given me strengths when I feel weak. He encourages me when I face difficult situations. He gives me smartness when I need it. He forgives my sins. He makes ways where there are not. He opened doors that I could not. He has been doing miracles in my life. He has been patient with me. He has been my shelter. I cannot measure his love, and I know that I have the biggest blessing that a person can have: I have him. I can make my own the words of Asaph in Psalm 73:23-26

Yet I am always with you;
you hold me by my right hand.
You guide me with your counsel,
and afterward you will take me into glory.
Whom have I in heaven but you?
And earth has nothing I desire besides you.
My flesh and my heart may fail,
but God is the strength of my heart
and my portion forever.
Amen!

I am also thankful to God for my wife–Jenny. She has been such a great blessing for me. Her love, encouragement, prayers, and godly heart make my life journey exciting and joyful. She has been on my side for the last twenty years! The last five years have been a gift for us, and her support and love helped me overcome the difficulties in the PhD program.

I am thankful to my parents, Raul and Elvira, for their prayers and the hard work that they did in raising me. I hope this degree to be a reward to them for all their sacrifice.

I also want to thank Seth Pruitt, David Schreindorfer, Hendrik Bessembinder, and Rajnish Mehra for their continuous support, guidance, and mentorship–my God bless you abundantly! Thank you for providing thoughtful feedback, keeping your door open to discuss any topic, and helping me in every stage during the PhD program. I am so thankful to God for your mentorship and friendship throughout the program. I hope my future academic path makes you proud.

I also owe many thanks to the finance faculty, especially to Yuri Tserlukevich, for his advice and continuous support since the first day I started the PhD program. Thank you, Yuri, for the first bike I had when I came to Tempe, which I appreciate.

Finally, I would like to acknowledge the generous financial and non-financial support provided by the ASU Finance Department throughout my period of study and the W. P. Carey School of Business for giving me the opportunity to pursue an academic career. My compromise is to keep high the name of the ASU Finance Department from now on.

I really enjoyed this amazing journey!

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Chapter 1

INTRODUCTION

Macro-finance is a field in economics that combines macroeconomics with finance. Specifically, this field focuses on connecting business cycle theories and corporate finance and asset pricing models. This dissertation belongs to the macro-finance area since I comprehensively study macroeconomics topics and corporate finance theories. Moreover, this dissertation is formed by three studies that combine theoretical models with empirical analysis. In every study, I develop a theoretical model of the firm's behavior to understand the economic transmission mechanisms between shocks and firms' decisions. Then I use an empirical model to test the theoretical predictions or documents that I observed in the data.

The first study examines the quantitative relevance of a crucial monetary policy mechanism by using a full corporate finance model of the firm dynamic. The second study analyzes the heterogeneous response among firms to unconventional monetary policy. Finally, the third study examines the relationship between capital utilization and the capital structure of a representative firm. This introductory chapter highlights each essay's main findings and contributions.

In the first essay (Chapter 2), I provide evidence that the working-capital channel of the monetary policy is not as big as the literature assumed, and it varies across industries. I use firm-level data to estimate a dynamic stochastic macro-finance model to measure this channel. In aggregate, I find a partial channel —about three-fourths of firms' labor bill is borrowed. But the strength of this channel varies across industries, reaching as low as one-half for retail firms and as high as one for agriculture and construction. This provides evidence that monetary policy could have varying effects across industries through the working capital channel.

In Chapter 3, I show a heterogeneous response among firms when the Federal Reserve announces an Unconventional Monetary Policy (UMP) of purchasing corporate bonds. This policy was announced in the COVID-19 crisis, and a crucial question for policy design is whether this policy has been effective in boosting the firm's production and investment. While answering this question is challenging from a theoretical and empirical perspective, I provide a step forward in understanding the possible effects of this policy on firms' decisions using a theoretical and *analytical* model.

The model suggests that the firm's default probability plays a crucial role in transmitting the effects of COVID-19 shock and the UMP. Using the model to evaluate two kinds of heterogeneities (size and initial credit risk), I show that large firms and high-risk firms are more affected by COVID-19 shock and are more responsive to the UMP. I then use a cross-sectional regression to evaluate the model's prediction on the heterogeneity effects of UMP across firm size and to study the role of firms' characteristics in the effects of UMP. The estimation results support the size-firm hypothesis and suggest that the firm's characteristics, such as assets and operating income, are relevant to understanding the UMP effects.

In Chapter 4 (co-authored with Diogo Duarte and Alexis Montecinos), I document that capital utilization and short-term debt are procyclical. Moreover, we show that a strong positive relationship exists both at the aggregate and firm levels, and it persists even when we control the regressions for firm size, profits, growth, and business cycle effects. In addition, our DSGE model shows that in the presence of capital utilization, positive real and financial shocks cause the firm to change its financing of the equity payout policy from earnings to debt, resulting in an increase in short-term debt. Therefore, ignoring the firm's optimal decision on capital utilization may lead to misleading conclusions on how leverage is undertaken.

Studying macroeconomics theories jointly with corporate finance models has shed light on our understanding of firm behavior. As a result, this literature has experienced consistent growth in the last years. However, many important questions regarding economic policy and firms' decisions are still open. This dissertation aims to contribute to this pending research agenda by analyzing monetary policy and a firm's decisions. I hope these essays help researchers interested in this area.

Chapter 2

IS THE WORKING CAPITAL CHANNEL OF THE MONETARY POLICY QUANTITATIVELY RELEVANT? A STRUCTURAL ESTIMATION APPROACH

2.1 Introduction

The working capital channel is a key element of modern monetary policy models (Christiano *et al.*, 2010; Demirel, 2013). This channel has been used in general equilibrium to argue that monetary policy has real effects through the increasing marginal cost of the firm. Furthermore, this channel has been used to explain the price puzzle [1]—a crucial empirical fact in macroeconomics (Ravenna and Walsh, 2006; Christiano *et al.*, 2010; Henzel *et al.*, 2009). However, few studies have investigated the quantitative relevance of this channel using microeconomic data, or addressed whether or not it is the same across firms. In this paper, I contribute to the literature by estimating the working capital channel based on microeconomic data at the firm level for the entire sample available in Compustat, I develop a macro-finance model in which the firm invests and depends on cash and working capital loans to finance its labor bill, and I estimate key structural parameters via the Simulated Method of Moments (SMM).

Working capital is defined as funds that the firm needs to operate its business normally in the short term. Since there is a mismatch between the payment of some production input and the realization of revenues, a firm needs to get loans to finance its requirement of working capital. This kind of loan is known as a working capital

[1] The price puzzle is the inability of the standard monetary model (e.g., Gali and Gertler, 1999) to capture the empirical fact of a short-run decrease in prices after monetary tightening (reduction in interest rate). This puzzle is solved when the working capital channel is included in the standard monetary model.

loan.

Borrowing rates affect firm decisions. A positive shock in the interest rate (increase) generates an increase in the marginal cost of production inputs which are financed by working capital loans. As a result, a firm optimally decreases working capital demand, hence production decreases. If instead the firm had sufficient cash to finance the working capital necessities, then working capital loans are not necessary, and hence the impact of the interest rate on the firm's decision disappears. Therefore, understanding the size of this channel—i.e., how much working capital is financed via working capital loans—is crucial for understanding the effects of monetary policy.

There are several reasons to take the working capital channel seriously. Barth and Ramey (2001) argue that the gross working capital -measured as the value of inventories plus trade receivables- is equal to 17 months of final sales on average over the period 1959 to 2000. These authors conclude that, for the US economy, interest rate shocks affect prices and real activity through changes in the cost of working capital. Chowdhury *et al.* (2006), using data for the US and UK, find estimates implying that firms' marginal costs are raised more than one-for-one by changes in the monetary policy rate, indicating the existence of financial market frictions amplifying the working capital channel's effects. Additionally, Ravenna and Walsh (2006) provide additional evidence supporting the working capital channel. Based on instrumental variables, these authors estimate a suitably modified Phillips curve under the assumption that the working capital channel is full. Finally, Bae and Goyal (2009) find that investment and working capital requirements are the two most important goals of loan demands, with equal weights of 44%.

Given the relevance of the working capital in a firm's decisions, several general equilibrium macroeconomic models have explicitly analyzed the supply-side effects of monetary policy through the working capital channel (Blinder, 1987; Christiano and Eichenbaum, 1992; Christiano, 1997; Christiano *et al.*, 2010, 2015; Ravenna and Walsh, 2006; Mendoza, 2010; Jermann and Quadrini, 2012; Mahmoudzadeh *et al.*, 2018). All of these models rationalize the working capital channel assuming that firms must pay their factors of production before they receive revenues from sales and must borrow to finance these payments.

These models have two features in common. The first one is that they use aggregate data. The second one is that they assume that a firm finances the totality of its variable cost through working capital loans. This means that the working capital channel is "complete" in the economy. But, what if firms do not take out loans and instead save cash? Additionally, it is highly probable that the amount borrowed could be quantitatively different across industries.

I address this issue with an alternative technique. I estimate a structural model of investment with working capital loans using SMM. To do this, I follow three steps. First, I solve the model numerically and analyze the policy functions to understand the role of the working capital channel when the firm suffers an interest rate shock. Second, I identify what moments depend on the value of the main parameter that I estimate—the proportion of working capital requirement that is financed by loans ϕ. With this goal in mind, I evaluate six empirical moments: the mean and variance of profitability, investment rate, and working capital loans. Finally, I estimate ϕ by SMM for the entire sample which includes all firms listed in Compustat (except firms related to financial services, utilities, and government administration), allowing ϕ to vary across seven industries.

If I impose that ϕ is constant across industries, the estimation suggests that its value is 0.758. This means that firms, on average, finance 75.8 percent of their working capital requirements with loans. Although this value is not equal to one as macroeconomic models usually assume (e.g., Christiano *et al.*, 2010), this value is quantitatively important. This estimation differs from Christiano *et al.* (2015) (0.56) for two reasons: data sample and firm's variables (short-term debt). As I explain later, using short-term debt at the firm level is more informative to estimate the working capital channel, which is absent in Christiano *et al.* (2015). However, ϕ looks to vary in the data. The Retail Trade sector has the lowest value of ϕ (0.482), while three sectors (Agriculture, Construction, and Wholesale Trade) have a full working capital channel ($\phi = 1$). This means that a positive interest rate shock will have greater effects for Agriculture, Construction, and Wholesale Trade firms, than for retail firms. Meanwhile, for the Manufacturing sector, which represents almost 60 percent of the data [2], ϕ is strong (0.701).

This paper fits into both the theoretical and empirical literature on corporate borrowing. The theoretical model that I develop is closely related to those in Riddick and Whited (2009) and Michaels *et al.* (2019). Riddick and Whited (2009) study the saving decision of a firm in a dynamic model. I keep the main variables such as profits and investment, but I consider the additional assumption of requiring working capital, and hence the possibility that an interest rate shock affects the firm's decisions. In recent work, Michaels *et al.* (2019) study the relationship between labor and leverage in a financing frictions environment. I study the same relationship but with an additional constraint: the firm needs loans to finance labor costs. This constraint is not present in Michaels *et al.* (2019).

Furthermore, this paper is related to Jermann and Quadrini (2012) in considering the working capital requirement. The main difference is that Jermann and Quadrini (2012) assume that there is not an interest rate of working capital loans and that the firms need working capital to finance not only labor but also investment. Under these

[2] It is measured as the number of observations in the manufacturing sector over the total number of observations in the annual sample 1971-2018, after applying standard filters (see Section 2.4).

assumptions, these authors cannot study the working capital channel or the effects of interest rate shock. Moreover, since investment is more related to long-term debt, it is more accurate to assume that the working capital loans only finance a firm's short-term necessities. In other paper related to this, Mahmoudzadeh *et al.* (2018) studied the real consequences of variations in the first and second moments of the working capital requirement (WCR) in the presence of financial frictions. They found that firms with higher WCR may face financial constraints. My model is similar to Mahmoudzadeh *et al.* (2018) in explicitly assuming a working capital channel, but differs in that I am allowing the possibility of a partial working capital channel that may vary across firms.

Furthermore, this paper is related to the monetary policy literature. The main assumption of this literature is that the working capital channel is full—that is, the firm needs to finance the totality of its variable cost with working capital loans—and this literature usually uses only aggregate data (e.g. Ravenna and Walsh, 2006). For instance, Christiano *et al.* (2010) in a general equilibrium model evaluate the effects of an increase of interest rates on the supply side of the economy. My model is related to this in that I analyze the interest rate shock as well, but I differ in not assuming that the working capital is full. Instead, I estimate with microeconomic data the parameter that controls the working capital channel. Another study related to this is Ravenna and Walsh (2006). These authors show that a cost-push shock arises endogenously when a cost channel for monetary policy is introduced into the new Keynesian model. They provide empirical evidence for a working capital channel and explore its implications for optimal monetary policy.

Moreover, this paper complements the previous estimation of ϕ based on aggregate data. Christiano *et al.* (2015) in a general equilibrium model assume that a firm finances a proportion of all its working capital as I do in this paper. Based on

Bayesian inference and aggregate data, these authors find that the estimated value of this parameter is 0.56. Why is this estimation different from what I have in this paper? Two possible reasons. First, the sample data is different. While Christiano *et al.* (2015) use quarterly data from 1951.I to 2008.IV, I use annual data from 1971 to 2018. It is common in firm-level data in corporate finance to use Compustat since at least 1970 due to the fact that several firm accounting variables contain incomplete information before that year (Hennessy and Whited, 2007; Riddick and Whited, 2009; Nikolov and Whited, 2014). Second and most importantly, I use short-term debt as a proxy of working capital loans, which is absent in the Christiano *et al.* (2015) estimation. Considering short-term debt would be more accurate to estimate the working capital channel at the firm level and hence at the aggregate level.

From a methodology perspective, this paper belongs to the growing literature of structural estimation in corporate finance (Nikolov and Whited, 2014; DeAngelo *et al.*, 2011; Hennessy and Whited, 2007; Michaels *et al.*, 2019).

The paper is organized as follows. Section 2.2 presents the model. Section 2.3 describes the model simulation and its results. Section 2.4 describes the data. Section 2.5 presents the estimation procedure and the identification strategy. Section 2.6 explains the results for the entire sample and across industries, and Section 2.7 concludes.

2.2 A Model with Working Capital Channel

To motivate my empirical work and understand the economic forces underlying the working capital channel, I present a discrete-time, infinite-horizon, partial-equilibrium model of investment with working capital loans. First, I describe technology and working capital debt. Then, I move on to a description of the manager's objective function and optimal policies.

2.2.1 *Production Technology*

The real side of the firm is characterized by a production technology that uses capital k and labor n. Revenue per period is given by $y = zk^{\alpha}n^{1-\alpha}$, in which α and $1-\alpha$ are the production elasticity of capital and labor respectively, and z is a productivity shock observed by managers each period before making any investment or working capital decisions. It is usual in structural models in corporate finance and macroeconomics to consider that z is the main shock that generates endogenous movements in the economy. This setting is useful when analyzing the firm's behavior in the context of expansion (good times) or recession (bad times). Since this paper aims to investigate how any movement in interest rate could affect the firm's decisions by means of the working capital channel, it is natural to study what happens with the economy when it faces an interest rate shock instead of considering a productivity shock. Therefore, I normalize z to be equal to 1 in the model.

Investment, I, is defined as

$$I \equiv k' - (1-\delta)k, \tag{2.1}$$

in which δ is the capital depreciation rate, $0 < \delta < 1$, k' is the next period capital stock, and k is the current capital stock. Since the microeconomics literature in investment suggests the firm's investment is lumpy, a kind of friction is necessary to capture this behavior (e.g., Caballero, 1999; Doms and Dunne, 1998). In particular, I assume that investment is partially irreversible. I follow Michaels *et al.* (2019) in modeling this friction. Specifically, I normalize the price of investment goods to one, and the price of selling capital (negative investment) is expressed by $\theta_i \in (0, 1)$. Irreversible investment suggests that the firm sells capital at a lower price than it paid to buy it. As a result, the cost of investment is $C(I)$ defined as:

$$C(I) \equiv I \cdot 1_{[I \geq 0]} + \theta_i I \cdot 1_{[I<0]} \tag{2.2}$$

2.2.2 *Working Capital Loans*

It is well-known in corporate finance literature that a firm needs to cover the cash flow mismatch between the payments made at the beginning of the period and the realization of revenues (Mahmoudzadeh *et al.*, 2018; Michaels *et al.*, 2019). These funds in advance needed by the firm are known as working capital. I model this fact assuming that a firm needs to finance in advance a fraction ϕ of its total variable cost. I assume that total variable cost is generated by labor input wn, in which w is the real wage per hour and n represents the number of working hours. As a result, ϕwn represents the working capital needed by the firm which would be financed by working capital loans at the beginning of the period. Considering that R is the gross interest rate for working capital loans, the total variable cost faced by the firm is $R * (\phi wn)$, which is paid at the end of the period. Furthermore, the gross interest rate R follows a discrete Markov process [3]

$$R' = R_{ss}(1-\rho) + \rho R + \varepsilon', \quad \varepsilon \sim N(0, \sigma_\varepsilon^2) \tag{2.3}$$

in which R_{ss} is the steady-state value of R, ρ is the persistent parameter, and ε is the interest rate shock. The innovation ε has a normal distribution with mean zero and variance σ_ε^2. The way in which R is modeled allows us to consider the real mean value of R, which is obtained from the data. The set of the possible value of R is

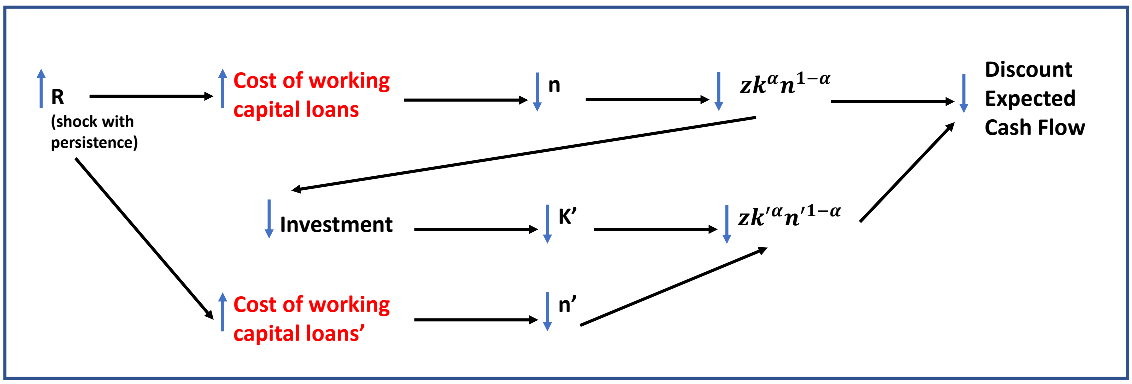
[3] Alternatively, one can consider an *endogenous* interest rate. However, I do not follow this strategy for two reasons. First, with an endogenous interest rate, another shock, such as productivity shock, is necessary to generate the economy's dynamic. The downside of this is that the movement in the interest rate is not the result of a monetary policy shock, and then it does not capture the working capital channel. Second, this paper aims to show what happens with the economy when the monetary authority moves the interest rate, keeping constant the firm's productivity level. Hence, considering an exogenous interest rate is a reasonable way to do that.

bounded since R cannot be lower than one because the net interest rate would be negative. In addition, R cannot be greater than two because if it so the net interest rate would be greater than 100 percent which is not common in the data. Then, R has a lower and upper bound. In particular, I assume that R in $[1, 1.08]$ with a Markov transition probability function associated to (2.3) as $q(R', R)$. Importantly, innovations in interest rates are crucial for firms since most bank loans have floating rates tied to monetary policy rates. This connection allows monetary policy to affect the liquidity and investment decisions of firms (e.g., Ippolito *et al.*, 2018).

An important characteristic of working capital loans is that they are a kind of short-term debt. The firm needs cash to finance the labor payments at the beginning of the period before the realization of profits which are obtained at the end of the period. Then, the working capital loans are paid with the cash flows derived from revenue. As a result, working capital loans can be considered as short-term debt or intra-period debt. Additionally, it is common that banks do not require collateral for working capital loans. Because of that, I do not consider a collateral constraint for working capital loans in the model as previous studies do (Mahmoudzadeh *et al.*, 2018).

In order to illustrate the relevant role of the working capital channel in the firm's behavior, I describe what happens in the economy when there is a positive interest rate shock. The first effect of this shock is the increase in the working capital cost. The firm faces a trade-off. On the one hand, the firm could reduce its working capital demand by reducing labor demand. This reduces the total variable cost and hence increases the cash flow. On the other hand, with lower labor, the production decreases with negative effects on the investment and hence the next period capital stock. With lower capital stock in the next period, the profits would be lower, and it negatively affects the expected discount value of cash flow. Furthermore, if the shock persists over time, it will contribute dynamically to push down labor in the future strengthens the initial effects on discounted expected cash flow. Therefore, the manager must decide the optimal value of labor which balances the benefits and costs in the presence of gross interest rate shock.

Figure 2.1: Working Capital Channel



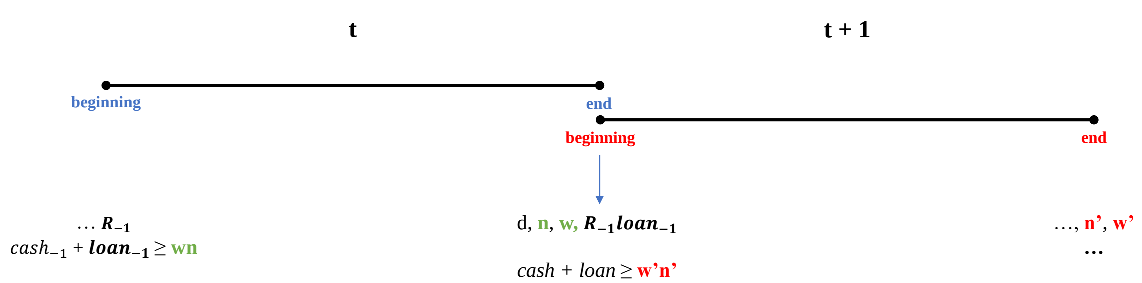
Clearly, the fraction of wn which is financed by working capital loans ϕ is important to determine the relevance of the interest rate shock on a firm's decisions. Figure 2.1 shows the dynamic effects of interest rate shock through a working capital channel. This channel is controlled by ϕ. Two extreme cases emerge in this model. The first one is when a firm does not need money in advance to finance the variable cost. In this case, ϕ is zero and the working capital channel is not relevant to transmit effects from interest rate shocks. Indeed, in this setting, the firm's decisions are not affected by the interest rate. The second case is when a firm finances all its variable costs with working capital loans. In this case, ϕ is one and the firm is sensitive to any movement in the interest rate. Therefore, any movement in the interest rate affects a firm's decisions, and hence the working capital channel is very important. In this context, the relevant empirical question is, how big is ϕ for the entire economy and if ϕ is different across industries. Given the relevance of the working capital channel, measuring ϕ is of the first order of importance.

2.2.3 The Objective Function

Before describing the firm's objective function, I explain the timing convention used in the model. This is important since the model attempts to capture the timing lag between the working capital requirement at the *beginning* of a period and the profit realization at the *end* of the period. Fig. 2.2 illustrates the timing characteristics of the model. First, every period has a beginning and an end point. Second, the end of a period represents the beginning of the next period. For instance, the end of period t is the beginning of period $t+1$. Third, a variable without apostrophe (') means that this variable is at the *end* of the period t (e.g., labor n). A variable with apostrophe means that this variable is at the *end* of the period $t+1$ (e.g., n'), and a variable with subscript "-1" means that this variable is at the *end* of the period $t-1$ or equivalently at the beginning of the period t (e.g., the gross interest rate R_{-1}).

For instance, at the end of the period t, the firm distributes its cash flow d to shareholders, uses labor n for production, and pays the previous loans $R_{-1}loan_{-1}$, where $loan_{-1}$ represents the debt obtained at the beginning of period t. Furthermore, the firm decides its *cash* and new debt ($loan$) to finance in advance its labor cost $n'w'$ (see Figure 2.2).

Figure 2.2: Timing



Because I assume that there are no agency costs between shareholders and managers, there is no difference between the manager's and shareholders' objective function. In particular, the risk-neutral manager maximizes the cash flows d that go to shareholders. Under the standard accounting identity, I can express distributions to shareholders as

$$d(k, k', n, R) \equiv zk^{\alpha}n^{1-\alpha} - C(I) - \text{cash} - R_{-1}\text{loan}_{-1} \tag{2.4}$$

The first term of Eq. (2.4) represents operating profits at the *end* of the period t. These profits are then spent on investment $C(I)$, on cash, and on paying the previous debt $R_{-1}\text{loan}_{-1}$, which was obtained at the *beginning* of the period t since the firm needs to finance its variable cost in advance (working capital requirements).

The common assumption in monetary policy models is that the entire labor cost $w'n'$ is financed in advance only with loans: $loan = w'n'$. I relax this strong assumption assuming that working capital loans finance a fraction ϕ of the total labor cost:

$$\text{loan} = \phi w'n' \tag{2.5}$$

My goal is to allow the data tells us what the value of ϕ is across industries and for the entire Compustat sample. Additionally, complementary to loan financing, I allow that the firm can finance its working capital requirement with cash. As a result, the firm uses cash and loans today to pay in advance its future labor cost.

$$\text{cash} + \text{loan} \geq w'n' \tag{2.6}$$

Eq. (2.6) reflects that the firm faces a cash-in-advance constraint since there exists a mismatch between the working capital payment at the *beginning* of the period and the profits realization at the *end* of the same period.

Considering Eq. (2.5) for t and $t-1$ and Eq. (2.6) with equality into the shareholders distribution identity (Eq. 2.4), we have:

$$d(k,k',n,n',R) \equiv zk^{\alpha}n^{1-\alpha} - C(I) - R_{-1}\phi wn - (1-\phi)w'n' \tag{2.7}$$

where $R_{-1}\phi wn$ is the interest and principal payment of the working capital loans in $t-1$ that should be paid in t. Additionally, $(1-\phi)w'n'$ represents the fraction of working capital requirement that is financed with cash in t. Implicitly, I assume that investment can be financed by internal sources after paying working capital loans and by issuing equity (negative d).

Furthermore, if there is equity issuance, the shareholders incur an issuing cost λ. A positive firm's cash flow is distributed to its shareholders, while a negative cash flow implies that the firm obtains funds from shareholders. In latter case, the firm would pays a linear cost, λ. Thus, shareholder's final cash flows are given by

$$d^*(k,k',n,n',R) = d(k,k',n,R), \qquad \text{if} \quad d(k,k',n,R) \geq 0 \tag{2.8}$$

$$d^*(k,k',n,n',R) = (1+\lambda)d(k,k',n,R), \qquad \text{if} \quad d(k,k',n,R) < 0 \tag{2.9}$$

In a compact form, $d^*(k,k',n,n',R)$ would be:

$$d^*(k,k',n,n',R) = d(k,k',n,n',R) \cdot (1 + \lambda \cdot 1_{d<0}) \tag{2.10}$$

The manager's objective function is the expected present value of cash flows given by (2.10), which can be expressed recursively as

$$V(k,n,R) = \max_{\{k',n'\}} \left\{ d^*(k,k',n,n',R) + E[S' \cdot V(k',n',R')] \right\} \tag{2.11}$$

in which $V(k, n, R)$ is the value of the firm's equity and $S' = \beta c_t/c_{t+1}$ is the stochastic discount factor [4] that the manager uses to discount the firm's cash flows. The manager makes choices $\{k', n'\}$ so that the shareholders obtain the maximum cash flows. Assuming a finite state space A, $E[S' \cdot V(k', n', R')]$ can be expressed as $\sum_A [q(R', R) \cdot S' \cdot V(k', n', R')]$ in which $q(R', R)$ represents the probability of jumping from one state in t to another state in $t + 1$.

2.2.4 Optimal Policies

The main goal of this paper is to understand how the working capital channel affects the firm's decisions by estimating this structural model directly. With this goal in mind, two steps are important to analyze the economic implications of the model carefully. The first one is to understand the estimation results and the second one is to identify the model parameters. Both steps require understanding the economics behind the model. To do this, I analyze the manager's maximization problem by examining the first-order conditions for optimal investment and labor.

From first-order conditions, I obtain the labor demand expressed as

$$(1 + \lambda 1_{d<0})(1 - \phi)w' = E\big[S'((1 - \alpha)z'k'^{\alpha}n'^{-\alpha} - R\phi w')(1 + \lambda 1_{d'<0})\big] \tag{2.12}$$

To explain the intuition of the role of the interest rate on labor demand, I consider Eq. (2.12) without the equity issuance friction ($\lambda = 0$). As a result, the labor demand becomes:

$$\underbrace{(1 - \phi)w' + E\big[S'R\phi w'\big]}_{\substack{\text{Present value of the \textbf{marginal cost}} \\ \text{of 1 additional unit of labor}}} = \underbrace{E\big[S'((1 - \alpha)z'k'^{\alpha}n'^{-\alpha})\big]}_{\substack{\text{Present value of the \textbf{marginal benefit}} \\ \text{of 1 additional unit of labor}}} \tag{2.13}$$

[4] S' is obtained by assuming a log utility function. Since I solve and simulate the model considering that the consumption is in steady state, the discount factor becomes constant β. This is consistent with the risk-neutral manager assumption.

The left side of Eq. (2.13) is the present value of the marginal cost of an additional unit of labor. It is compounded by two terms: the first is the fraction of the cost of one unit of labor financed with cash $(1-\phi)w'$, and the second is the present value of the loan that the firm should pay to finance the remaining fraction of labor cost $E\left[S'R\phi w'\right]$. The firm compares that marginal cost with the present value of the marginal benefit of an additional unit of labor (right side of Eq. 2.13). This marginal benefit is the marginal productivity of labor represented by $(1-\alpha)z'k'^{\alpha}n'^{-\alpha}$.

Equation (2.13) shows the direct effect of the working capital channel on the labor demand. An unexpected increase in interest rate pushes up the marginal cost of labor and hence decreases the labor demand. The effect of that shock is controlled by ϕ— the proportion of variable cost $w'n'$ financed by working capital loans. The second important equation is the optimal investment which is expressed as

$$[1_{I\geq 0}+\theta 1_{I<0}](1+\lambda 1_{d<0}) = E\left[S'[\alpha z'k'^{\alpha-1}n'^{1-\alpha}+(1-\delta)(1_{I'\geq 0}+\theta 1_{I'<0})](1+\lambda 1_{d'<0})\right] \tag{2.14}$$

If the investment is totally reversible ($\theta = 1$) and there is no friction in issuing equity ($\lambda = 0$), the Eq. (2.14) turns out a standard investment equation without frictions:

$$1 = E[S'(\alpha z'k'^{\alpha-1}n'^{1-\alpha}+(1-\delta))] \tag{2.15}$$

Two additional equations. Furthermore, to close the model, I need to define two additional conditions. The first one is the equilibrium in the goods market which is represented by

$$y = c + I \tag{2.16}$$

in which y is the firm's production function $zk^{\alpha}n^{1-\alpha}$ or revenues, c is consumption, and I is the investment as defined in the previous subsection. The second condition is the labor supply to have equilibrium in the labor market. I assume that the labor supply is characterized as

$$w = \frac{\theta_n c}{1-n} \tag{2.17}$$

in which w is the real wage, θ_n is a parameter which measures the relevance of labor (or leisure) in a utility function, and n is labor.

In order to analyze the model numerically, it is worth summarizing the equations of the model. The Table 2.1 shows the equations' model.

Table 2.1: Model Equations

$(1+\lambda 1_{d<0})(1-\phi)w' = E\big[S'((1-\alpha)z'k'^{\alpha}n'^{-\alpha} - R\phi w')(1+\lambda 1_{d'<0})\big]$	Labor demand
$w = \frac{\theta_n c}{1-n}$	Labor supply
$I \equiv k' - (1-\delta)k$	Law of capital stock movement
$C(I) \equiv I \cdot 1_{[I\geq 0]} + \theta I \cdot 1_{[I<0]}$	Cost of investment (irreversibility)
$[1_{I\geq 0} + \theta 1_{I<0}](1+\lambda 1_{d<0}) = E\big[S'[\alpha z'k'^{\alpha-1}n'^{1-\alpha} + (1-\delta)(1_{I'\geq 0} + \theta 1_{I'<0})](1+\lambda 1_{d'<0})\big]$	Optimal investment
$d \equiv zk^{\alpha}n^{1-\alpha} - C(I) - R_{-1}\phi wn - (1-\phi)w'n'$	Cash flow (dividends)
$y = zk^{\alpha}n^{1-\alpha}$	Revenue
$y = c + I$	Goods market equilibrium
$I_{rate} = I/k$	Investment rate
$prof = y/k$	Profitability
$wc_{ratio} = \phi w'n'/k$	Working capital ratio
$R' = R_{ss}(1-\rho) + \rho R + \varepsilon'$	Gross interest rate shock

2.3 Simulations

I solve the model numerically and study the role of the working capital channel. I first find the policy functions considering the calibration of all parameters and three different levels of the interest rate shock. I then explain how the working capital channel works by assuming three cases: the first case, a firm finances all its variable costs with cash, and then there is no working capital loan or channel. The second case is that a firm partially finances its variable cost with working capital loans, and in the last case, a firm finances all of its variable cost with working capital loans. After that, I explore how model parametrization can affect the moments of some simulated variables. The results of this last analysis provide us information to identify the parameter ϕ which I estimate later on.

2.3.1 Numerical Policy Functions

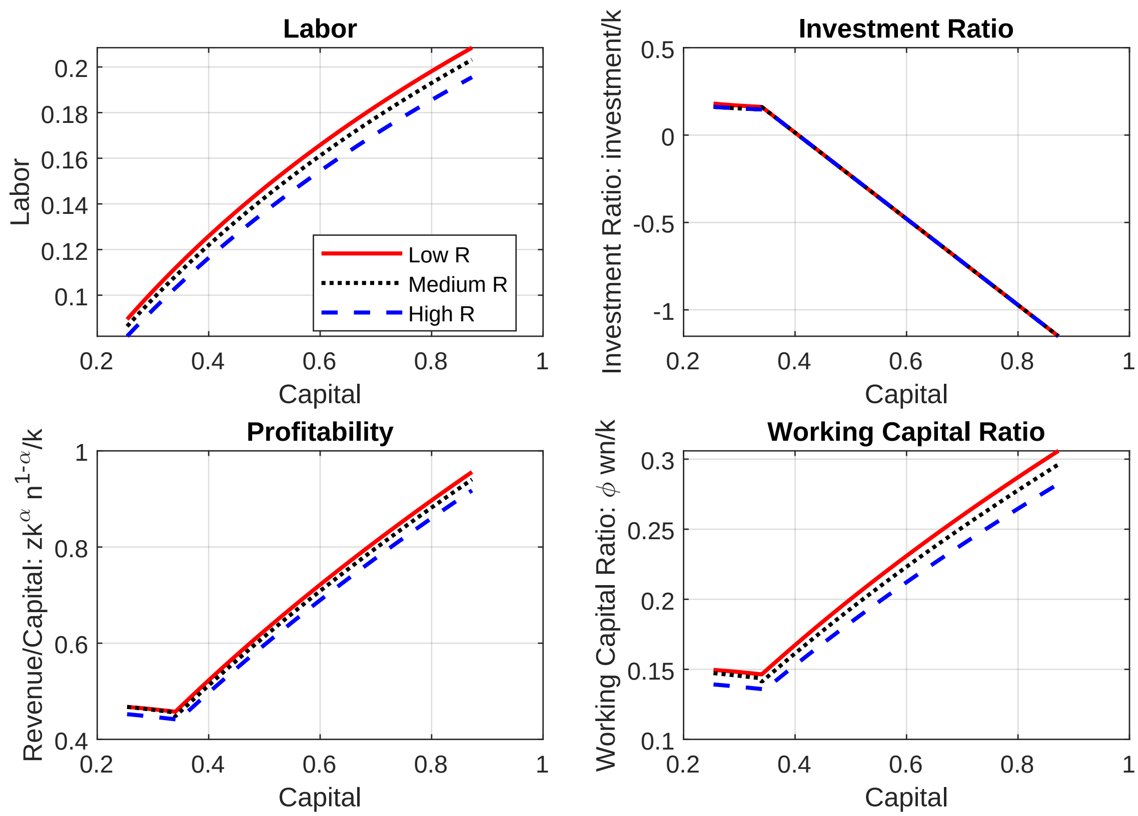
In this section, I examine the policy functions $\{k', n'\} = g(k, n, R)$ in order to gain more intuition about the model. Furthermore, the firm value v—which is calculated as the expected discount cash flows $v = \sum_{t=0}^{\infty} S_t d_t$—is analyzed as well as profitability y/k, investment rate i/k, and working capital ratio $\phi w' n'/k$. The optimal response of the firm expressed in the dynamic behavior of these variables allows us to understand how the interest rate shock is transmitted by the working capital channel to the firm's decisions.

In order to analyze the policy functions, I need to assign the corresponding value to every parameter of the model. The literature related to dynamic models suggests two main approaches to do so. The first one is to estimate these parameters, and the second one is to calibrate them. Since I am interested in estimating the parameter that controls the working capital channel—that is ϕ, I am using the structural model and data from Compustat for estimating it which is explained carefully in the following sections. However, since the aim of this section is to understand how interest shock affects the firm's decisions through the working capital channel, I calibrate all parameters based on previous studies, and I assume an intermediate value of ϕ ($\phi = 0.5$). This last assumption means that the firm finances half of its variable cost with working capital loans.

Calibration.

The average of the share of capital in the total production α is around 0.77 in accordance with Nikolov and Whited (2014). The value of the depreciation rate is 10 percent annually, which is a standard assumption in business cycle literature. Regarding the discount factor parameter β, it is 0.96 according to the steady-state value of gross interest rate $R_{ss} = 1.04$. The equity issue cost as the percent of distributions λ is 0.04 based on Michaels *et al.* (2019), and I also use their estimate for the parameter that drives investment irreversibility θ, which is 0.534. Christiano *et al.* (2010) suggest that the persistence and the standard deviation of the interest rate shock in terms of monetary policy are 0.87 and 0.51 respectively. However, not all the volatility of the monetary shock is transmitted to the interest rate of loans. As a result, I assume that the relevant volatility of the interest rate shock for the firm is one-third of the corresponding monetary policy, but the persistence is the same. In other words, I am assuming that ρ and σ_ε are 0.87 and 0.51/3 respectively. Additionally, I calibrate θ—which measures the relevance of labor (or leisure) in an utility function—to be consistent with the value of the steady state of labor $n_{ss} = 0.2$. As a result, θ_n is equal to 3.36. Finally, I do not consider income effects on labor supply. To do that, I keep the level of consumption at its steady-state value ($C_{ss} = 0.25$) which allows us to get the consumption-output ratio in steady state equal to 75 percent and the investment-output ratio in steady state equal to 25 percent. Considering that consumption takes its steady-state value all the time, the upward-sloping labor supply curve under interest rate shocks allows us to study the effects of this shock on labor through the response of labor demand.

Figure 2.3: Policy Function



Note. The figure depicts the optimal response of the labor, investment rate, profitability, and working capital ratio in response to the interest rate shock R for every level of capital. Low R, medium R, and high R correspond to $R = 1$, $R = 1.04$, and $R = 1.08$ respectively.

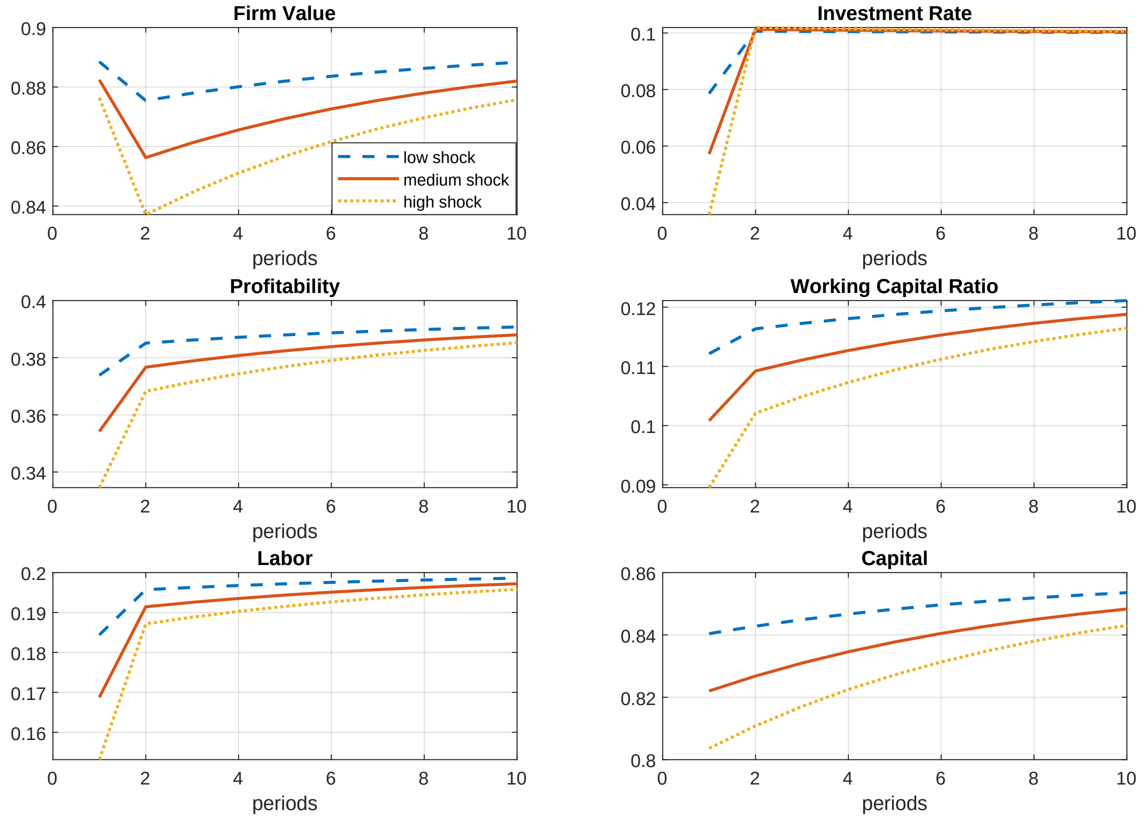
Simulated policy functions.

With the previous calibration of the model and considering $\phi = 0.5$, I solve the model numerically by iterating the Bellman equation which produces the value function $V(k, n, R)$ and policy function $\{k', n'\} = g(k, n, R)$. I leave details of the numerical solution for Appendix A. Since investment rate, profitability, and working capital loans depend on $\{k, n, R\}$, I can analyze these variables when firms are affected by a positive interest rate shock. In particular, these policy functions are shown in the Figure 2.3. This figure shows the firm's optimal response in the *same period* when the interest rate shock occurs for every level of the firm's capital. Three main conclusions emerge from these simulated policy functions. First, interest rate shock is important to determine labor, profit, and working capital loans for the firm. The intensity of that shock moves the optimal level of these variables. Second, high-interest rate shock reduces the level of these variables because of the marginal cost of financing the working capital requirements increase. The optimal response to this shock is to reduce labor demand with effects on production and hence on revenue and profitability. Finally, the investment ratio seems not to react under interest rate shock.

Impulse response function.

How does firm response over time when an interest rate shock occurs? Since the policy functions show us what the *current* firm's optimal response is when shocks occur, the impulse-response function shows us how this optimal response behaves over time. Usually, the impulse-response function considers that the shock occurs in $t = 1$, and its persistence decreases over time until it returns to the steady-state value. The dynamic of the interest rate shock is described by the Equation (2.3). In particular, I study the firm's optimal response in three intensive levels of interest rate shock, which is illustrated in Figure 2.4. Clearly, if the shock is stronger, the working capital channel transmits and amplifies this shock to the firm's behavior. In this case, the firm's value, profitability, investment rate, and working capital ratio reduce their values. Why do these variables decrease? This is because the firm optimally adjusts the degree of labor demand in its production process since the marginal labor cost

Figure 2.4: Impulse Response Function



Note. The figure depicts the optimal response of the firm's value, investment rate, profitability, and working capital ratio in response to the interest rate shock R. These results are obtained from a calibrated model assuming $\phi = 0.5$ and three levels of R shock: low shock is 50 percent lower than the medium shock ($\sigma_\varepsilon = 0.51/3$) and high shock is 50 percent greater than the medium shock.

has been increased. This reduction in labor generates lower profits, investment, and working capital debt.

It is worth noting that the investment rate decreases only in the same period in which the shock is realized and immediately goes back to its steady-state value (upper left-side panel of Figure 2.4). This is because the shock is almost fully absorbed by the labor demand which is partially financed by working capital loans. This behavior is consistent with the literature in corporate finance since working capital requirements are financed by short-term debts, and investment is more connected to long-term debts. As a result, any movement in short-term debt should affect the firm's working capital decisions instead of affecting investment. Additionally, investment in my model is financed by revenues, and if it is not enough, the firm issues equity.

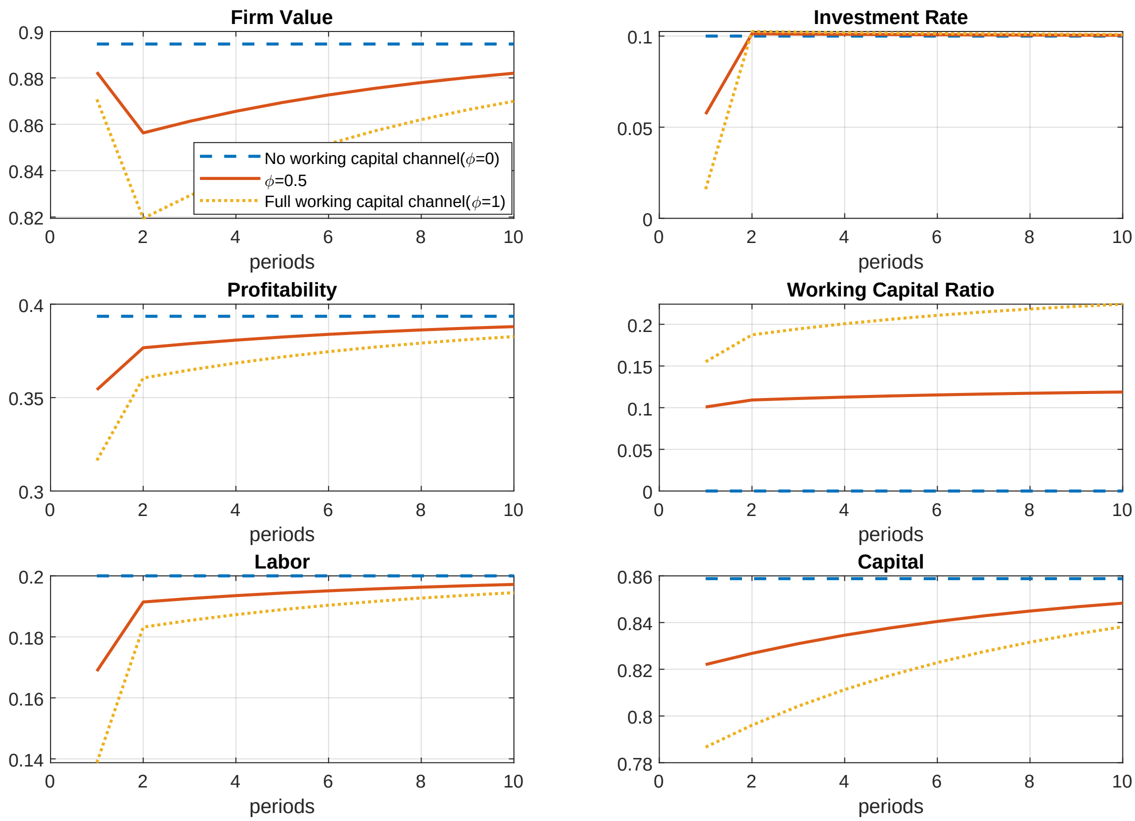
2.3.2 Analysis of Working Capital Channel

An important quantitative question is how big the working capital channel is. I address this question with annual data for firms listed in Compustat which will be discussed later on. Before that, it is important to understand how the endogenous variables respond in different settings of the working capital channel. Figure 2.5 shows three cases for the working capital channel. In the first one, this mechanism is absent. Hence any movement in interest rate does not affect the firm's decisions, and all variables remain in their steady-state values. This setting corresponds to the case in which the firm finances all its variable cost with cash, which is paid at the end of the period. In this case, we do not have the cash-flow mismatch problem.

The second case is when the firm finances in advance, at the beginning of the period, 50 percent of its variable costs with working capital loans ($\phi = 0.5$). In this case, the interest rate shock affects the economy through the working capital channel. As we can see in the bottom-left-side panel of Figure 2.5, the firm optimally reduces its labor demand since the labor marginal cost has been increased. The underlying effect is the reduction of revenue and hence profits. All of these effects reduce the current and future cash flows with a negative impact on the firm's value as we can see in Figure 2.5.

The last case is when a firm finances all its variable costs in advance with working capital loans. In this case, the effect of interest rate shock is stronger than previous cases since the working capital channel transmits all the shock to the firm's decisions. As a result, the labor demand, firm's value, profitability, and investment rate decrease significantly (see Figure 2.5).

Figure 2.5: Relevance of Working Capital Channel in the Firm's Decisions



Note. This figure shows the impulse response functions. Specifically, it shows a firm's value, investment rate, profitability, and working capital ratio behave in three cases: no working capital channel ($\phi = 0$), a moderate working capital channel ($\phi = 0.5$), and a full working capital channel ($\phi = 1$).

2.4 The Data

The data come from Compustat. I consider a sample period from 1971 until 2018 with annual frequency. Firms associated with financial services, utilities, and government administration are not considered in the sample. Furthermore, I eliminate any row in the sample when any of the main variables (operating income, total assets, capital expenditure, and debt in current liabilities) have no information. Additionally, I winsorize the variables profitability, investment rate, and working capital ratio at the 1st and 99th percentiles. After these filters, the final panel has 86,911 observations for 5,739 firms, for the period 1971 to 2018 at an annual frequency. I consider working capital loans as Debt in Current Liabilities. This variable represents liabilities due within one year, including the current portion of long-term debt. In particular, this variable is the sum of accounts payable, other current liabilities, debt in current liabilities, and income taxes. Table 2.2 contains the variable definitions.

Table 2.2: Data Definitions

Variable	Definition
Profitability	Operating Income (OIBDP)/ Total Assets (TA)
Investment rate	Capital Expenditure (CAPX) / Total Assets (TA)
Working capital ratio	Debt in Current Liabilities (DLC) / Total Assets (TA)

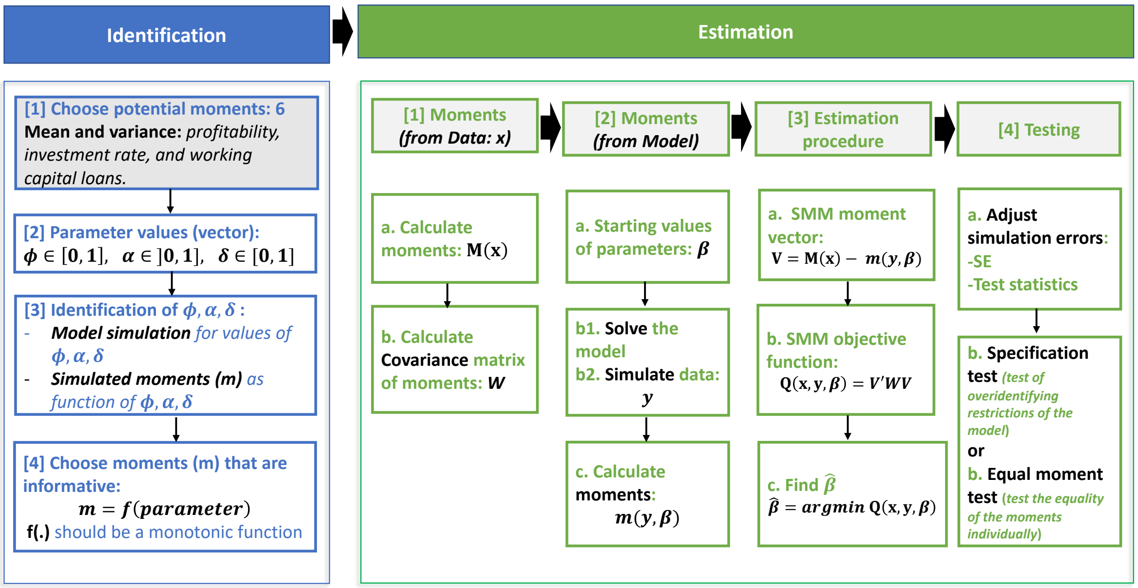
Note. The data is obtained from Compustat.

Since there exists the possibility that working capital ratio varies across industries, I split the sample by type of industry. Table A.1 shows descriptive statistics for the entire sample and every industry.

2.5 Identification and Estimation

In this section, I discuss the identification strategy and the estimation technique. Figure 2.6 shows the steps in the identification and estimation process in the same spirit as Strebulaev and Whited (2012). Specifically, identification involves four main tasks: (i) choose potential moments, (ii) define a vector of values for each of the parameters that I want to estimate, (iii) simulate the model with those values, and compute the simulated moments, and (iv) choose informative moments. Next, the estimation process also starts with four main tasks: (i) compute moments from the data (empirical moments), (ii) compute moments from the model (theoretical moments), (iii) use SMM technique to estimate the target parameters, and (iv) evaluate

Figure 2.6: The Identification and Estimation Process



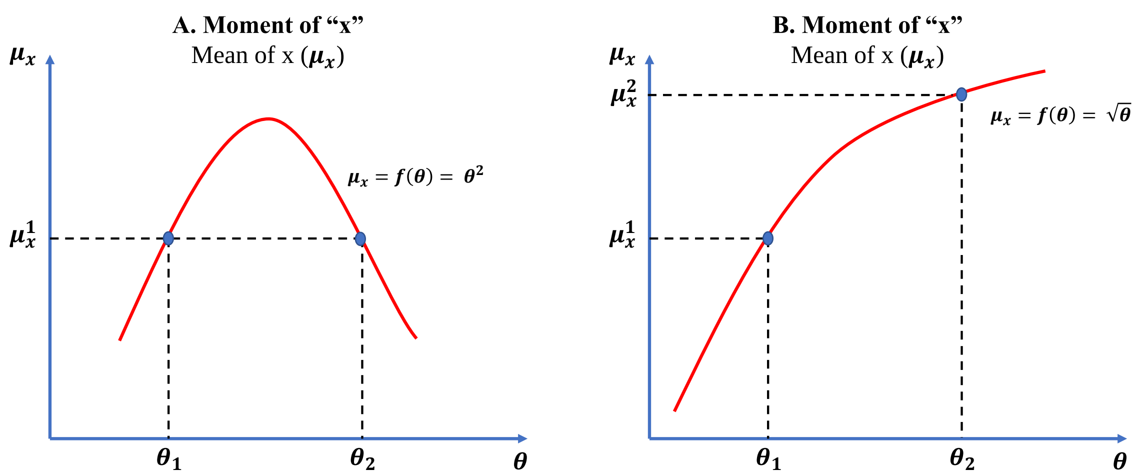
Note. This figure shows the steps in parameters identification and estimation procedure.

the accuracy of our estimation.

2.5.1 *Identification*

The model identification is a cornerstone in the SMM technique. The identification requires choosing moments that are sensitive to variations in the structural parameters. In technical terms, identification requires that the relationship between the model parameters and the moments be one-to-one and onto. For example, let's suppose that the mean of the variable x, μ_x, is a function of *only* one parameter of the model, θ. This means that $\mu_x = f(\theta)$. Additionally, let's assume that this function f is quadratic in θ, so $f(\theta) = \theta^2$. After simulating the mean of the variable x for a range of values of θ, we have panel B of Figure 2.7. As we can see, for a particular value of the mean of x, μ_x^1, we have *two* possible values of the parameter θ: θ_1 and θ_2. Which of these parameter values is the correct? We can get the same value of μ_x with both. As a result, we cannot identify *exactly* the value of θ. This is because the function f, which maps moments to parameters, is *not* one-to-one and onto. In contrast, in panel A of Figure 2.7, we have that f is one-to-one and onto function, $f(\theta) = \sqrt{\theta}$. In this case, for every value of μ_x we have *only one* value of θ associated with it. This allows us to identify exactly the parameter θ. This example illustrates that the identification condition requires that the mapping between moments and structural parameters must be one-to-one and onto. Furthermore, this identification condition suggests that the relationship between moments and parameters should be steep and monotonic, which means that moments are informative about parameters.

Figure 2.7: Identification & No Identification



Note. This figure shows that the identification condition requires that the function that maps moments to parameters must be one-to-one and onto. The left-hand figure shows non-identification while the right-hand figure shows identification.

I now describe six moments that are potentially informative to identify the three parameters of interest (ϕ, α, and δ). In particular, I explore two moments (mean and variance) associated with three main variables: profitability, investment rate, and working capital ratio. I choose these variables due to their connections with the structural parameters in the theoretical model, and because I have available data in Compustat which allows me to construct these variables.

Identification of ϕ.

I evaluate the sensitivity of the described six moments to ϕ, the fraction of working capital that is financed by loans. As we can see in Figure 2.8, the mean of the profitability goes down monotonically when ϕ increases. This is because the interest payment increases with the amount of debt. Since greater ϕ means more debt, then the firm must pay more interest. As a result, the level of profit decreases. However, the magnitude of this change is not significant, then this moment is not informative to identify ϕ.

Regarding the mean of working capital, it goes up when ϕ increases. Since the definition of working capital loans is ϕwn, then any increase in ϕ naturally increases this variable. For this reason, we can see this increasing pattern. The next two important moments which I evaluate are the variance of profitability and the variance of working capital ratio. Both moments are increasing in ϕ since the first one is affected by labor variable cost, and the second one is affected directly by ϕ.

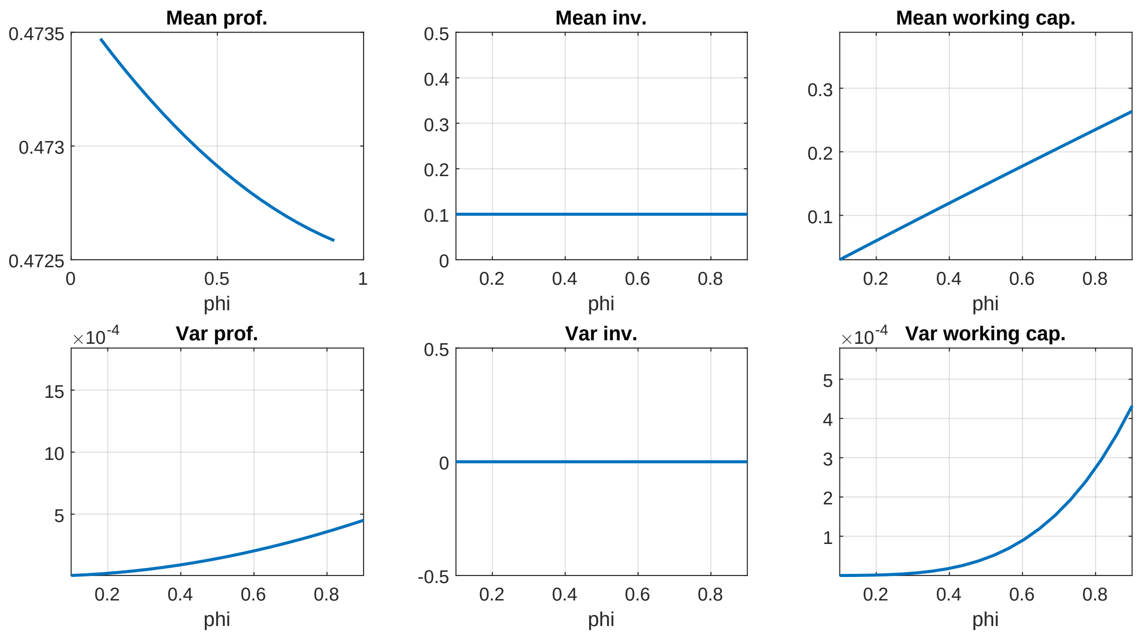
However, both variances vary from 0 to almost $5 \cdot 10^{-4}$, which suggests that changes in ϕ do not produce significant changes in both variances, then these moments are not informative even if they are monotonic.

Finally, the two moments of investment rate are not informative over the range of ϕ. For instance, the mean of investment ratio does not react when ϕ varies. This suggests that these investment moments do not have information to identify ϕ. A conclusion of the identification process of ϕ is the mean of profitability and the mean of the working capital ratio delivers relevant information to identify ϕ. I will use these moments in the estimation section to find ϕ.

Identification of α.

I now study how sensitive the same previous six moments are to α, the elasticity of

Figure 2.8: Identification - ϕ



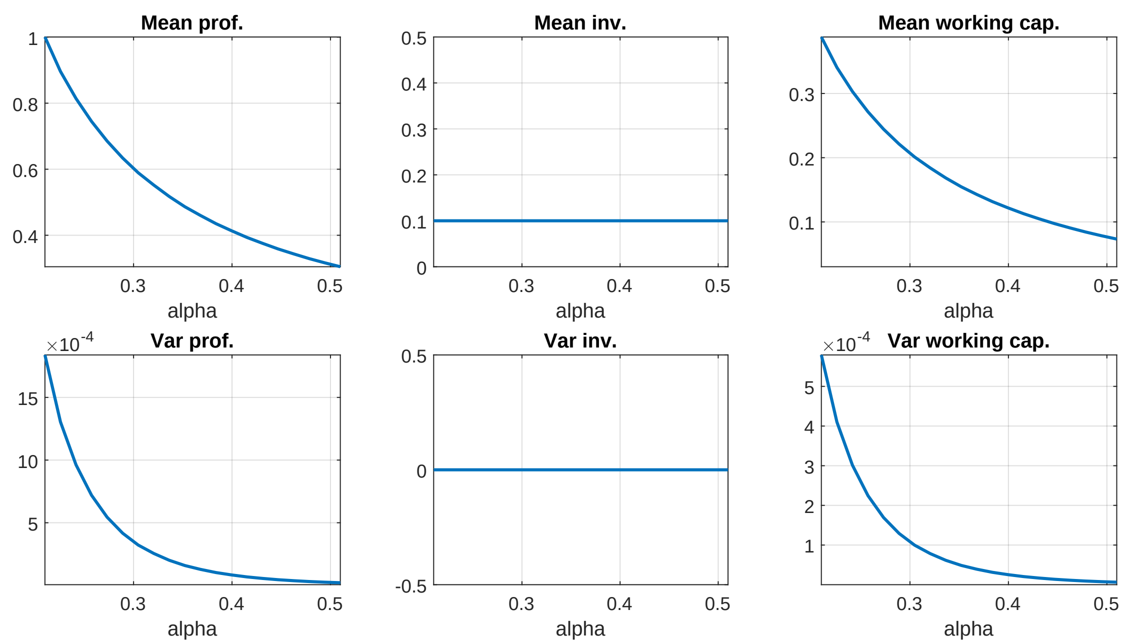
Note. This figure shows how six moments vary with the value of ϕ.

output to capital (see Figure 2.9). Since α is present in revenue $zk^{\alpha}n^{1-\alpha}$, changes in the value of α should be reflected in changes in revenue as well. As a result, I expect that both moments (mean and variance) of profitability experiences movements when α varies as we can see in Figure 2.9.

However, the variance of profitability faces small movements when α increases, which does not help to identify this parameter. On the other hand, the mean of the profitability is monotonically decreasing in the entire range of α, providing information for the identification process. When I evaluate the mean and variance of the investment rate, I find that both moments do not contain information to identify α.

In particular, the mean and variance of the investment rate are constant over the range of α. Finally, moments of working capital ratio seem to be informative since both are decreasing monotonically. Nevertheless, only the mean of working capital changes significantly with the movement of α. What is the economic intuition about that? The working capital ratio is defined as $\phi wn/k$, where n is the firm's labor demand. When α increases, the marginal productivity of capital increases as well, but the marginal productivity of labor decreases. Given that labor demand is essentially controlled by labor marginal productivity, the firm optimally decides to reduce its labor demand and hence the working capital ratio. For this reason, we can see that an increasing α is associated with a decreasing working-capital-ratio mean. Finally, from this identification analysis, I conclude that the mean of profitability and the mean of working capital contains information to identify α.

Figure 2.9: Identification - α



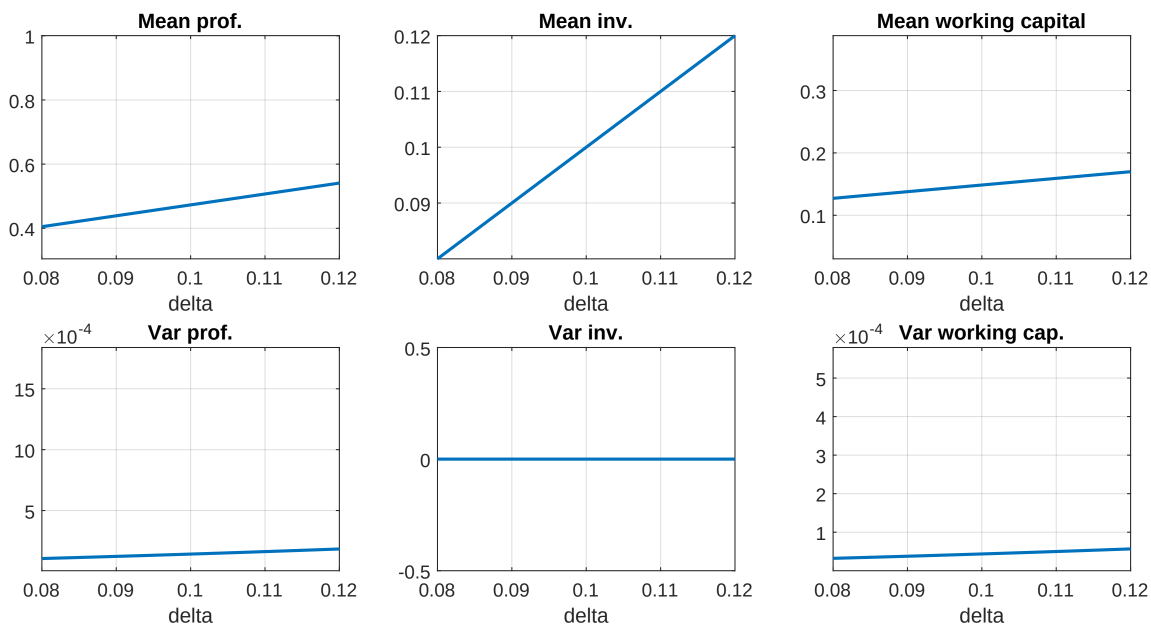
Note. This figure shows how six moments vary with the value of α

Identification of δ.

In the case of δ—which represents the capital depreciation rate—, the mean of investment rate, of the profitability, and the working capital ratio are informative to identify this parameter. In particular, the mean of investment rate seems to be more informative due to varying significantly over the range of δ. Furthermore, as we can see in Figure 2.10, the variance of profitability and working capital ratio are monotonic but with small changes and hence are not informative.

Finally, the variance of investment rate does not vary avoiding the identification of δ. The identification analysis of δ suggests that the mean of profitability, investment rate, and working capital contain information to identify this parameter.

Figure 2.10: Identification - δ



Note. This figure shows how six moments vary with the value of δ.

I summarize the identification process in Table 2.3 . As we can see, the mean of the working capital ratio is connected to three parameters α, ϕ, and δ. Additionally, the mean of profitability depends on α and δ. Furthermore, δ is related to the mean of the investment ratio.

I express these relationships between moments and parameters in the following equations to see clearly how the identification process works.

Table 2.3: Identification

	Profitability		**Investment rate**		**Working Capital ratio**	
	Mean	Variance	Mean	Variance	Mean	Variance
ϕ	Not informative	Not informative	Not informative	Not informative	**Monotone increase**	Not informative
α	**Monotone decrease**	Not informative	Not informative	Not informative	**Monotone decrease**	Not informative
δ	**Monotone increase**	Not informative	**Monotone increase**	Not informative	**Monotone increase**	Not informative

Note. This table summarizes the characteristic of six moments (mean and variance for three variables) for every parameter.

$$\text{Mean(working capital ratio)} = f_1(\alpha, \phi, \delta, \Psi) \tag{2.18}$$

$$\text{Mean(profitability)} = f_2(\alpha, \delta, \Psi) \tag{2.19}$$

$$\text{Mean(investment rate)} = f_3(\delta, \Psi) \tag{2.20}$$

where f_1, f_2, and f_3 represent functions that map moments to parameters. Potentially, moments could depend on several parameters, not only those that I want to study such as α, ϕ, and δ. Then, the variable Ψ contains all the remaining parameters present in the model which are calibrated such as the persistence of interest rate ρ and the standard deviation of the innovation of interest rate σ_ε. As I mentioned in the paragraphs above, the identification process requires that moments of some variables are related to the parameters that I want to estimate. In this case, we can proceed recursively, from equation (2.20) we can obtain δ. Next, from equation (2.19), we can exactly identify α since we know δ. Equation (2.18) allows me to identify the value of ϕ given the value of δ and α. In conclusion, for identifying the three parameters (α, ϕ, and δ), I can use three informative moments: the mean of working capital ratio, the mean of profitability, and the mean of investment ratio. The model is *exactly* identified since I have three parameters and three moments. Given that the variance of profitability reacts to all three parameters in different degrees, I will use it in the estimation process. In that last case, the model is overidentified since I have more moments that parameters.

2.5.2 Estimation

I estimate the model parameter of the working capital channel ϕ, the capital-output elasticity α, and the depreciation rate δ using SMM. The remaining parameters of the model are calibrated based on previous studies. The SMM estimation technique is well-known in econometric literature, and its basic idea is to adjust the parameter of interest—let's say β—to get similar properties for the observed endogenous variables y_t and for their simulated counterparts y_t^s (Gouriéroux and Monfort, 1996). In particular, SMM finds θ such that the empirical moments of variables y_t are as close as possible to the moments of the simulated variable y_t^s which come from the structural model. To be explicit about how I am applying this procedure to the structural model described before, I split the procedure into two sets of steps in the spirit of Strebulaev and Whited (2012): moments and estimation procedure (see Figure 2.6).

Moments. First of all, I choose a *set of moments* that initially I want to match. Since in the model, I have three main variables—profitability, investment rate, and working capital ratio—, the moments chosen are the average and variance of these variables. As a result, I have six moments. It is worth noting that in this step I do not know if I finally will require that the model matches all these six moments. The identification process will tell me what moments of the six I need. Second, I *identify* what moments are relevant to estimate the three parameters ϕ, α, and δ. From the six moments chosen in the first step, I evaluate which of them provides information about the parameters. Since I am estimating three parameters, I need to choose at least three moments from the available six. The third step is to *simulate* the chosen moments from identification step and save it in $m(y^s, \beta)$ and do the same for variables in the real data and save their moments in $M(y)$. In order to get the simulated moments, I choose the starting value of the set of parameters. The next step is to calculate the covariance matrix of the empirical moments. The inverse of this matrix represents the GMM weight matrix. I denote this matrix as W.

So far, we have a subset of moments that are related to the parameters of interest ϕ, α, and δ. Furthermore, we have empirical and simulated moments and the GMM weight matrix. Now, I start the estimation process.

Estimation procedure. SMM chooses ϕ, α, and δ such that these parameters minimize the SMM objective function $Q(y, y^s, \phi, \alpha, \delta)$. This function is the sum of the square of the difference between the empirical moments and the simulated moments weighted by the inverse of the covariance matrix of empirical moments W.

$$Q(y, y^s, \phi, \alpha, \delta) \equiv (M(y) - m(y^s, \phi, \alpha, \delta))' W (M(y) - m(y^s, \phi, \alpha, \delta)) \tag{2.21}$$

After estimating ϕ, α, and δ, I adjust the standard errors and test statistics for simulation error. Finally, I use a specification test which refers to a general test of the overidentifying restrictions of the model which can be written as:

$$\frac{NJ}{1+J} Q(y, y^s, \phi, \alpha, \delta)$$

in which J is the ratio of the number of observations in the simulated data to the number of observations in the real data N.

2.6 Results

I first present the results of estimating the model for the entire sample. I then estimate the model for seven industries: Agriculture, Mining, Construction, Manufacturing, Wholesale Trade, Retail Trade, and Services.

2.6.1 Full Sample Results and by Industry

Table 2.4 presents the parameter estimates. In particular, I estimate α, δ, and ϕ. α is the capital share in total profits, δ is the depreciation rate, and ϕ is the proportion of working capital which is financed by working capital loans.

Entire sample. For the entire sample, the estimated α is 0.71 which is close to the previous estimation at the firm level: 0.773 for Nikolov and Whited (2014) and 0.868 for Michaels *et al.* (2019). The estimation of δ (5.6%) is also consistent with the estimated value of 8.4% of Michaels *et al.* (2019). The estimated value of δ of Nikolov and Whited (2014) is higher (13%) than I estimate here. A possible explanation is that the presence of investment irreversibility—absent in Nikolov and Whited (2014)—encourages firms to use its capital more intensively generating more depreciation. Regarding ϕ, the full sample estimation suggests that this parameter is 0.758. This means that firms in the entire sample on average finance 75.8 percent of their working capital requirements with loans. Although this value is not equal to one as macroeconomics models usually assume, this value is quantitatively important.

Across industries. Industries sample estimation suggests that ϕ is different across industries. The Retail Trade sector has the lowest value of ϕ (0.482) while three sectors (Agriculture, Construction, and Wholesale Trade) have a full working capital

Table 2.4: Structural Parameter Estimates

	α	δ	ϕ		α	δ	ϕ
Full sample	0.71	0.056	0.758	Manufacturing	0.70	0.055	0.701
	(0.01)	(0.001)	(0.156)		(0.01)	(0.001)	(0.279)
Agriculture*	0.796	0.062	1.00	Wholesale Trade	0.592	0.04	1.00
	(0.08)	(0.006)	(0.495)		(0.01)	(0.001)	(0.012)
Mining	0.89	0.093	0.619	Retail Trade	0.812	0.073	0.482
	(0.02)	(0.004)	(0.503)		(0.242)	(0.02)	(0.002)
Construction	0.793	0.043	1.00	Services	0.736	0.048	0.506
	(0.06)	(0.006)	(0.092)		(0.02)	(0.002)	(0.672)

Note. This table presents the estimated structural parameters, with standard errors in parenthesis; α is the capital share in total profits; δ is the depreciation rate, and ϕ is the proportion of working capital which is financed by working capital loans. I estimate these parameters for the entire sample and seven industries (Agriculture, Mining, Construction, Manufacturing, Wholesale Trade, Retail Trade, and Services)

*This industry includes forestry and fishing as well.

channel ($\phi = 1$). This means that a positive interest rate shock will affect these three industries more than the Retail Trade sector. For the Manufacturing sector, which represents almost 60 percent of the data, ϕ is strong (0.701).

What are the economic implications of these estimations? At least two important implications. First, these results suggest that the working capital channel is not *full* for the entire economy. This implies that the power of the monetary policy is not too strong through this channel, as policymakers assume. Second, since the working capital channel shows heterogeneity across industries, the monetary policy would have different effects on firms depending on what industry they belong to. For instance, it seems that any movement in the monetary policy interest rate would affect the Construction sector more than the Retail sector.

Given these results, the natural question is what economic forces explain these differences in the working capital channel across industries. Tentative answers could be related to the economic nature of every industry (e.g., seasonal sales, inventory accumulation), accessibility and cost of loans, capacity utilization, and financial frictions. Although studying these possible explanations is out of this paper's scope, this

Table 2.5: Simulated Moments Estimation

	Moments (%)							
	All Sample		Agriculture*		Mining		Construction	
	Data	Model	Data	Model	Data	Model	Data	Model
Mean Prof.	13.6	14.0	8.6	13.3	13.8	15.2	11.0	10.9
Var. Prof.	1.2	0.0	0.5	0.0	1.0	0.0	0.6	0.1
Mean Inv.	6.1	5.6	5.9	6.3	13.0	9.3	5.5	4.3
Var. WC Ratio	4.8	3.9	7.2	2.6	2.8	1.6	5.3	2.2
	Manufacturing		Wholesale trade		Retail trade		Services	
	Data	Model	Data	Model	Data	Model	Data	Model
Mean Prof.	14.6	14.2	8.7	14.5	15.0	14.2	13.6	12.5
Var. Prof.	0.8	0.0	3.5	0.0	0.9	0.0	1.0	0.0
Mean Inv.	5.6	5.5	4.1	4.0	7.6	7.3	5.7	4.8
Var. WC Ratio	4.6	4.1	7.7	5.7	3.8	2.6	3.6	3.2

Note. This table presents the comparison between moments from the data and moments from the model. Mean Prof. is the "mean of profitability (y/k)," Var. Prof. is the "variance of profitability," Mean Inv. is the "mean of investment rate (I/k)," and Var. WC ratio is the "variance of working capital ratio (wn/k)."
*This industry includes forestry and fishing as well.

represents an important research agenda.

Model evaluation. In order to evaluate whether the estimations are accurate, it is important to evaluate the theoretical model's ability to capture the moments of data. Table 2.5 presents the actual moments (from the data) versus simulated moments (from the model). At least four ideas emerge from this table.

First, the model generates moments that are close to the data for the entire sample, although with overestimation for profitability and underestimation for investment rate and working capital ratio. For instance, mean profitability in the data is 13.6 percent and in the model is 14.0 percent. Second, more accurate model moments are generated for the Manufacturing sector, which represents almost 60 percent of the data. For example, the variance of the working capital ratio is 4.6 percent which is very close to what the model generates (4.1 percent). Third, for industries with less sample data, the model generates a lower value of the variance of the working capital ratio. However, in general, the estimation of the mean of the investment ratio is well captured by the model across industries and for the entire sample. Finally, it is challenging for the model to replicate the variance of profitability. This is because I require the model to generate moments with only one shock -the interest rate-. A potential extension of the model would be to consider a productivity shock that allows the model to better fit with data moments. As I mentioned before, since this paper aims to study the working capital channel, an exogenous interest rate shock is more accurate. However, the cost of this is that I entail the model to replicate moments that are better obtained from productivity shock. Even so, the model is doing a good job in capturing data moments.

2.7 Conclusion

In this paper, I study the quantitative relevance of the working capital channel. Since one of the main assumptions in macroeconomic models is that this channel is full and hence monetary policy has important effects on firms' decisions, it is important to estimate this channel from microeconomic data. With this goal in mind, I develop a firm dynamic model with investment, financing frictions, and working capital requirements. I estimate the working capital channel using SMM technique for the entire sample from Compustat annual data from 1971 to 2018.

From full sample estimation, I find that the working capital channel is not full as it is assumed in macroeconomic models, but it is still quantitatively important (0.758). From industry estimation, I find this parameter is different across industries. All these results provide support of the quantitative relevance of the working capital channel, but it suggests that it is not the same for every industry and it is not full for the entire sample.

These results trigger important questions: what is the magnitude of the working capital over the business cycle? Is ϕ different for expansion and recessions? Is ϕ

different for constrained and unconstrained firms? or for small, medium, and large firms? Taking into account the magnitude of the working capital channel, how could monetary policy affect the capital structure of the firm through this channel? Is this effect different due to firm's characteristics? All of these questions open an interesting and promising research agenda.

Chapter 3

WHAT KIND OF FIRM IS MORE RESPONSIVE TO THE UNCONVENTIONAL MONETARY POLICY?

3.1 Introduction

The COVID-19 pandemic has affected significantly the financial markets and the real side of the economy since the mid of March 2020. As a policy response, the Federal Reserve announced at the end of March its *Unconventional* Monetary Policy (UMP) related to the corporate bond market. This policy consists of two instruments called the *Primary* and *Secondary* Market Corporate Credit Facility (PMCCF and SMCCF respectively). The PMCCF consists of buying debt directly from investment-grade US companies with the goal to provide the funding that they need to maintain business operations and capacity [1]. Complementarily, the SMCCF consists of purchasing in the secondary market eligible corporate bonds as well as US-listed exchange-traded funds (ETFs) that invested in US investment-grade corporate bonds. The goal of the SMCCF is to provide liquidity to the market [2].

In this context, an important question for policy design is still open: Has been the UMP related to the corporate bond primary market (i.e. PMCCF) effective? While answering this question is challenging from a theoretical and empirical perspective, I provide -in this paper- a step forward in understanding the possible effects of this policy on firms' decisions using a theoretical and *analytical* model.

[1] *Business operations* is everything that happens within a company to keep it running and earning money. Business operations encompass three fundamental management imperatives that collectively aim to maximize value harvested from business assets: generate recurring income, increase the value of the business assets, and secure the income and value of the business. *Business capacity* is the maximum output level a company can sustain to provide its products or services.

[2] For more details about SMCCF and PMCCF, see the Federal Reserve webpage in the following link

Specifically, I develop a two-period model in which the representative firm has a default option and faces financial constraints in the external financing market such as no equity issuance and bankruptcy cost. I also consider investor behavior to obtain a corporate bond demand. Additionally, the COVID-19 shock is modeled as a supply shock, i.e. a reduction in the firm's productivity level, and the unconventional monetary policy in the primary corporate bonds market is interpreted as a reduction in the firm's default probability.

I use this model to study the effects of COVID-19 shock and more important to study the effects of the PMCCF on the firm's decisions. Since the PMCCF's goal is related to help *business operations* and *business capacity* of non-financial firms, policymakers expect that this policy to have effects on real variables such as production and investment. I use the analytical framework described above to study that and to understand what are the economic mechanisms through COVID-19 shock and the UMP influence the economy. It is worth noting that this is the first time that Federal Reserve uses this policy (i.e. PMCCF). Previous UMP tools were related to quantitative easing applied to financial intermediaries. In contrast, PMCCF is a tool that directly influences non-financial firms.

A main takeaway of the base model is that firm's default probability plays a key role in transmitting the effects of COVID-19 shock and the UMP. Also, the assumption of a constrained firm is relevant to link corporate debt with investment. Under the model's assumptions, while the UMP -PMCCF- is effective to reduce the interest rate of corporate bonds, to increase the corporate bond issuance, and to recover the firm's investment and production; its effects are not sufficiently strong to offset the COVID-19 shock as we can see in the data.

I then evaluate the effects of COVID-19 shock and the UMP when firms are heterogeneous in size and the initial credit risk. Regarding heterogeneity in the firm size, I extend the model to consider two different firms: large and small firms. To this end, I assume a different asset in place in the initial period for these two firms. What firm is more responsive to COVID-19 shock and UMP? The model suggests that a large firm is more affected by COVID-19 shock than a small one. Similarly, a large firm is more responsive to UMP than a small one. The economic reason for that is that a large firm is more external-financing dependent since it has a low cash-asset ratio [3]. Regarding the heterogeneity in the initial firm's credit risk, I extend the model assuming two firms with different default probability at the initial period: low-risk firm and high-risk firm. Based on the model, I show that a high-risk firm is more affected by COVID-19 shock and is more responsive to the UMP. However, taking into account all of these effects, a high-risk firm shows the worst equilibrium than a low-risk one.

Finally, I test the prediction of the model about the heterogeneity effects of UMP across firm size. Considering the growth rate of long-term debt ($\Delta\%$ LT-Debt) as a indicator of firm's response to UMP, I estimate a cross-sectional regression for 2020Q2 to evaluate whether the prediction of the model about the heterogeneity response across firms by size is supported by data. I also examine whether growth rate in long-term debt between 2020Q1 and 2020Q2 can be explained by firm characteristics.

The estimation results suggest three main ideas. First, that there exists heterogeneity responses across firms by size: $\Delta\%$ LT-Debt of medium firms are more sensitive to change in assets than small and large firms, and large firms are more sensitive to change in operating income (-) and ST-debt(-). Second, an interesting result is that firms with positive profitability in 2020Q1 show a positive correlation between $\Delta\%$ cash and $\Delta\%$ LT-Debt. Furthermore, firms with higher cash/asset ratio

[3] Using annual data from COMPUSTAT from 1971 to 2018, the average cash-asset ratio for small firms is 2.3 times corresponding to large firms. Firms with total assets in the first quartile are considered as small firms and firms with total assets in the upper quartile are considered as large firms.

in 2020Q1 have increased more its LT-Debt in 2020Q2. This behavior could due to the precautionary motive. Third, some firms characteristics such as growth rate of assets and operating income provide information in explaining change in long-term debt in 2020Q2.

Literature review. This paper is related to unconventional monetary policy–a set of tools such as quantitative easing (QE) [4], credit easing schemes, forward guidance, and long-term repo operations- (Bernanke, 2020; Farmer, 2012; Breedon *et al.*, 2012). This literature has focused on the effects of "quantitative easing" on financial markets and the real economy. Studies for the United States have found a connection between QE and bank lending (Darmouni and Rodnyansky, 2017), household net worth and consumption (Beraja *et al.*, 2019; Di Maggio *et al.*, 2017), aggregate financing costs (Hancock and Passmore, 2011; Gilchrist *et al.*, 2015), and employment (Luck and Zimmermann, 2020). I complement this literature studying how a new unconventional monetary policy, named purchases of corporate bonds primary market, [5] used by the Federal Reserve affects the equilibrium of corporate bond prices, corporate bond issuance, and the corporate investment in a theoretical and analytical framework.

The purchase of corporate bonds by central banks was used in the European Union as a response to the last financial crisis. However, the literature about the real effects of this policy is not conclusive. For instance, Grosse-Rueschkamp *et al.* (2019) find that this policy had effects on corporate investment through the called "capital structure channel of monetary policy." Hohberger *et al.* (2019) suggest that QE of

[4] It involves large-scale asset purchases financed by the issuance of central bank money (Bowdler and Radia, 2012).

[5] The QE exercised by the Federal Reserve as a response to the financial crisis in 2009 was essentially applied to "financial intermediaries" such as banks. Now in the COVID-19 pandemic, the unconventional monetary policy is different. The Federal Reserve's policy is focused on non-financial firms instead of intermediaries through the direct purchase of corporate bonds from firms in the primary market. This did not happen before.

the European Central Bank had a significant effect on the Euro Area GDP growth. In contrast, Todorov (2020) finds that the main effect of this policy was on corporate bond prices, and firms used these funds mostly to increase dividends with no effects on investment. Since most of these studies use an empirical approach, I contribute to this literature in providing a theoretical framework.

This paper is also related to a growing literature that studies the relationship between firm-level investment and financial policies in presence of financial frictions. Gomes (2001) proposes a reduced-form representation of the cost of external finance. Models with full-fledged capital structure allow default, leverage, and equity issuance (Cooley and Quadrini, 2001; Moyen, 2004; Hennessy and Whited, 2005, 2007). These studies suggest that the major determinant of corporate investment is the availability and pricing of external funds when financial frictions are present. In a similar environment, Kuehn and Schmid (2014) complements the literature showing that macroeconomic risks are important for the firm's investment and financing policies. Specifically, they found that a large fraction of the level of credit spread can be explained by risk premia. I contribute to this literature in showing how the UMP related to the primary corporate bond market could affect the firm's investment under some conditions.

I also contribute to the literature that studies the effect of the monetary policy in presence of heterogeneous firms (Gertler and Gilchrist, 1994; Jeenas, 2019; Cloyne *et al.*, 2019). Ottonello and Winberry (2020) study how the *conventional* monetary policy could affect firm's investment. Empirically, they find that firms with low-default risk are more influenced by monetary policy and the theoretical argument for that is low-default firms face a flatter marginal cost curve for financing investment. I complement this literature studying how the *unconventional* monetary policy - corporate bonds purchases by the Federal Reserve- could influence the investment at the firm level when firms are different in size (small versus large) and when firms are different in the initial credit risk (low-risk versus high-risk) in an analytical framework.

In the literature, the closest paper to this work is Sims and Wu (2020) who evaluate the efficacy of the direct intervention of the Federal Reserve by lending to non-financial (Main Street QE) firms as opposed to interacting only with financial intermediaries (Wall Street QE). By using a macroeconomic model with a "cash-flow constraint", these authors show that when the cash constraint is binding, Main Street QE is highly effective to stimulate economic activity because it loosens the constraint facing non-financial firms and allows them to continue to issue debt to finance investment. Therefore, the policy recommendation is that it is not sufficient for a central bank to lend freely to combat the economic crisis. It is as important for the Federal Reserve to lend freely to *where constraints are more binding*. I use a complementary analytical model that shows the relevance of the firm's probability default and firm heterogeneities in the efficacy of UMP. Another close paper is Haddad *et al.* (2020). They also study the effects of the intervention of the Federal Reserve on debt markets. They focus on the effects of this policy on corporate bond prices, i.e., effects on the financial markets. In contrast, I study the effects of this policy on the firm's investment, i.e, effects on the real sector of the economy.

The paper proceeds as follows. Section 3.2 describes some empirical facts related to the COVID-19 crisis and the subsequent UMP. Section 4.3 describes the two-period model: assumptions, a household, a constrained firm, first-order conditions, the COVID-19 shock, and the UMP. Section 3.4 describes the effects of COVID-19 shock and UMP when firms are heterogeneous in size and initial credit risk. Section 3.5 shows the cross-sectional estimation results. Section 4.5 concludes and suggests a future research agenda.

3.2 The COVID-19 Shock and the Unconventional Monetary Policy

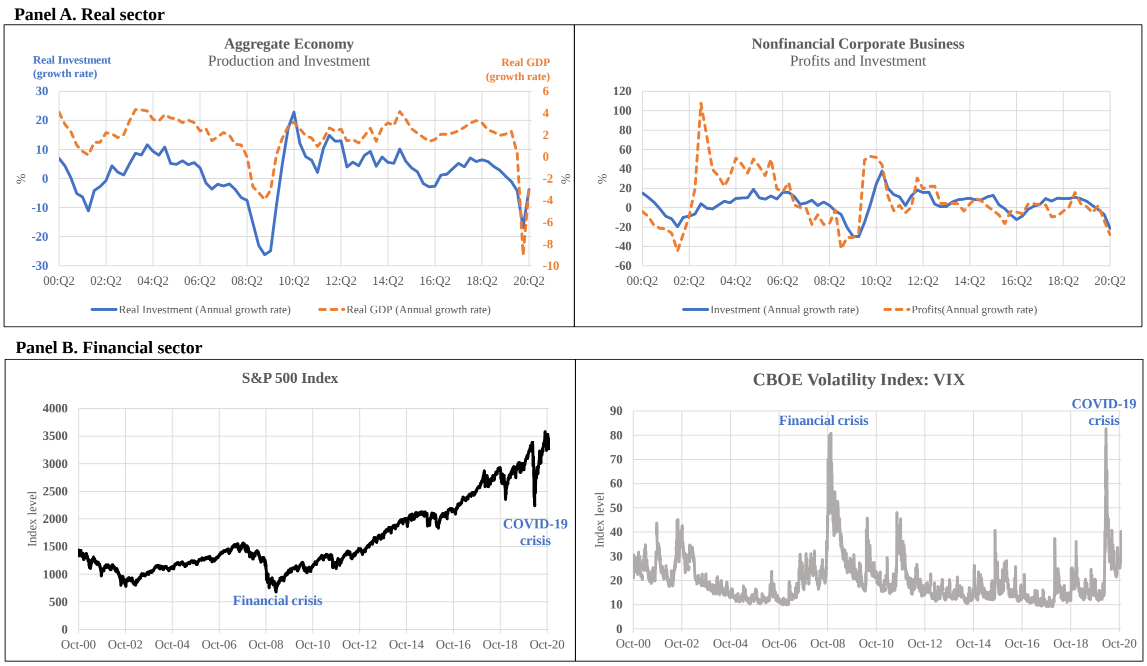
In this section, I describe the effects of the COVID-19 crisis in the US economy, the possible effects of the Federal Reserve's unconventional monetary policy as a policy response of this shock, and the *economic forces* behind the effects of this policy.

It is usual in economics that when the economy faces a shock (demand/supply or real/financial one), the policymakers react using conventional tools to smooth these effects. This pattern has not been different since the onset of the COVID-19 crisis in March 2020. However, the nature of this shock is different and, in some degree, the policy's response accordingly has been *no conventional*. There is still a discussion about the nature of this shock. Some researchers consider that COVID-19 shock is more related to a supply one (Bekaert *et al.*, 2020; e Castro *et al.*, 2020; Fornaro and Wolf, 2020; Sims and Wu, 2020; Caballero and Simsek, 2020b), others suggests that it is more close to a demand one (e Castro, 2020; Bigio *et al.*, 2020). However, growing literature claims that this shock is a mix of supply and demand one (Guerrieri *et al.*, 2020; Kiley, 2020; Caballero and Simsek, 2020a). This is natural since the onset of the COVID-19 pandemic and the following lockdown policies affect the firm's production (supply shock) and hence the unemployment rate affecting the household's income and then the consumption (demand shock).

Regarding policy's response, the Federal Reserve has used lending operations and asset purchases, in both cases in short- and long-term [6]. However, this is the first time that the Federal Reserve implements a policy directly on primary corporate bond markets (PMCCF). The efficacy of this policy is still an open research question from a theoretical and empirical perspective. This paper sheds light on our understanding of the effects of this policy under an analytical model.

[6] In BIS Bulletin, Cavallino and Fiore (2020) summarize the central bank's response of five main economies.

Figure 3.1: Covid-19 Effects on Real Sector and Financial Markets



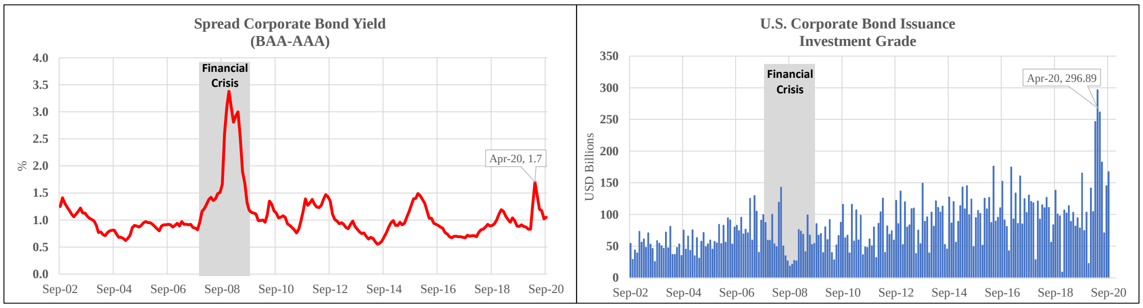
Note. Federal Reserve Bank of St. Louis. S&P500 data (2000-2019) comes from Compustat. Panel A is expressed in quarterly frequency while Panel B in monthly frequency data.

COVID-19 effects. Figure 3.1 shows the effects of COVID-19 on real (panel A) and financial sector (panel B). Two takeaways emerge from Panel A. First, the COVID-19 crisis has affected *more* the aggregate production than the financial crisis 2007-2008 (see the left-hand figure in panel A). The lowest annual GDP growth in the financial crisis was -3.9% in 2009.Q1 while it was -9% in the COVID-19 crisis (2020.Q1). Although the recovery of the COVID-19 crisis seems to be faster than the financial crisis, there is too earlier to claim that since there is still uncertainty about the arrival date and effectiveness of the vaccine, future waves, and lockdown policies. Second, the COVID-19 crisis has affected *less* the nonfinancial corporate profit than the financial crisis 2007-2008 (see the right-hand figure in panel A). The annual growth rate of profits was -28% in 2020Q2 while the lowest growth rate in the financial crisis was -43% in 2008Q4. This is surprising since COVID-19 shock involves a supply and demand shock with a higher impact on production than the financial crisis. However, this shock has affected differently across industries Guerrieri *et al.* (2020); Woodford (2020); Baqaee and Farhi (2020). Indeed, some companies could have been benefited from it (e.g. Amazon).

Panel B of Figure 3.1 shows the financial effects of COVID-19. I point out two main ideas. First, the financial market -represented by S&P 500 index- fell faster than in the financial crisis (see the left-hand figure in panel B). Between November 2007 and March 2009 (the higher and lowest value during the financial crisis), the S&P 500 decreases by 35%. Almost the same magnitude experienced this index with COVID-19 shock (33%); however, this strong reduction was in a short time, between February and March 2020. Second, the market expectation of volatility (VIX) is almost the same for COVID-19 and financial crisis, however, the volatility generated by COVID-19 seems to be persistent since the uncertainty of future lockdown policies and waves (see the right-hand figure in panel B).

Unconventional monetary policy effects. Has been this policy succeeded? Data suggest that the SMCCF effectively increased the price of corporate bonds in the secondary market, increasing the liquidity (see the left-hand graph of Figure 3.2) and hence reducing the corporate bond spread. This is important since it represents a reduction in external financing costs. Firms also decided to issue new corporate bonds in the market given the announcement of the Federal Reserve, which suggests the impact of PMCCF on financial markets (see right-graph of Figure 3.2). Importantly, this corporate bond issuance has been the highest in the last 20 years. However, since the goal of the PMCCF is that firms maintain business operations and capacity, an open question is whether these new funds obtained would have effects on firms' production and investment. I make a step forward in this paper to understand that.

Figure 3.2: Unconventional Monetary Policy Effects: Spread and Corporate Bonds Issuance



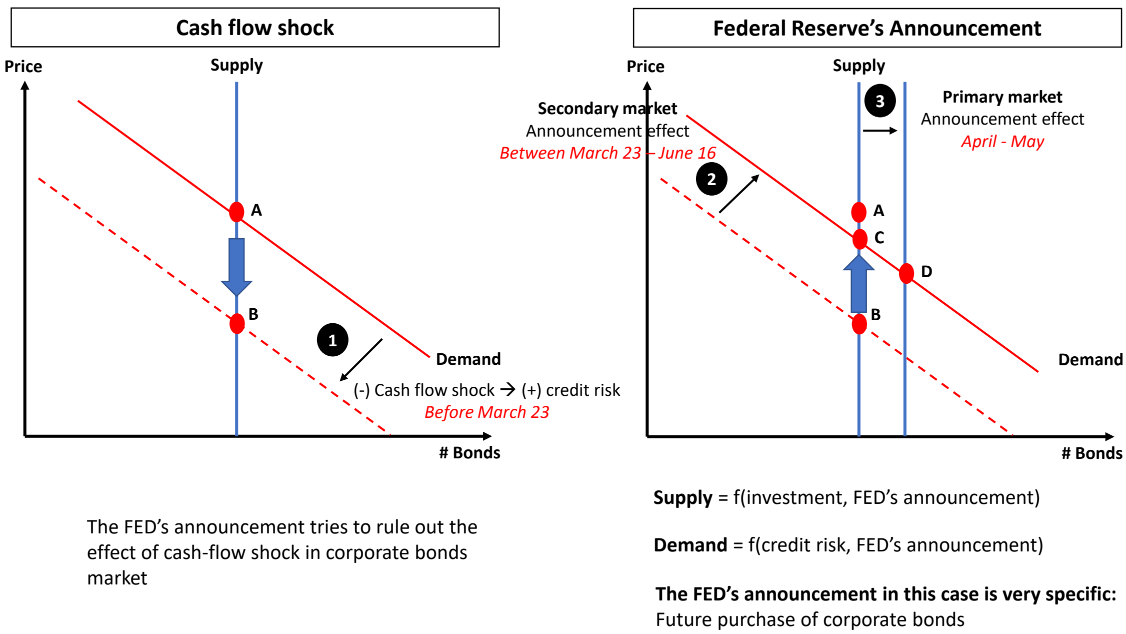
Note. Corporate bonds issuance come from Securities Industry and Financial Markets Association (SIFMA) and the spread is calculated as a difference between Moody's Seasoned Baa Corporate Bond Yield and Moody's Seasoned and Aaa Corporate Bond Yield from Federal Reserve Bank of St. Louis.

To illustrate the economic forces behind the effects of UMP -in particular the PMCCF-, I use a supply-demand approach in the corporate bond market. Figure 3.3 presents the effects of the cash-flow shock (COVID-19 shock) and the Federal Reserve's announcement on the corporate bond market. The sequence of events is as follows. First, the COVID-19 shock affects the economy reducing the firm's cash flow which increases the firm's credit risk. As a result, investors decide to reduce their corporate bond demand (point B). In this equilibrium, the corporate bond price is lower increasing the cost of external financing. In this context, the Federal Reserve announces its policy: a commitment to buy corporate bonds in the *primary* market. This means an increase in corporate bond demand with a reduction in external financing costs (point C). The final equilibrium (point D) shows an increase in corporate bond issuance and an increase in corporate bond prices.

3.3 A Model With Financial Frictions

I develop a two-period model in which the representative firm is subject to two financial constraints (no equity issuance and costly default) with the default option

Figure 3.3: Federal Reserve's Announcement Effects



and exogenous default probability. I use this model to study the effects of COVID-19 and the Federal Reserve's unconventional monetary policy related to the primary corporate bond market.

3.3.1 Assumptions

The economy is formed by two agents: a household and a constrained firm. The behavior of the household is important to obtain "corporate bond demand." Furthermore, the constrained firm faces total capital depreciation ($\delta = 1$).

I assume that the firm is subject to financial friction in the equity market such that it cannot issue new equity. Therefore, dividends in both periods must be greater or equal than zero $d_0, d_1 \geqslant 0$. Additionally, this firm is constrained in period 0: $d_0 = 0$. This last assumption allows the model to connect "debt" with "investment."

Furthermore, I interpret the UMP in corporate bond primary market as a *reduction* in firm's default probability ($\downarrow \lambda$). The economic argument of this assumption is as follow: given that the announcement of the Federal Reserve in March 2020 of buying corporate bonds in the primary market is a commitment to provide funding to firms in order to maintain their business operation and capacity, firms expect to maintain or increase their future cash flows which reduce the credit risk reflected in lower default probabilities.

Regarding COVID-19 shock, the literature is still debating whether this shock is either a supply (Guerrieri *et al.*, 2020; Fornaro and Wolf, 2020; Caballero and Simsek, 2020b) or a demand one (e Castro, 2020) or a combination of both (Kiley, 2020; Guerrieri *et al.*, 2020). From an empirical perspective, Bekaert *et al.* (2020) suggest that COVID-19 shock is more related to a negative supply one. They estimate that two-thirds of GDP growth in the second quarter of 2020 was due to a reduction in aggregate supply. Based on that, I model COVID-19 shock as a negative supply one. Especially, this shock is captured by a reduction in the productivity level ($\downarrow Z$).

Lastly, since COVID-19 shock affects the firm's production and hence the firm's cash flows, which increase the default probability, I model the latter as a negative linear function of productivity level. This assumption is consistent with Giesecke *et al.* (2011), who show that a change in GDP is a strong predictor of corporate bond default rates.

$$\lambda = a - bZ + \varepsilon_{\text{UMP}} * 1_{(\text{UMP starts})}, \qquad a > 0, b > 0 \tag{3.1}$$

Where ε_{UMP} represents the UMP (a reduction in default probability) and $1_{(\text{UMP starts})}$ is an indicator function which is equal to one when the Federal Reserve starts its UMP.

3.3.2 Household

In the economy, a representative household is present. In the initial period ($t = 0$), the income of the household comes from the initial endowment ($w_0 > 0$) and he uses it to invest in corporate bonds (b_1) and consumption (c_0). Corporate bonds are bought at discount fashion at gross interest rate R_b. In the next period ($t = 1$), the household faces uncertainty about the payoff of his investment in corporate bonds. In particular, period 1 is characterized by two possible states: default and no default. If the firm defaults in $t = 1$, the household obtains the remaining of the firm's revenues after deducting the bankruptcy cost ($\varepsilon Z k_1^{\alpha}$). In contrast, if the firm does not default, the household obtains the face value of corporate bonds. In both cases, the household receives the corresponding endowment in $t = 1$ ($w_1 > 0$) and uses his income to consume (c_1): c_1^d represents the consumption in period $t = 1$ in default state and c_1^{nd} represents the consumption in period $t = 1$ in *no* default state. The instantaneous utility function is modeled as $U(c) = log(c)$ and the expected utility is represented as

$$E[U(c_1)] = \lambda U(c_1^d) + (1 - \lambda) U(c_1^{nd}) \tag{3.2}$$

where λ is the firm's default probability. Therefore, the household's *optimization problem* is as follows:

$$\max_{\{c_0, c_1, b_1\}} U(c_0) + \beta E[U(c_1)]$$

subject to:

$$c_0 = w_0 - b_1/R_b \tag{3.3}$$

$$c_1^d = w_1 + (1 - \varepsilon) Z k_1^{\alpha} \tag{3.4}$$

$$c_1^{nd} = w_1 + b_1 \tag{3.5}$$

where β is a discount factor. From the first order condition, the corporate bond demand is characterized as follows:

$$R_b = \frac{w_1}{\beta(1 - \lambda) w_0} + \left(\frac{1 + \beta(1 - \lambda)}{\beta(1 - \lambda) w_0} \right) b_1 \tag{3.6}$$

An important feature of this equation is that default probability (λ) plays a key role in the slope and movement of corporate bond demand. An increase in λ, the credit risk goes up which pushes up the bond interest rate (R_b) generating a reduction in corporate bond demand.

$$\uparrow \lambda(\text{def prob}) \rightarrow\uparrow R_b \rightarrow\downarrow \text{CorpBond demand}$$

Furthermore, given the relationship between default probability and corporate bond demand, I model the Federal Reserve's corporate bond demand (increase) as a *reduction* in λ which is the UMP.

3.3.3 A Constrained Firm

In this economy, there exists a constrained firm as I described in the assumptions section. There are no information frictions between the shareholders and the manager. As a result, the manager maximizes the firm value at $t = 0$ (V_0). In the period $t = 0$, the firm obtains income from corporate bond issuance (b_1/R_b) and along with the initial cash (x_0), this firm could use these funds to invest (k_1) and pay dividends (d_0). In the next period (t=1), the firm decides to default or not. In the case of default, the firm cannot pay back completely the face value of corporate bonds issued in $t = 0$ and it incurs a bankruptcy cost ($\varepsilon Z k_1^\alpha$). The remaining amount $(1-\varepsilon)Zk_1^\alpha$ is taken by the household. As a result, the firm in this default state obtains zero in dividends ($d_1^d = 0$). In contrast, in *no* default state, the firm can pay back its debt and dividends are positive ($d_1^{nd} > 0$). Furthermore, the future cash flow is discounted by β and the expected cash flow is represented by

$$E[d_1] = \lambda d_1^d + (1-\lambda)d_1^{nd} \tag{3.7}$$

Taking all these together, the firm optimization problem is as follows:

$$V_0 = \max_{\{d_0,k_1\}} \left\{ d_0 + \beta E[d_1] \right\}$$

subject to:

$$d_0 = x_0 + b_1/R_b - k_1 \tag{3.8}$$

$$d_1^d = 0 \tag{3.9}$$

$$d_1^{nd} = Z k_1^\alpha - b_1 \tag{3.10}$$

From the first-order condition, the optimal investment equation is expressed as

$$1 = \beta(1-\lambda)\alpha Z k_1^{\alpha-1} \tag{3.11}$$

Two important features emerge from this equation. First, the default probability affects the optimal investment, and -since it depends on the productivity level (Z)- λ amplifies the COVID-19 shock (Z). Second, a reduction in Z discourages investment. Both effects are illustrated below.

$$\uparrow \lambda(\text{def prob}) \rightarrow \downarrow k_1 \text{ Investment}$$

$$\uparrow Z(\text{productivity}) \rightarrow \uparrow k_1 \text{ Investment}$$

An important question is when the firm defaults. I follow Moyen (2004) and Hennessy and Whited (2007) in assuming that firm defaults when its equity value is equal zero. This allows me to find the level of productivity ($\overline{z}$) that makes the firm's value equals zero. If the firm experiences a productivity level below of $\overline{z}$, then the firm defaults.

$$V_0(\overline{z}) = 0 \tag{3.12}$$

$$\overline{z} = b_1/k_1^{\alpha} \tag{3.13}$$

$$Z \leqslant \overline{z} \tag{3.14}$$

Finally, since the firm is constrained, its dividends in $t = 0$ are equal to zero. This characteristic allows the model to obtain a relationship between investment and corporate bonds issuance.

$$d_0 = x_0 + b_1/R_b - k_1 = 0 \tag{3.15}$$

$$b_1 = (k_1 - x_0)R_b \tag{3.16}$$

I infer two important relationships from this equation. The first one is the negative relationship between initial cash (x_0) and corporate bond issuance (b_1). It suggests that whether the firm has more initial cash before the COVID-19 shock, then it would be less dependent on external financing. Moreover, a low level of x_0 could be interpreted as a *net* cash: initial cash minus the initial debt. A debt-overhang firm would have a low x_0, which makes the firm more external-financing dependent. The second interesting relationship is between corporate bond issuance and investment. This relationship is positive suggesting that firm issues debt to finance investment. Both relationships are illustrated below.

$$\uparrow x_0(\text{cash}) \rightarrow\downarrow b_1 \text{ debt}$$

$$\uparrow k_1(\text{investment}) \rightarrow\uparrow b_1 \text{ debt}$$

3.3.4 Model Calibration

Fundamental parameters. Two standard parameters in the dynamic firms literature is the discount factor (β) and capital-production elasticity (α). Their values are 0.96 and 0.36 respectively as Real Business Cycle literature suggests (e.g. Moyen, 2004). I assume that the endowment in $t = 1$ (w_1) is 80% of its value in $t = 0$ (w_0): $w_1 = 80\% w_0$. I assume that w_0 is five consumption units and then w_1 is four consumption units.

COVID-19 shock. I use the production function to calculate the level of productivity shock in COVID-19 crisis. Let y_a and y_b the production *after* and *before* COVID-19 shock. Using the functional form of the production function assumed in the model, I have:

$$y_a = Z_a k_a^\alpha \tag{3.17}$$

$$y_b = Z_b k_b^\alpha \tag{3.18}$$

Doing the corresponding algebra, the ratio between Z_a and Z_b is as follows:

$$\frac{Z_a}{Z_b} = \left(\frac{y_a}{y_b}\right)\left(\frac{k_a}{k_b}\right)^{-\alpha} \tag{3.19}$$

The corresponding empirical variable of production y in the model is the real gross domestic product (real GDP) and investment in the model k is the real gross private domestic investment. I also consider data in the last quarter of 2019 as the stage of the economy *before* COVID-19 shock. Furthermore, the first quarter of 2020 is considered as the stage of the economy *after* COVID-19 shock. Using aggregate quarterly data from the Federal Reserve of Saint Louis, the ratio between productivity levels would be

$$\frac{Z_a}{Z_b} = 0.69 * (0.85)^{-0.36} = 0.65 \quad (3.20)$$

I normalize Z_b to one, then Z_a is equals to 0.65. That means that COVID-19 shock represents a reduction of 35% in productivity.

The UMP. I model the UMP as a reduction in the firm's default probability (λ). Since this variable is strongly related to the interest rate spread between AAA and BAA corporate bonds. I use this spread to infer the magnitude of $\Delta\lambda$ which reflects the UMP. Since the COVID-19 crisis started in the midst of March 2020, I consider February 2020 as a period *before* that shock. In that month, the spread AAA-BBA was 0.8% and I assume that the corresponding default probability level is 0.2. Furthermore, I consider from March 2020 to April 2020 as a period *before* Federal Reserve implemented its UMP. I use the monthly growth rate of the spread AAA-BBA to calculate the monthly level of default probability. For instance, the spread in March was 1.3% which represents a growth rate of 53% in comparison with its level in February. I then apply this growth rate (53%) to default probability: 0.2 in February and (1+53%)0.2 in March. As a result, the default probability in March is 0.31. I follow this computation for March, April, and May. After that, I calculate the mean of default probability (March-May), which I consider as the level of default probability generated by COVID-19 shock. This value is $\lambda = 0.36$.

Since the Federal Reserve's unconventional monetary policy started being implemented in June and it is still ongoing [7]. I consider the effects of this policy on the spread AAA-BBA and hence on default probability between June 2020 and September 2020. I follow the same strategy applied to calculate the default probability

[7] The Federal Reserve *announced* its unconventional monetary policy related to the primary corporate bond market in March 23rd, 2020 and started buying these bonds since the end of June 2020 (news link).

generated by COVID-19 shock. The difference now is the sample period: from June to September. As a result, the default probability after the UMP started is $\lambda = 0.26$. This means that the UMP reduces λ from 0.36 to 0.26. Therefore, I consider that the UMP is a reduction of λ in 10% (level).

The firm's probability default. The default probability is characterized by two parameters: a and b (see equation (3.1)). I calibrate both parameters before the UMP started ($1_{(\text{UMP starts})} = 0$) and considering the relation between Z and λ before and after COVID-19 shock: $Z = 1$ and $\lambda = 0.2$ (before COVID-19 shock) and $Z = 0.65$ and $\lambda = 0.36$ (after COVID-19 shock).

$$\lambda = a - bZ \tag{3.21}$$

$$0.2 = a - b * 1 \tag{3.22}$$

$$0.36 = a - b * 0.65 \tag{3.23}$$

Doing simple algebra, the values of a and b are 0.66 and 0.44 respectively. A summary of the calibrated parameters is below.

$$\beta = 0.96, \alpha = 0.36, x_0 = 0.01(7\%k_1), w_1 = 80\%w_0, a = 0.66, b = 0.44$$

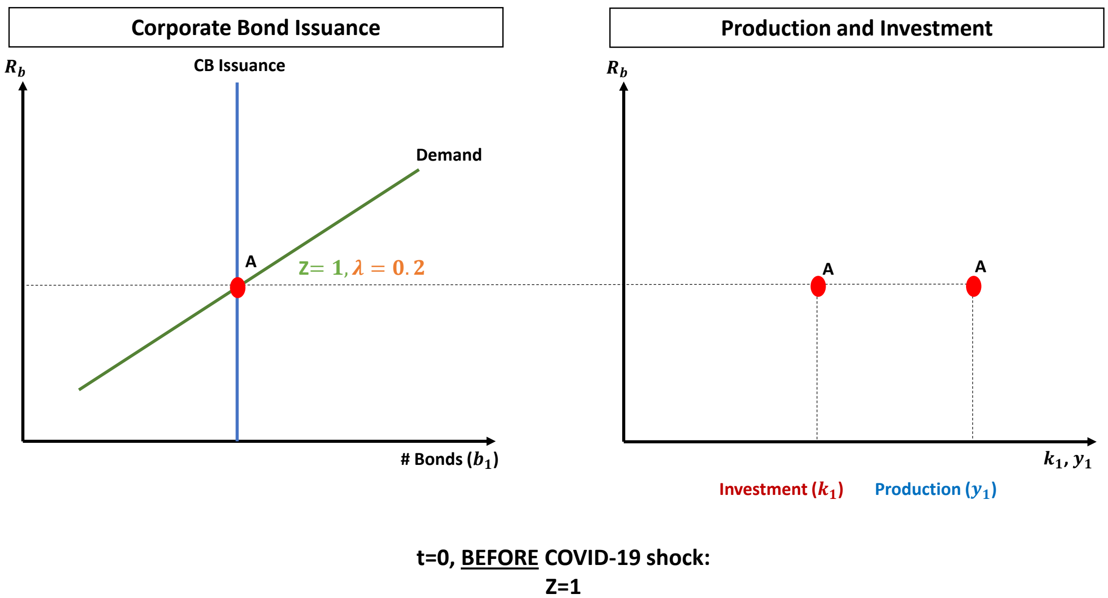
$$\text{COVID-19 shock} = 65\%Z$$

$$\text{UMP} : \varepsilon_{\text{UMP}} = \Delta\lambda = -10\%(\text{level})$$

3.3.5 Using the Model to Illustrate COVID-19 Shock and UMP

In this section, I use the calibrated model described before to evaluate first the effects of COVID-19 shock on the financial and real decisions of the firm. After the equilibrium generated by COVID-19, I use the model to evaluate the effects of UMP on the firm's decisions.

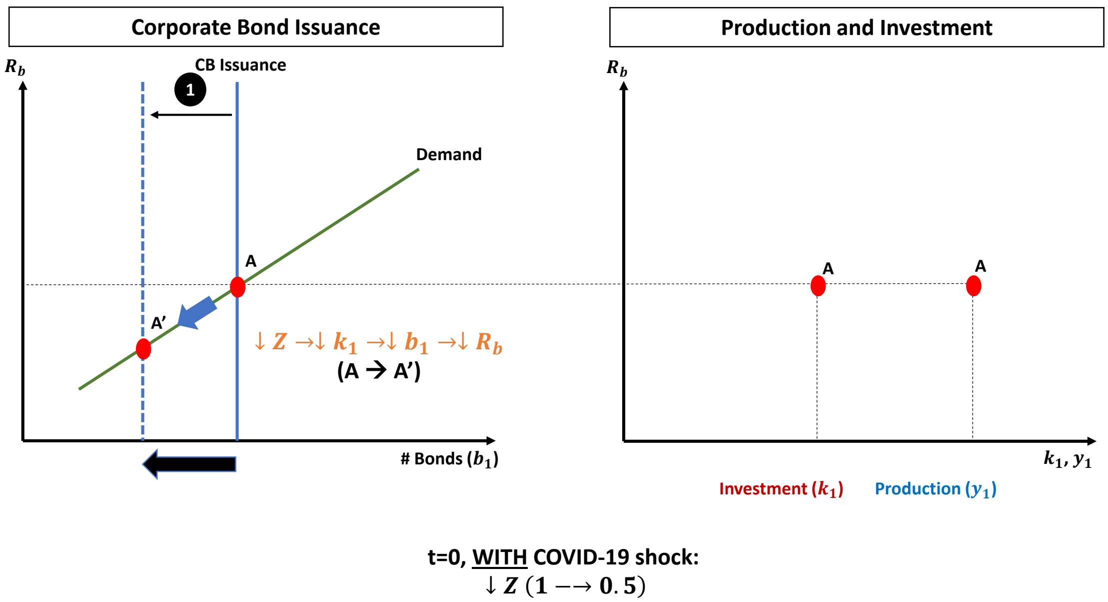
Figure 3.4: The Initial State of the Economy



The initial state of the economy. The initial equilibrium of this economy is characterized by the *point A* in Figure 3.4. This equilibrium reflects the state of the economy before COVID-19 shock with productivity level (Z) equals one and with corresponding default probability (λ) equals 0.2. The left-hand graph represents the primary corporate bond market and the right-hand graph represents the production and investment level at this equilibrium.

COVID-19 Shock: 1st effect (Corporate Bond Market - Supply). Figure 3.5 shows the first effect of the COVID-19 shock in this economy: a reduction in corporate bond issuance. The economic intuition behind this effect is as follows: the COVID-19 is represented by a reduction in Z (from 1 to 0.65), which -from the firm's first-order condition- reduces the optimal level of investment. Since the firm

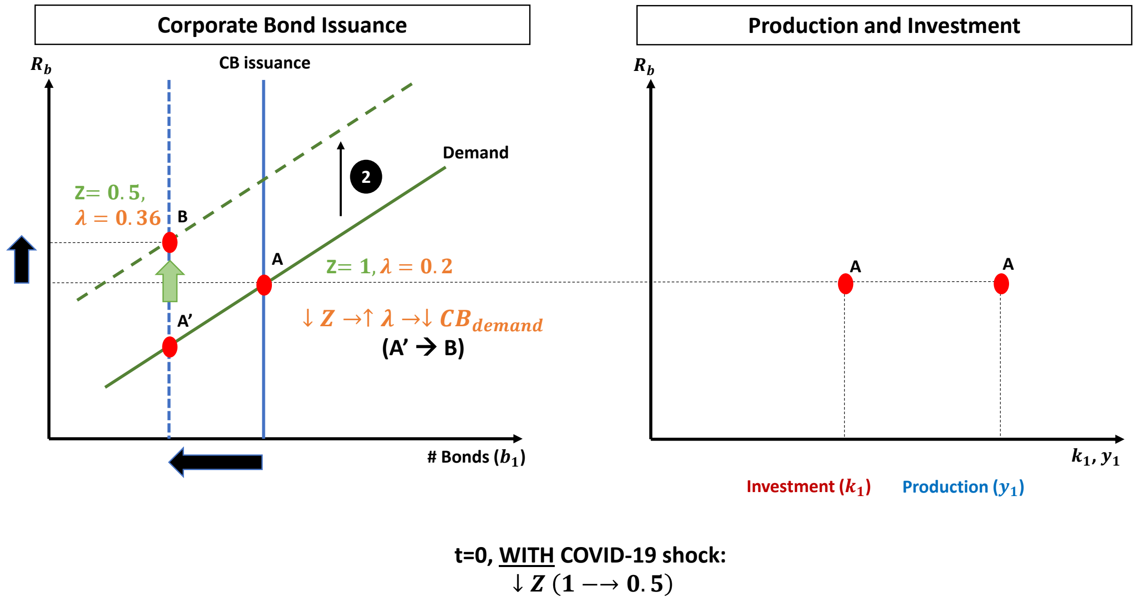
Figure 3.5: Covid-19 Shock: 1st Effect (Corporate Bond Market - Supply)



is constrained ($d_0 = 0$), a reduction in investment pushes down external financing. As a result, the corporate bond issuance now is lower than the initial equilibrium ($A \rightarrow A'$). It is worth noting that A' is not the final equilibrium of COVID-19 shock, it is just a *intermediary* one since there is another effect that is described below.

COVID-19 Shock: 2nd effect (Corporate Bond market - Demand). The second effect of COVID-19 is on corporate bond demand (see the left-hand panel of Figure 3.6). The reduction in Z increases the default probability (λ) which increases the credit risk affecting the willingness of the household in buying corporate bonds. As a result, households optimally decide to reduce their corporate bond demand. Now, the new equilibrium is *point B* in which the level of productivity is 0.65 and the default probability is 0.36. Importantly, in the new equilibrium (point B), the productivity level is lower and the default probability is higher than those values at the initial equilibrium (point A). Furthermore, this new equilibrium shows a higher

Figure 3.6: Covid-19 Shock: 2nd Effect (Corporate Bond market - Demand)



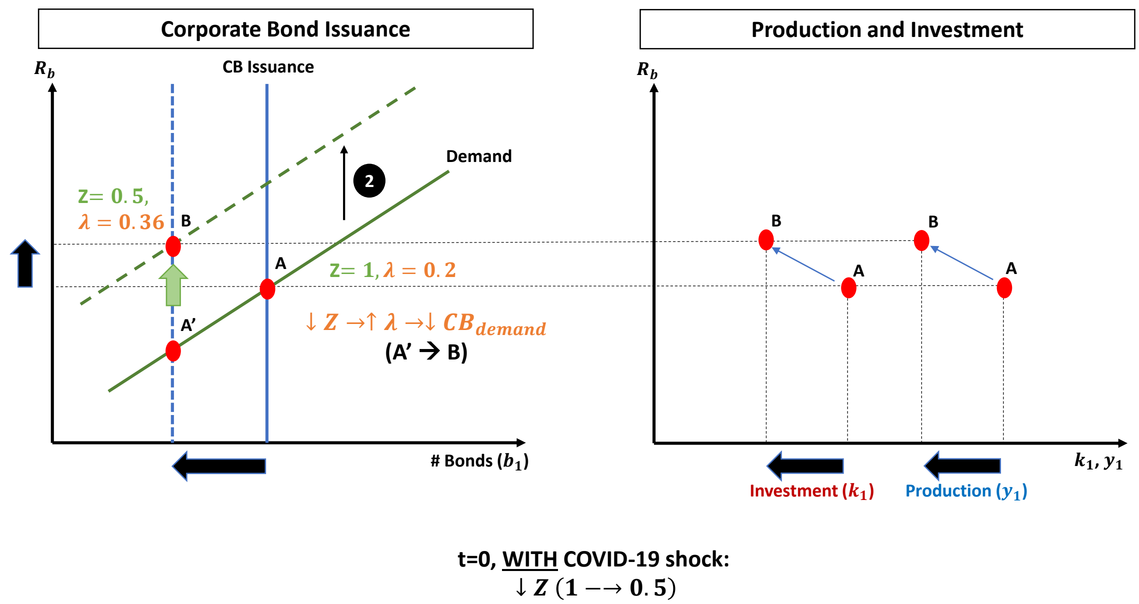
gross interest rate (R_b) than the corresponding value at the initial state of the economy, which is consistent with the data.

COVID-19 Shock: 3rd effect (Real Sector). The previous two effects of COVID-19 in the model have been on the corporate bond market. However, what are the effects on real variables of the firm such as production and investment? The left-hand graph of Figure 3.7 shows these effects. In particular, the COVID-19 shock has reduced the level of investment and production as we can observe in the data.

Therefore, the COVID-19 shock in the model has the following effects: (i) a reduction in corporate bond issuance, (ii) an increase in the interest rate of corporate bonds, (iii) a reduction in production and investment. In this context, the Federal Reserve started its UMP which its effects are studied by the lens of the model.

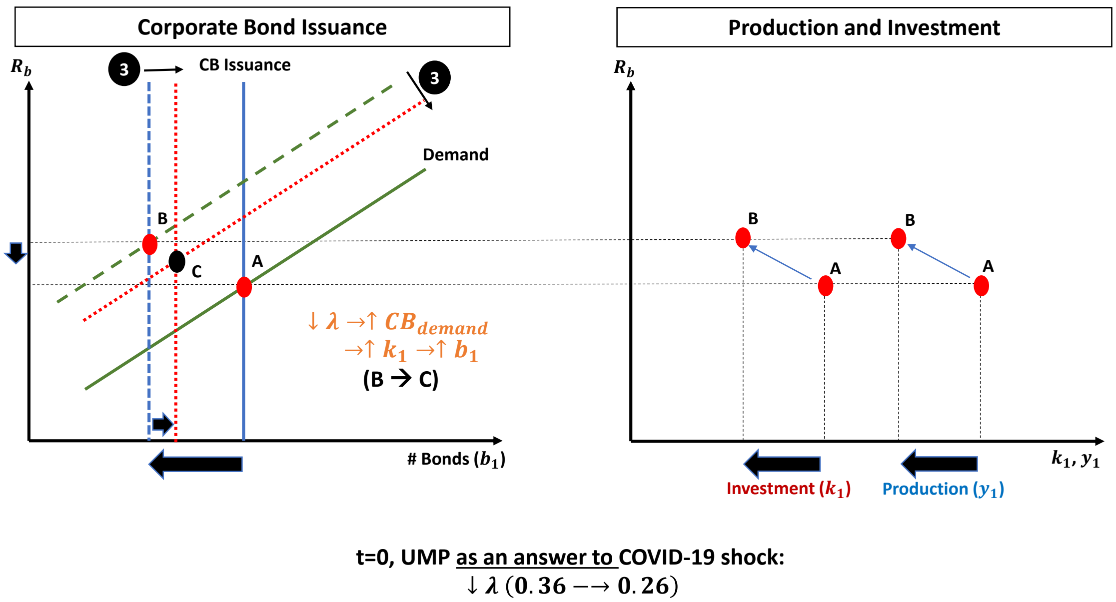
UMP: 1st effect (Corporate Bond market). Since the UMP is interpreted as

Figure 3.7: Covid-19 Shock: 3rd Effect (Real Sector)



a reduction in default probability, this policy has effects on the demand and supply schedule of corporate bonds. Regarding the demand schedule, a reduction in default probability is interpreted by investors as the firm's credit risk is going down. This encourages investors to buy more corporate bonds generating an increase in its demand. Regarding the supply side, a reduction in default probability increases the firm's optimal investment. This is because a low default probability reduces the external financing cost making it much easier for the firm to obtain funds to boost investment. Moreover, since this firm is constrained, an increase in investment generates an increase in external financing. As a result, the corporate bond issuance increases. The left-hand graph of figure 3.8 shows these effects. In particular, the new equilibrium in the corporate bond market is represented by the *point C*. In this equilibrium, the gross interest rate (R_b) is lower than the COVID-19 equilibrium (point B) but it still higher than the equilibrium pre-COVID-19 shock (point A) which is consistent with data.

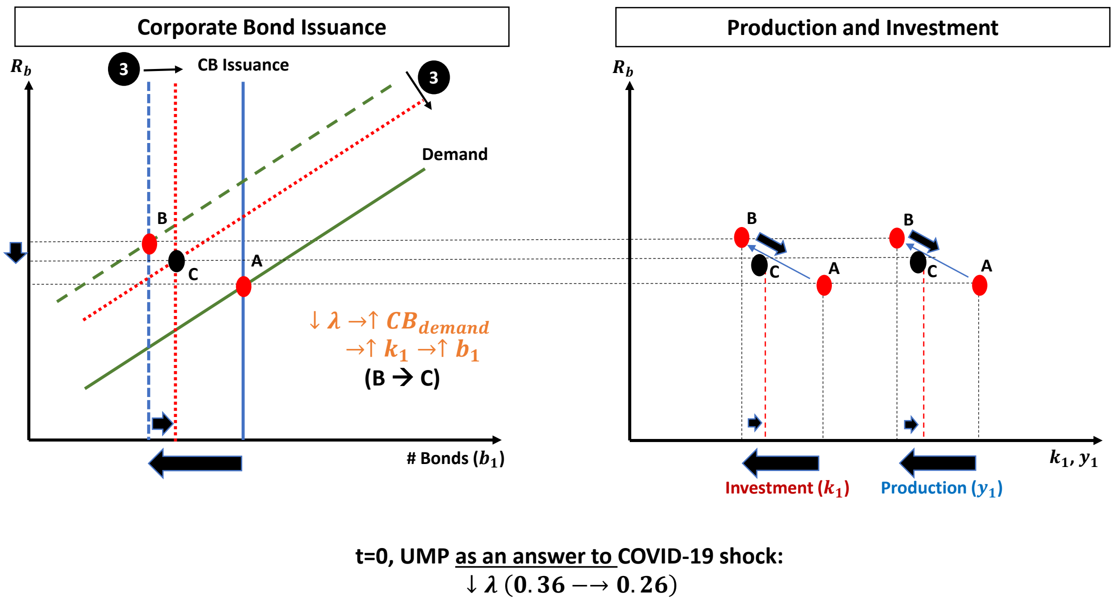
Figure 3.8: Unconventional Monetary Policy: Corporate Bond market



UMP: 2nd effect (Real effects). Since the goal of the UMP is related to real variables, the natural question is: *what are the real effects of this UMP?* The right-hand graph of figure 3.9 shows the effects of UMP on investment and production. As we can see in that figure, the UMP helps the firm to increase investment and production from the COVID-19 equilibrium (point B). Therefore, the UMP through the lens of this model has the following effects: (i) a reduction of the interest rate of the corporate bond, (ii) an increase in corporate bond issuance, (iii) an increase in production and investment.

Taking into account all these effects from COVID-19 shock and UMP, the final equilibrium of this economy (point C) is characterized by a high-interest rate, low corporate bond issuance, and low production and investment. The model is consistent with the data except in the magnitude of bond issuance. While the model suggests the UMP encourages to increase bond issuance, this is not strong enough as we can see in the data. A possible explanation is the firms are using this external funding

Figure 3.9: Unconventional Monetary Policy: Real Effects



from UMP to finance other decisions rather than investment. It is possible that firms are using a small fraction of this funding to increases investment and production (as the model claims) and the remaining for other motives such as accumulating cash, portfolio investment, debt/equity repurchase and pay dividends. A similar pattern happened in Europe in the last financial crisis when European Central Bank recapitalized banks to boost the economy. However, firms that receive loans used these funds not to increase real economic activity, such as employment and investment, but to accumulate cash (Acharya *et al.*, 2019).

3.4 What Kind of Firm is More Responsive to the UMP?

In this section, I use the previous model to study two important heterogeneities across firms: size (large versus small firms) and initial credit risk (low-risk versus high-risk firms). Table 3.1 summarizes the effects of COVID-19 shock and the UMP in both cases.

Table 3.1: What Kind of Firm is More Responsive?

	Panel A									
	Large Firm					**Small Firm**				
	Z	λ	b_1	i_1	d_1	Z	λ	b_1	i_1	d_1
Initial state	1	0.2	0.11	0.11	0.37	1	0.2	0.13	0.13	0.36
			Δb_1	Δi_1	Δd_1			Δb_1	Δi_1	Δd_1
COVID-19 shock	0.65	0.36	-80%	-76%	-72%	0.65	0.36	-69%	-69%	-74%
UMP	0.65	0.26	48%	45%	93%	0.65	0.26	23%	31%	107%
Δ Equilibrium			**-70%**	**-65%**	**-46%**			**-62%**	**-59%**	**-47%**
	Panel B									
	Low Risk Firm					**High Risk Firm**				
	Z	λ	b_1	k_1	d_1	Z	λ	b_1	k_1	d_1
Initial state	1	0.2	0.14	0.13	0.35	1	0.4	0.11	0.09	0.30
			Δb_1	Δk_1	Δd_1			Δb_1	Δk_1	Δd_1
COVID-19 shock	0.65	0.36	-63%	-64%	-77%	0.65	0.56	-71%	-69%	-78%
UMP	0.65	0.26	15%	26%	120%	0.65	0.46	31%	38%	132%
Δ Equilibrium			**-57%**	**-55%**	**-49%**			**-61%**	**-57%**	**-49%**

Note. In the Panel A, investment i_1 is represented by $i_1 = k_1 - (1-\delta)k_0$. In contrast, in the Panel B, the firm size is not considered and hence $\delta = 1$. As a result, investment is $i_1 = k_1$.

What firm is more responsive to UMP: large or small firms? I use the model to evaluate whether the size of the firm is an important characteristic in the firm's response to COVID-19 shock and UMP. To do that, I add to the model an initial physical capital k_0 and the capital accumulation equation: $k_1 = (1-\delta)k_0 + i_1$. Where i_t is firm's investment and δ is capital depreciation rate which now it is equal to 0.1 as it is commonly assumed in investment literature (e.g. Moyen, 2004). Based on that, the equation that reflects that the firm is constrained ($d_0 = 0$) would be:

$$b_1 = (k_1 - (1-\delta)k_0 - x_0)R_b \tag{3.24}$$

The small firm is characterized by k_0^s, which is lower than the size of the large firm k_0^l. To calibrate k_0^s and k_0^l, I use an important empirical fact: the cash-asset ratio of small firms is 2.3 times corresponding to large firms. This ratio is calculated using COMPUSTAT annually data from 1971 to 2018. Also, I assume that the initial cash (level) x_0 is the same for both kind of firms, then the relation between large and small firm is as follows:

$$\frac{k_0^l}{k_0^s} = 2.3 \tag{3.25}$$

Assuming that k_0^s is 0.01, then k_0^l is equal to 0.023.

The Panel A of Table 3.1 shows the values of the initial state of the economy for five variables: productivity (Z), default probability (λ), corporate bond issuance (b_1), investment (i_1), and dividends (d_1) for large and small firms. This table, also, shows the effects of COVID-19 shock and UMP on these variables. In particular, the values in the row related to COVID-19 shock reflect the percentage change of the equilibrium under COVID-19 shock and the initial state of the economy. Similarly, the values of the row related to UMP reflect the percentage change of the equilibrium after UMP is applied and the *previous* COVID-19 equilibrium. Finally, the last row of the first panel (Δ equilibrium) represents the growth rate of these variables between the final equilibrium (after UMP) and the initial one (before COVID-19 shock).

Initial state of the economy. The main difference between the large and small firms before the COVID-19 shock is the initial assets (firm size). In this equilibrium, the large firm issues lower corporate bonds than the small firm. Since the initial size of the firm can be interpreted as the asset in place $(1 - \delta)k_0$, a high size k_0 increases the "total initial cash" $(x_0 + (1 - \delta)k_0)$. This reduces bond issuance since the firm is constrained. Finally, the small firm invests more than the large firm since the former has a higher cash-asset ratio.

COVID-19 shock. The model suggests that large firms are more affected by COVID-19 shock than small firms. For instance, the new equilibrium after COVID-19 shock for a large firm is characterized by a reduction in 80% and 76% in corporate bond issuance and investment. In contrast, a small firm reacts to this shock with a reduction of 69% in both variables. A small firm reduces less its external financing and investment since it has more internal funding (high cash-asset ratio) which makes this firm less external-financing dependent.

UMP. The model also shows that large firms are more responsive to UMP than small firms. We can note this in the higher increase of both variables -bond issuance and investment- for large firms than small firms. Why is this happening? The economic argument is as follows: since large firms are external-financing dependent, the UMP ($\downarrow \lambda$) allows these firms to access the corporate bond market at lower funding costs. The natural result is more corporate bond issuance of these firms with a major impact on the recovery of investment. This is not the case for small firms that depends more on internal financing.

Δ *Equilibrium.* This row shows the percentage change between the final equilibrium -after UMP- and the initial equilibrium -before COVID-19 shock-. Regarding investment, large firms reduce their investment by 65% in comparison to a lower reduction of small firms (59%). The same behavior is showed in corporate bond issuance: large firms reduce greater bonds issuance than small firms.

What firm is more responsive to UMP: low-risk or high-risk firms? Another important firm's characteristic is the level of *credit risk* (default probability) before the COVID-19 crisis started. I study that assuming in the model two kinds of firms: low-risk and high-risk firms. The former has a default probability equals to 0.2 and the latter 0.4 -two times the level of the low-risk firm-. I also keep the initial assumption about the total depreciation (δ) and that there is no difference between firms by their size.

The Panel B of Table 3.1 shows the values of the initial state of the economy for five variables: productivity (Z), default probability (λ), corporate bond issuance (b_1), investment (k_1), and dividends (d_1) for low-risk and high-risk firms.

Initial state of the economy. Before the COVID-19 shock, the low-risk firm presents more corporate bond issuance and investment than high-risk firms.

COVID-19 shock. The model suggests that high-risk firms are more affected by COVID-19 shock than low-risk firms. For instance, high-risk firms reduce in 71% and 69% of its bonds issuance and investment respectively. In contrast, low-risk firms reduce 63% and 64% of both variables respectively. The economic reason behind this model prediction is as follows: since high-risk firms face a more inelastic corporate bond demand due to the effect of λ in its slope, a reduction in that demand increases more the interest rate paid by high-risk firm than low-risk firms. As a result, external financing for the high-risk firm is much higher than the low-risk firms.

UMP. Since the UMP is implemented as a reduction in λ, the high-risk firm is more benefited by this policy due to its effects on the elasticity of bonds demand. For instance, high-risk firms increase their corporate bond issuance by 31% from COVID-19 equilibrium. In contrast, the bond issuance growth rate of low-risk firms is half of the high-firm risk. We can observe the same pattern in investment: high-risk firms increase their investment as a consequence of UMP in 38% while low-risk firms do in 26%.

Δ *Equilibrium.* After taking into account the negative effects of COVID-19 shock and the positive effects of UMP, high-risk firms are more affected than low-risk firms.

3.5 Empirically, What Kind of Firm Has Been More Responsive to UMP?

In this section, I complement the theoretical model by examining whether the growth rate in long-term debt between 2020Q1 and 2020Q2 can be explained by firm characteristics. Since corporate bonds represent long-term debt, it is reasonable to consider the growth rate of this variable as an indicator of the firm's *response* to UMP. I also evaluate whether the prediction of the model about the heterogeneity response across firms by size is supported by data.

Data. The data comes from quarterly Compustat files. The initial sample consists of data for the first and second quarters of 2020 with 20,963 observations (10,673 firms). The first quarter (January-March) was affected by COVID-19 shock and the second one is more related to UMP actions. I consider firms which variables are calculated for all the calendar quarter. For instance, a firm with operating income in 2020Q1 that is calculated from January to March is considered, but firms with different period of calculation (i.e. December-February) are ruled out. With that, the sample contains 17,010 observations. I rule out observation with missing values for main variables (operating income, total assets, capital expenditures, short- and long-term debt, and cash). As a result, the sample is formed for 9,238 observations and 4,798 firms. I split this sample in two by profitability in 2020Q1 since the initial financial health of firms could be important to explain the behavior of the firm's long-term debt in 2020Q2. The first subsample contains firms for both quarters but with profitability greater or equal to zero in 2020Q1. It contains 5,457 observations. The second one -with negative profitability in 2020Q1- contains 3,781.

Regarding the first subsample (positive profitability in Q1), after considering only observations in 2020Q2 and ruling out missing values for the growth rate of main variables and outliers (p1/p5-p99/95), the final subsample contains 1,987 observations/firms. I use this for the cross-sectional regression. Furthermore, following the same procedure for the second subsample (negative profitability in Q1), it finally contains 824 observations/firms which are used in the regression.

Table 3.2 describes the variables used in the cross-sectional regression. I use a growth rate operator to evaluate whether the change in the firm's characteristics can explain changes in the firm's long-term debt. Also, I consider the initial firm's ratios (e.g. profitability and cash/asset) to evaluate whether the change in long-term debt depends on the initial financial health of the firm.

Table 3.2: Data Definitions

Variable	Definition
DLTTQ	Long-Term Debt - Total
ATQ	Assets - Total
OIBDPQ	Operating Income Before Depreciation
CHEQ	Cash and Short-Term Investments
DLCQ	Debt in Current Liabilities
CAPXY	Capital Expenditures
Δ% LT-debt	DLTTQ-2020Q2/DLTTQ-2020Q1 - 1
Δ% assets	ATQ-2020Q2/ATQ-2020Q1 - 1
Δ% op. income	OIBDPQ-2020Q2/OIBDPQ-2020Q1 - 1
Δ% cash	CHEQ-2020Q2/CHEQ-2020Q1 - 1
Δ% ST-debt	DLCQ-2020Q2/DLCQ-2020Q1 - 1
Δ% investment	CAPXY-2020Q2/CAPXY-2020Q1 - 1
LT-debt/assets	DLCQ/ATQ
Profitability rate	OIBDPQ/ATQ
cash/assets	CHEQ/ATQ
ST-debt/assets	DLCQ/ATQ
investment rate	CAPXY/ATQ

This table presents definitions for variable used in cross-sectional regressions.

Regression model. The cross-sectional regression is as follows:

$$\Delta\%\text{LT-Debt}_{2020Q2} = \alpha + \beta * \Delta\%X_{2020Q2} + \theta * \text{Ratio}_{2020Q1} + \epsilon_{2020Q2} \tag{3.26}$$

where the dependent variable is the growth rate of long-term debt between 2020Q1 and 2020Q2. The independent variables are split in two sets. The first one ($\Delta\%X_{2020Q2}$) contains growth rate of X variables which are *assets, operating income, cash, ST-debt, and investment*. The second set Ratio_{2020Q1} contains firm's ratios at 2020Q1 such as *LT-debt/assets, profitability rate, cash/assets, ST-debt/assets, and investment rate*. I use the first set of independent variables to evaluate whether the *change in firm characteristic* could help to explain $\Delta\%$LT-Debt and the second set to study whether the *initial state* of the firm -before UMP is applied- provides information in explaining $\Delta\%$LT-Debt.

Results. Table 3.4 reports the regression results for two subsamples: positive (≥ 0) and negative profitability in 2020Q1. This table also shows estimations for firm size (small, medium, large) for the first subsample. I start showing the growth rate of LT-Debt across these subsamples in Table 3.3. Three takeaways emerge from this table. First, independently if firms had positive or negative profitability in 2020Q1, they in *average* increase its long-term debt in the second quarter. Second, surprisingly, firms with negative profitability in the first-quarter increase -on average- its long-term debt more than those with positive profitability in the same quarter. A possible explanation is that they could have been benefited significantly from the Federal Reserve policy in corporate bond markets. Third, large firms increase their long-term debt while small firms reduce it. This heterogeneity is consistent with the theoretical model described in the previous section even though the model suggests that small firms also increase their long-term (LT) debt.

Table 3.3: $\Delta\%$ Long-term Debt

Sample	Profitability rate ≥ 0 in 2020Q1				Profitability rate < 0 in 2020Q1
	Entire Subsample	Small Firms	Medium Firms	Large Firms	
Mean	1.4%	-0.6%	0.3%	4.4%	5.7%

The natural question now is What are the determinants of this particular long-term debt behavior in 2020Q2? or What firm's characteristics could help to explain this average increase in long-term debt as a result of the COVID-19 crisis and the UMP? I address these questions using a cross-sectional regression and the results are showed in Table 3.4.

Analyzing across samples, I point out two important findings. First, the growth rate of assets (+) and operating income (-) are relevant to explain $\Delta\%$ LT-Debt. Growth long-term debt of firms with positive profitability in Q1 is more sensitive to changes in assets in contrast to those with negative profitability. Also, small firms are less sensitive to $\Delta\%$ assets than large firms. Regarding the operating income, large firms are the most sensitive across samples. That means that a significant reduction in operating income of large firms is accompanied by a higher LT-Debt. This could be explained by the external-financing dependence of these kinds of firms. Second, the results show a substitution between short- and long-term debt. If the firms face difficulty obtaining funds from the short-term credit market, they could opt to reach the long-term credit market.

Firms with positive profitability rate in 2020Q1. An interesting result is that these firms show a correlation between $\Delta\%$ cash and $\Delta\%$ LT-Debt. This could mean that these firms are obtaining external funding to accumulate cash, which could be explained for the precautionary motive since there still exists future uncertainty. The presence of lag cash/asset ratio supports this argument. Since its sign is positive, this means that firms with higher cash/asset ratio in Q1 have increased more its LT-Debt. Why is this happening? The precautionary motive could be a possible answer. Furthermore, this hypothesis is supported by the results for small firms that maintain a high cash/asset ratio. Another result is that the estimated coefficient of lag ST-debt/assets ratio is negative. If we interpret lag ST-debt/assets as a measurement of debt-overhang, this implies that firms with a higher previous level of short-term debt are not able to obtain more external financing. Furthermore, firms with a larger investment rate in Q1 have increased their LT-debt in Q2.

Heterogeneity in firm size matter? Estimation results suggest important heterogeneities across firms by size. First, medium firms are more sensitive to change in assets (1.36) than others. Second, large firms are more sensitive to change in operating income (-) and ST-debt(-). Finally, the investment seems to play an important role in LT-debt for large firms. A high lag of investment rate increases the LT-debt, but an increase of investment between 2020Q1 and 2020Q2 reduces the long-term financing. It could be due to the preference of firms to finance investment with equity financing or cash.

Firms with negative profitability rate in 2020Q1. These firms show the least sensitivity to change in assets(+) and operating income(-). It could respond to more severe frictions that these firms face in external financing markets than other firms. These frictions could push the financing cost up making it more difficult to obtain financing. Consistent with that is the presence of lag cash/assets with a negative sign. This means that firms with higher cash/ratio in Q1 have increased less their LT-debt.

Table 3.4: Cross-sectional Regression (2020q2): Determinants of Δ% Long-term Debt

	1	2	3	4	5
Sample	Prof* rate ≥ 0 in 2020Q1				Prof rate < 0 in 2020Q1
	Entire Subsample	Small Firms	Medium Firms	Large Firms	
Dependent Variable	Δ% LT Debt		Δ% LT Debt		Δ% LT Debt
Intercept	−0.0251**	−0.0373**	-0.0132	0.0379	0.117***
	0.0100	0.0178	0.0096	0.0237	0.0205
Δ% assets	0.8688***	0.6704***	1.3574***	0.9347***	0.1623***
	0.0547	0.0911	0.11103	0.0822	0.0413
Δ% OP	−0.0251***	−0.02012***	−0.0206**	−0.05358***	−0.0102**
	0.0046	0.0069	0.00863	0.0103	0.0047
Δ% ST-debt	−0.1011***	−0.0741**	−0.0910***	−0.1209***	
	0.0144	0.0329	0.0245	0.0195	
Δ% cash	0.0153**	0.0319**			
	0.0062	0.0135			
Δ% Invest				−0.0604***	
				0.0185	
Lag STD/A	−0.0892***	−0.1034**			
	0.0341	0.0422			
Lag cash/A	0.0942*	0.1446*			−0.1716***
	0.0495	0.0764			0.0414
Lag InvR	1.0610**			2.8022***	
	0.4498			1.0515	
Obs	1987	655	656	676	824
Adjusted R^2	0.1546	0.1275	0.1867	0.2056	0.0326

Note. This table reports the estimated of cross-sectional regression for 2020Q2, with standard errors in parentheses. I estimate 5 alternative specifications. Profitability rate ≥ 0 in Q1 (specification 1). This sample is split by firm size (ATQ): small − <p33 of ATQ-(specification 2), medium firms -[p33,p66] of ATQ-(specification 3), large firms ->p66 of ATQ-(specification 4). Finally, firms with profitability rate < 0 in Q1 (specification 5).Significance levels are indicated by *, **, and *** for 10%, 5%, and 1%, respectively. OP is operating income, Invest is investment, STD/A is ST-debt/assets, A is assets, InvR is investment rate.*Prof means profitability.

3.6 Conclusion

In this paper, I develop an analytical general equilibrium two-period model to study the effects of COVID-19 shock and unconventional monetary policy in corporate bond markets.

The main conclusion of the base model is that firm's default probability plays a key role in transmitting the effects of COVID-19 shock and the UMP. Furthermore, under the model's assumptions, the UMP -PMCCF- is effective to reduce the interest rate of corporate bonds, to increase the corporate bond issuance, and to recover the firm's investment and production; its effects are not sufficiently strong to offset the COVID-19 shock as we can see in the data.

I also evaluate the effects of COVID-19 shock and the UMP when firms are heterogeneous in size and the initial credit risk. The model suggests that a large firm is more affected by COVID-19 shock than a small one. Similarly, a large firm is more responsive to UMP than a small one. The economic reason for that is that a large firm is more external-financing dependent since it has a low cash-asset ratio. Regarding the heterogeneity in the initial firm's credit risk, the model shows that a high-risk firm is more affected by COVID-19 shock and is more responsive to the UMP. However, taking into account all of these effects, a large firm shows a worst equilibrium than a small one.

I then conduct an empirical study. I test the prediction of the model about the heterogeneity effects of UMP across firm size. Considering the growth rate of long-term debt as an indicator of the firm's response to UMP, I estimate a cross-sectional regression for 2020Q2 to evaluate whether the prediction of the model about the heterogeneity response across firms by size is supported by data. I also examine whether the growth rate in long-term debt between 2020Q1 and 2020Q2 can be explained by firm characteristics. The estimation results suggest that there exists heterogeneity responses across firms by size and some firms' characteristics such as growth rate of assets and operating income provide information in explaining the change in long-term debt in 2020Q2.

Finally, several research questions are still open and lead to future research. For instance, under what conditions firms are willing to use the funding from PMCCF to increase investment? What is the role of financial frictions such as equity/debt issuance costs in amplifying or moderating the effects of the UMP? What is the role of real friction such as investment irreversibility on the efficacy of UMP? All of these questions will shed light on our understanding of the UMP and provide insights for a better policy design. Furthermore, from a theoretical perspective, to study this policy in a full heterogeneous firms framework will be valuable since it could provide light on what kind of firms are more responsive to the UMP and why.

Chapter 4

LEVERAGE AND CAPITAL UTILIZATION

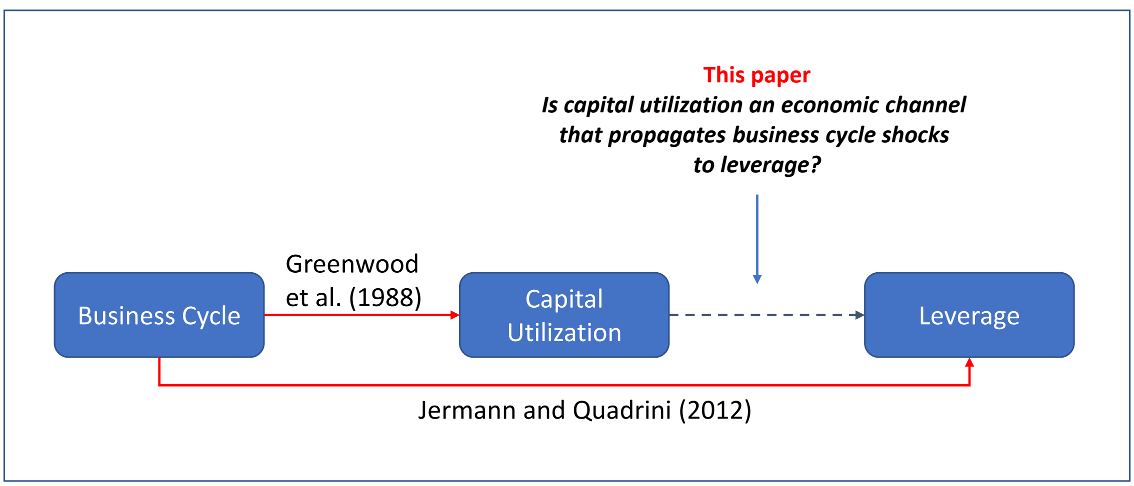
4.1 Introduction

Capital utilization corresponds to the fraction of the existing stock of capital that is currently employed. The ability to tune the amount of capital in use grants firms the flexibility to adjust to business cycles, such as booms and recessions, in a timely manner. For this reason, the economic literature has investigated the effects of capital utilization on macroeconomic aggregates. For instance, Kydland and Prescott (1988) show that when capital utilization is endogenously determined in a real business cycle (RBC) model, aggregate fluctuations are amplified, better reproducing the empirical variability of output, consumption, and investment. Greenwood *et al.* (1988) verify that endogenous capital utilization induces an intratemporal substitution away from leisure and toward consumption that generates the realistic procyclical pattern between consumption and labor. Jaimovich and Rebelo (2009) show how variable capital utilization and adjustment costs to investment can generate the comovement of output, consumption, investment, and labor at both the aggregate and sectoral levels.

While considerable progress has been made on the macroeconomic front in the past half-century, studies evaluating the impact of capital utilization on financial variables are surprisingly scarce. This observation might come as a surprise, given the intense financialization of the economy in the past three decades (see, for example, Cavaglia *et al.* (2000), Epstein (2005), Krippner (2005), and Stockhammer *et al.* (2010)) and the documented importance of capital utilization to macroeconomic quantities. A recent important contribution that links business cycles and the firm's financial flows is the study of Jermann and Quadrini (2012) that documents the procyclicality of debt and business cycles. The authors show that incorporating financial shocks and frictions is critical to bring dynamic stochastic general equilibrium (DSGE hereafter) models closer to the data. However, the authors do not provide any answers on how capital utilization and the firm's leverage are linked since capital utilization is not a feature of their model.

We close this gap in the literature by documenting that capital utilization and short-term debt are procyclical and investigating the connections between capital utilization and the capital structure of firms. To our knowledge, we are the first to study the comovement of capital utilization and leverage and to document this empirical regularity. In essence, our paper relates three primary variables (business cycles, capital utilization, and leverage) that have been studied separately in financial economics. Figure 4.1 shows where our paper fits in the existing literature.

Figure 4.1: Where Does This Paper Fit in the Literature?



In the first part of the paper, we delve into an empirical exploration of these two variables: capital utilization and leverage. We show that the cyclical component of aggregate capital utilization (proxied by the series Capital Utilization: Total Industry from FRED) and capital structure measurements, such as liabilities and debt in current liabilities, have a strong positive correlation. The high autocorrelation of these series leads us to further explore this relationship by analyzing their dynamic correlation. The analysis reveals that the dynamic correlation between capital utilization and liabilities varies in the interval $[0.46, 0.55]$ for a rolling window of one quarter. Knowing that the size of firms is an important component of their capital structure (see, for instance, Gonzalez and Gonzalez (2012) and Kurshev and Strebulaev (2015)), we use firm-level data in a second stage and group firms by size according to Frank and Goyal (2003) and Covas and Den Haan (2011) to investigate if the correlation between capital utilization and leverage persists. The dynamic correlation analysis confirms that the procyclicality of capital utilization and leverage is present in all groups of firms irrespective of their size. In the third step, we follow Frank and Goyal (2009) and perform an empirical leverage regression to check if the relationship persists after controlling for three characteristics of firms: size, growth, and income. Attesting to the robustness of our finding, the regression shows that capital utilization is a statistically significant factor explaining leverage at the 1% confidence level. In particular, if leverage is proxied by current liabilities over assets, the regression coefficient is highly significant and positive, with an adjusted R^2 of 0.69.

In the last part of our empirical investigation, we construct a firm-level capital utilization measure and use a panel data regression model to verify whether the relationship between capital utilization and leverage observed in previous analyses with the aggregate measure of capital utilization holds at the firm level as well. We define the firm-level capital utilization measure as the ratio of employees over capital expenditure on property, plant, and equipment for each firm in our sample. Similar to the previous analysis, we investigate three distinct measures of leverage: liabilities, debt in current liabilities, and long-term debt. After controlling for firm-specific effects, our panel data estimation confirms that capital utilization is a relevant factor explaining short-term debt at the firm level as well.

After documenting that capital utilization and short-term debt are procyclical in the first part of the paper, we develop a DSGE model that endogenizes the capital utilization decision. In essence, we extend the model of Jermann and Quadrini (2012) by incorporating capital utilization. Our theoretical framework investigates two main questions not previously addressed in the literature: (*i*) How does the link between capital utilization and short-term debt emerge endogenously? and (*ii*) Does capital utilization propagate real shocks to financial assets and financial shocks to macro variables while amplifying their effects on these variables?

Our model answers the first question as follows. Suppose a firm can optimally adjust its capital utilization at any point in time. While a higher capital utilization increases the firm's output (and, consequently, the firm's profits), more intense usage of the machines causes capital to depreciate faster. As a result, the firm has to increase investments to replenish the capital lost by a higher depreciation rate. Thus, capital utilization introduces a trade-off between two critical endogenous quantities: the firm's profit and the depreciation rate. This trade-off plays a critical role in propagating real and financial shocks to assets and explaining how capital utilization relates to the firm's short-term debt, as described next.

Consider a real negative shock to productivity that causes a reduction of the firm's profits. An immediate consequence is that retained earnings, which consist of the difference between profits and equity payout (i.e., dividends with their adjustment costs), decline as well. Since the firm finances its investment plan with short-term debt and retained earnings, any attempt to mitigate costly investment adjustments has to include a combination of higher levels of short-term debt and an increase in capital utilization, aiming to restore the firm's profits (and, consequently, retained earnings). But, as previously discussed, the higher level of capital utilization also increases the depreciation rate, forcing the firm to raise investments to keep optimal capital on its stable path. While a reduction of the equity payout boosts retained earnings that can be used to finance the additional investment, this strategy is sub-optimal because the adjustment of dividends is costly. Consequently, the firm opts to finance additional investment with more short-term debt, explaining the amplification mechanism generated by capital utilization.

To answer the second question, we analyze the impulse response function of real and financial assets to a marginal efficiency of investment (MEI) shock and a financial shock. The former shock is usually interpreted as a real shock, capturing the firm's ability to transform investment into capital stock, and the latter corresponds to the firm's ability to raise liquid funds to finance its operations. We find that when firms are allowed to adjust their capital utilization, a negative MEI shock leads the firm to reduce its capital utilization to keep the stock of capital at its optimal path. However, a decline in capital utilization negatively affects the firm's output and profits. Simultaneously, the increase in dividend payments results in a further drop in retained earnings. Once again, the costly adjustment of investment causes the firm to raise debt to compensate for the decline in retained earnings and, ultimately, stabilize the investment plan. This description illustrates the mechanism through which capital utilization propagates a real shock to short-term debt.

On the other hand, to see how capital utilization propagates financial shocks to macro variables, consider the realization of a negative financial shock that reduces the firm's ability to use its capital as collateral to borrow liquid funds and finance its operations. The shortage of funds limits the firm's ability to finance its investment with retained earnings, causing managers to rely more on short-term debt. In addition, the lower levels of investment lead the firm to reduce its capital utilization, diminishing the depreciation of capital and, consequently, restoring capital accumulation to its optimal path. However, the lower levels of capital utilization drive the firm's output downward even further. This shows that capital utilization is a crucial mechanism propagating financial shocks to macro variables, such as the firm's output and investment.

As in any model, our framework also has its limitations. On the empirical front, the fact that firms do not report data on workweek hours per capital prevents us from having a more accurate measure of capital utilization at the firm level. Thus, our annual firm-level measure of capital utilization (proxied by the number of employees over capital expenditure on property, plant, and equipment) misses the short-run effects only available at higher-frequency data such as workweek hours data. Nevertheless, we argue that for the aggregate-level analysis, the persistent long-run component is captured by our measure and generates interesting results. On the theoretical front, since our primary objective is understanding the *aggregate* effects of capital utilization on a firm's leverage, our framework relies on a DSGE model with a single representative firm and household. As a result, while our theoretical model can elucidate how capital utilization acts as a transmission channel propagating real shocks to financial variables and financial shocks to economic variables, it cannot address questions related to firms' heterogeneity. Thus, it does not provide any guidance on why firms of different sizes display different levels of correlation between capital utilization and leverage, as we document in our empirical analysis.

While the literature on the relationship between firms' leverage and capital utilization is extremely scarce, our paper is close to the study of Garlappi and Song (2017), addressing the role of capital utilization in the determination of asset prices. The authors argue that capital utilization and market power are critical mechanisms transmitting investment shocks to asset prices. The authors provide empirical evidence that the price of risk for investment shocks depends on the flexibility of capital utilization. However, the authors assume that firms are fully-equity-funded, precluding any analysis of the impact that capital utilization has on the leverage of firms. Thus, we complement their study by providing investigating the comovement of capital utilization and leverage.

Our empirical and theoretical analyses also complement the study of DeAngelo *et al.* (2011) that relies on the well-established empirical observation that "firms sometimes issue transitory debt and deviate deliberately, but temporarily, from a target in order to fund investment", by explaining the economic mechanism behind those temporary leverage deviations. Since we adopt a general equilibrium framework in contrast to the partial equilibrium model of the authors, our model sheds light on how capital utilization acts as a transmission channel that propagates real shocks to financial variables and financial shocks back to economic variables. In addition, our empirical investigation supports the relationship between capital utilization and short-term debt, a relation that is absent in DeAngelo *et al.* (2011) and is exclusive to our study.

Our results are also related to the findings of Korajczyk and Levy (2003) who document that financially constrained firms have procyclical leverage with business cycles. Similar to the balance sheet credit channel of Kiyotaki and Moore (1997), constrained firms explore their ability to borrow more when the value of their collateral is the highest (i.e., during favorable equity market conditions). The authors find that unconstrained firms adjust their target leverage by taking into consideration macroeconomic conditions, while constrained firms do not.

The remainder of the paper is organized as follows. Section 4.2 presents the data description and contains several empirical analyses that confirm the existence of a relationship between leverage and capital utilization at the aggregate and firm-level. Section 4.3 outlines the DSGE model, and Section 4.4 presents the quantitative implications of our theoretical model. Section 4.5 concludes.

4.2 Empirical Analysis

This section explores the empirical relationship between capital utilization and debt both at the *aggregate* and *fim* level. For the aggregate-level analysis, we rely on the capacity utilization measure Capacity Utilization: Total Industry (TCU) provided by the FRED. The series indicates the percentage of resources used by firms in the manufacturing, mining, mining, and utilities sectors to produce their goods. For example, in December 2017, the TCU index was 79.46, which indicated that firms used 79.46% of their total capacity to produce their goods that month. The data is at the monthly frequency, and our sample period ranges from 1980Q1 to 2017Q4. We change the data frequency to quarterly by averaging the monthly values of every quarter to match the frequency of the COMPUSTAT data.

For the firm-level analysis, we collect quarterly COMPUSTAT data on four measures of capital structure: total liabilities, debt in current liabilities, long-term debt, and total equity (defined as the sum of common/ordinary equity and preferred/preference stock). Additionally, we collect five other corporate finance variables: assets, liabilities, and stockholders' equity for our analysis. From the same source, we also collect data on the number of employees and capital expenditure on property, plant, and equipment to construct the firm-level capital utilization measure. This last dataset is at the annual frequency. Lastly, we obtain data on the real gross domestic product (GDP hereafter) from FRED to remove the business cycle component of the capital structure measures.

All series are seasonally adjusted with the X-13ARIMA-SEATS, and the cyclical components are extracted from the original series using the filter of Hodrick and Prescott (1997) (HP filter hereafter). Appendix B.2 presents a detailed explanation of these two procedures extensively used in this study.

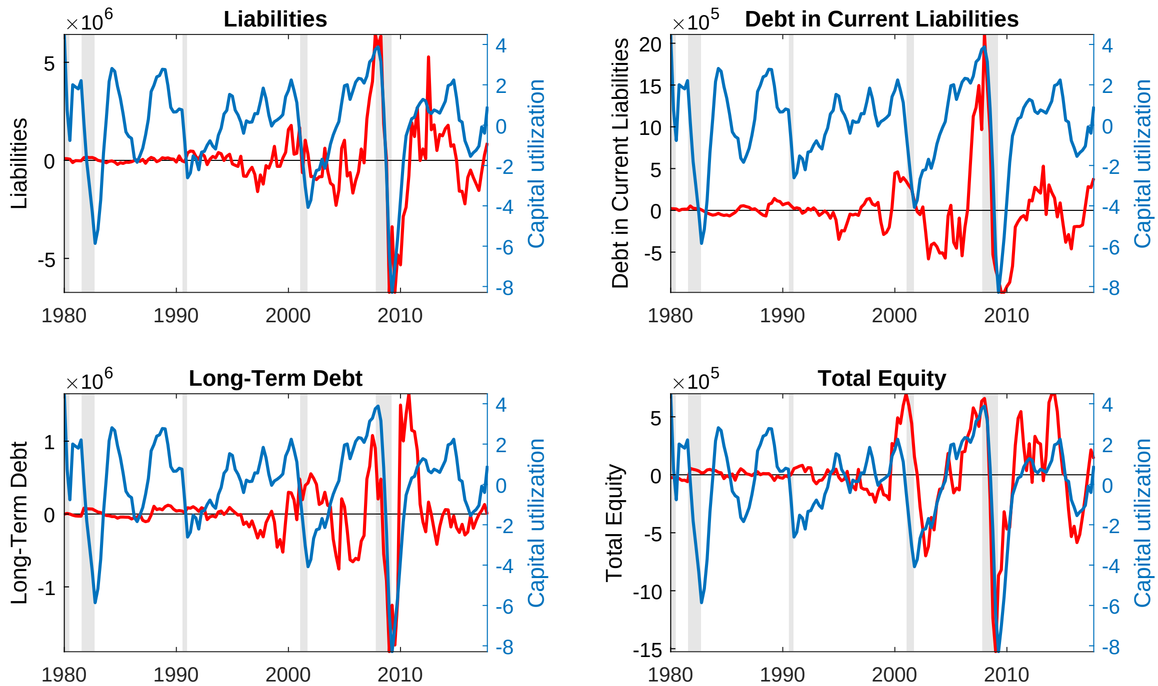
4.2.1 Aggregate-level Analysis

As mentioned in the introduction, the primary objective of our study is understanding the comovement between the cyclical components of capital utilization and leverage. We start visually exploring this relationship in Figure 4.2 by plotting the cyclical components of capital utilization and four capital structure variables: liabilities, debt in current liabilities, long-term debt, and total equity. The aggregate capital utilization measure (blue line) displayed in the figure is the cyclical component of the TCU index, and the aggregate financial variables (red line) is the cyclical component of the outstanding (i.e., aggregated across firms) capital structure measures.

The panels show that the relationship between these variables and capital utilization has been strengthening over time. While during the period 1980-2000, they do not appear to be highly correlated, these relationships apparently have been strengthening since the 2000s, especially during (and after) the finance. The correlation appears to be particularly high for liabilities, debt in current liabilities, and total equity.

Table 4.1 provides a set of descriptive statistics for the cyclical components presented in Figure 4.2 for four different periods: (1) the full sample period of 1980-2017, (2) the full sample without the finance, (2) the sample period of 1980-2000, and sample period of 2001-2017. As the correlation block indicates, aggregate capital utilization and capital structure measures are generally positively correlated, with the exception of long-term debt that displays a negative correlation with capital utilization for the sample periods (2), (3), and (4) (with correlations of -0.15, -0.04, and -0.23, respectively). Column (3) of the correlation block shows that the correlation for capital

Figure 4.2: Cyclical Components



Note. The panels illustrate the behavior of the cyclical components of capital utilization and four capital structure measures from 1980 to 2017. The right axis corresponds to the cyclical component of capital utilization (blue line), and the left axis corresponds to the cyclical component of the capital structure measure (red line). The shaded areas are NBER recessions.

utilization and the capital structure measures was particularly low during the period 1980-2000 and has indeed strengthened in the past 20 years as shown in column (4) and suggested by our previous visual analysis. Column (1) of the same block shows that aggregate liabilities have the strongest correlation with aggregate capital utilization (0.54) in the full sample. Once again, long-term debt displays the lowest correlation (0.21) among the financial variables in our sample, while total equity also displays a high positive correlation with capital utilization. In addition, liabilities displays the largest standard deviation (1.69), which is three times larger than the standard deviation of any other capital structure measure.

At the bottom part of the table, we show the same descriptive statistics for other capital structure metrics, such as assets, liabilities and stockholders' equity, common/ordinary equity, preferred/preference stock, and stockholders' equity. As before, the correlations between capital utilization and these capital structure metrics are large and positive, with the exception of preferred/preference stock. The standard deviation of liabilities and stockholders' equity is almost six times larger than the second-largest standard deviation (common/ordinary equity).

The last four columns of Table 4.1 show the autocorrelation results. As observed, capital utilization, debt in current liabilities, and total equity are all highly persistent, indicating that these variables may carry the effect of exogenous shocks for extended periods of time. In particular, the debt in current liabilities (our proxy for short-term debt) displays the largest autocorrelation value of 0.83 among the capital structure measures. Furthermore, these high levels of persistence suggest that the effects of an increase in current capital utilization might propagate to the cyclical component of the financial variables in the following quarters. In other words, the high persistence of these financial variables accompanied by their high correlation with capital utilization may constitute a critical mechanism of shock propagation and amplification that links the real and financial sides of the economy.

While Table 4.1 documents a deeper connection between the concurrent levels of debt and capital utilization, the findings on the autocorrelation of these series suggest that a dynamic analysis of these variables is worth considering. For this reason, we report in Table 4.2 the dynamic correlation of the cyclical component of the aggregate capital structure measures and capital utilization.

The dynamic correlation presented in Table 4.2 is computed as the standard Pearson's correlation between capital utilization and the capital structure measures lagged or forwarded by j quarters, with $j \in \{\pm 1, \pm 2, \pm 3, \pm 4\}$. As observed, both liabilities and debt in current liabilities display large and positive correlations for three consecutive quarters after an increase in capital utilization, suggesting that firms rely on

Table 4.1: Descriptive Statistics of the Cyclical Components

Variable	**Standard Deviation**				**Corr(CapUt, Variable)**				**Autocorrelation**			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Capital Utilization (CapUt)	2.15	1.82	1.83	1.82	1.00	1.00	1.00	1.00	0.88	0.81	0.83	0.79
Capital Structure												
- Liabilities	1.69	1.27	0.44	1.9	**0.54**	**0.33**	**-0.03**	**0.54**	0.74	0.41	0.63	0.39
- Debt in Current Liabilities	0.41	0.31	0.13	0.46	**0.49**	**0.31**	**0.1**	**0.47**	0.83	0.73	0.77	0.71
- Long-Term Debt	0.47	0.38	0.13	0.55	**0.21**	**-0.15**	**-0.04**	**-0.23**	0.69	0.85	0.7	0.85
- Total Equity	0.33	0.27	0.13	0.38	**0.52**	**0.33**	**0.01**	**0.56**	0.84	0.8	0.69	0.77
Asset, Liabilities, and Equity measures												
- Assets	1.98	1.49	0.56	2.21	0.57	0.36	0	0.58	0.75	0.48	0.69	0.45
- Liabilities and Stockholders Equity	1.98	1.49	0.56	2.21	0.57	0.36	0	0.58	0.75	0.48	0.69	0.45
- Common/Ordinary Equity	0.35	0.28	0.12	0.4	0.55	0.36	0.01	0.6	0.84	0.79	0.67	0.77
- Preferred/Preference Stock (Capital)	0.04	0.02	0.01	0.03	-0.67	-0.5	-0.05	-0.82	0.83	0.81	0.86	0.78
- Stockholders Equity	0.33	0.26	0.12	0.38	0.53	0.34	0.01	0.57	0.84	0.79	0.68	0.76

Note. The table displays the standard deviations, the correlations between capital utilization and the capital structure measures, and the autocorrelation of the time series. The statistics are calculated using aggregated US quarterly data, and the period ranges from 1980Q1 to 2017Q4. All series are seasonally adjusted by an X-13ARIMA-SEATS and detrended by an HP filter. With the exception of the TCU index, the standard deviation of all variables has a factor of 10^6, since the financial measures are in millions of dollars. The descriptive statistics for the full sample, the full sample without the 2007-2009 financial crises, subsample 1980-2000, and the subsample 2001-2017 without the financial crises are shown in columns (1), (2), (3), and (4), respectively.

short-term debt to finance the operating costs generated by an increase in the capital utilization ratio. Furthermore, the lagged series of liabilities and debt in current liabilities increase monotonically in the quarters before the capital utilization goes up at $j = 0$, which might indicate the firms' need to finance their expected intense capital utilization in the following quarters. Lastly, notice that long-term debt displays a lower correlation with capital utility, especially in the subsequent quarters where it becomes negative, suggesting that there might be a reduction in long-term obligations when firms increase in the current levels of capital utilization, especially if the increase of the capital utilization is financed with short-term debt.

Controlling for Firm Size

A well-known fact in the empirical capital structure literature is that the size of assets plays a key role in the determination of firms' leverage (see, for instance, Gonzalez and Gonzalez (2012) and Kurshev and Strebulaev (2015)). Since our primary objective is investigating the relationship between leverage and capital utilization, we check next if the firm size impacts the relationship between capital utilization and debt documented in the previous analyses. We proceed as follows.

We categorize firms according to their size using three different methodologies as a robustness check. The first approach is based on Covas and Den Haan (2011) and consists of sorting firms by the size of their assets and subdividing the ordered set into seven percentiles: $[0, 25]$, $[25, 50]$, $[50, 75]$, $[75, 90]$, $[90, 95]$, $[95, 99]$, and $[99, 100]$. We complement this first analysis by investigating the effects on the winsorized sample at the top 1% and 5% (i.e., the percentiles $[0, 99]$ and $[0, 99]$). The second approach is based on Frank and Goyal (2003) and consists of splitting the sample into two percentiles: $[0, 33]$ and $[33, 100]$. Firms in the first percentile are categorized as small and the others as large. The third approach consists of grouping the firms in three

Table 4.2: Dynamic Correlation of the Cyclical Components

	Corr(CapUt$_t$, Variable$_{t+j}$)								
Variable / Quarter j	-4	-3	-2	-1	0	$+1$	$+2$	$+3$	$+4$
Capital Structure									
- Liabilities	-0.13	0.07	0.28	0.46	0.54	0.55	0.49	0.38	0.25
- Debt in Current Liabilities	-0.22	-0.02	0.21	0.39	0.49	0.51	0.49	0.43	0.36
- Long-Term Debt	0.00	0.11	0.22	0.26	0.21	0.10	-0.06	-0.24	-0.37
- Total Equity	0.09	0.27	0.44	0.54	0.52	0.44	0.33	0.21	0.11
Asset, Liabilities, and Equity Measures									
- Assets	-0.09	0.11	0.33	0.49	0.57	0.56	0.49	0.37	0.23
- Liabilities and Stockholders' Equity	-0.09	0.11	0.33	0.49	0.57	0.56	0.49	0.37	0.23
- Common/Ordinary Equity	0.11	0.30	0.47	0.57	0.55	0.46	0.35	0.22	0.11
- Preferred/Preference Stock	-0.27	-0.44	-0.59	-0.69	-0.66	-0.56	-0.40	-0.25	-0.12
- Stockholders' Equity	0.10	0.29	0.46	0.55	0.53	0.44	0.32	0.19	0.08

Note. The table shows the dynamic correlation between the cyclical component of the financial variables and the cyclical component of capital utilization. The dynamic correlation is calculated by fixing the capital utilization for a specific date and computing its correlation with the lagged/forward financial variable. The lags vary from -4 to $+4$ quarters. The sample period ranges from 1980Q1 to 2017Q4. All series are seasonally adjusted by an X-13ARIMA-SEATS and detrended by an HP filter. Further detail is provided in Appendix B.2.

percentiles: $[0, 33]$, $[33, 75]$, and $[33, 100]$. Firms in these percentiles are categorized as small, medium, and large, respectively. For each percentile, we create the group capital structure measures by aggregating the corresponding firm-level capital structure metrics of the group.

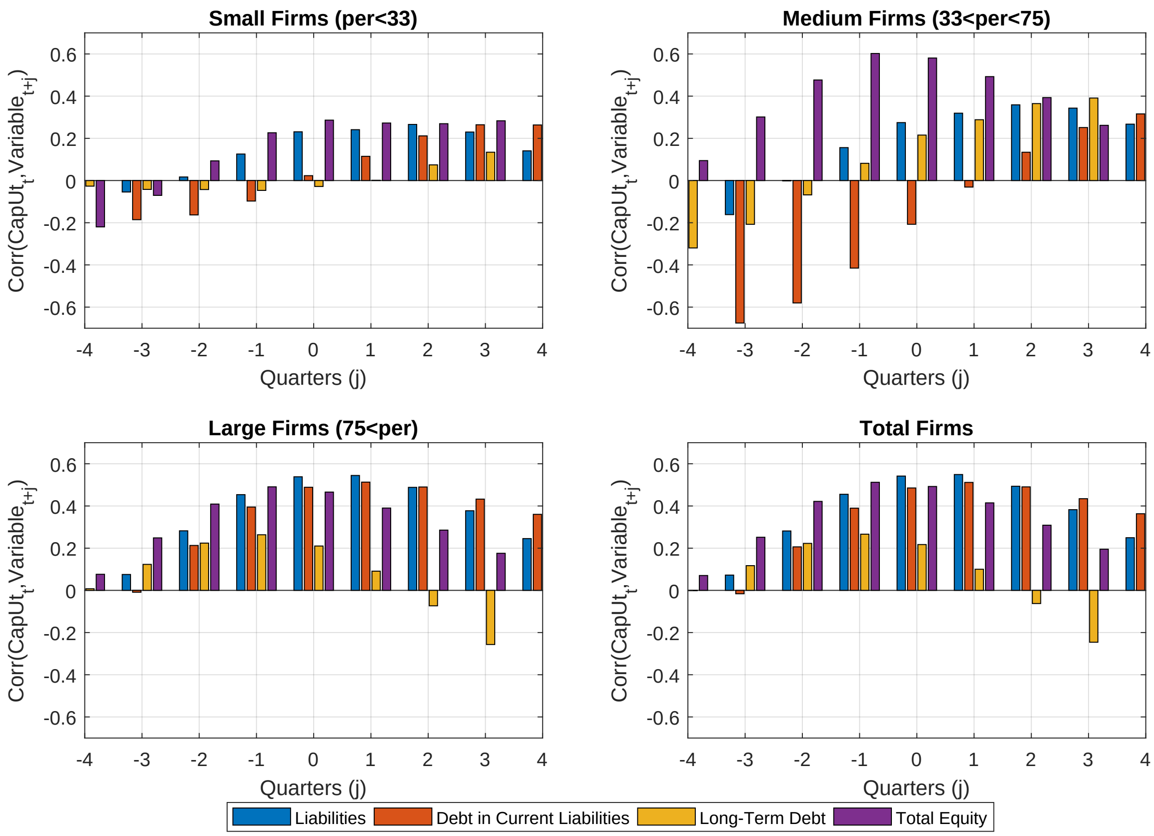
Table 4.3 reports the correlation between the cyclical component of capital utilization and the group capital structure variables controlling for firm size. As illustrated, the correlations display large cross-sectional variation. The largest firms display the largest correlation between capital utilization and the proxies for short-term debt, such as liabilities and debt in current liabilities. The winsorized samples confirm that the top one percentile has a substantial impact on the correlation of these variables. In particular, when we exclude the top one percentile in our sample, the correlation between capital utilization and debt in current liabilities drops to 0.31 (from 0.49 for the full sample). A similar pattern is observed for liabilities. The correlations of small firms are considerably smaller and negative in the case of long-term debt. These patterns emerge for the other two size classifications as well, suggesting that large (small) firms increase (decrease) their debt in current liabilities with capital utilization.

Lastly, we document that the correlation between equity and capital utilization is quite large, especially for medium and large firms. Curiously, in contrast to the short-term debt case, firms in the top one percentile display a lower correlation between capital utilization and equity than firms in the 99%. This finding complements studies in the literature that empirically show the procyclicality of equity and business cycles but are silent with respect to the relationship between equity and capital utilization. For instance, Korajczyk *et al.* (1990) document that aggregate equity issuance is more frequent during abnormal equity market performances, suggesting that macroeconomic conditions play a critical role in the financing choices of firms (equity markets perform particularly well during expansions). Choe *et al.* (1993) show that firms tend to increase equity issues in expansionary periods and show that business cycle variables have significant explanatory power over it. Covas and Den Haan (2011) show that debt and equity issuance are procyclical and that the procyclicality of equity issuance decreases monotonically with the firm size.

A natural question that emerges from the previous analysis is what happens to the *dynamic* correlation of capital utilization and the capital structure variables if we perform the same control by firm size. We present in Figure 4.3 the answer to this question.

First, we note that the capital structure variables of small firms (top-left panel) have a low correlation with capital utilization. Although the correlation of debt in current liabilities increases continuously for three quarters, it remains relatively small. A similar pattern is observed for medium firms (top-right panel), suggesting that the possible effects of capital utilization on the leverage of these firms are better captured not contemporaneously but rather in subsequent periods. Second, medium firms reduce their debt in current liabilities when expecting an increase in capital utilization in the following quarters. In contrast, long-term debt increases after a positive change in capital utilization. Third, large firms (bottom-left panel) display a high correlation between debt in current liabilities and capital utilization for three quarters after the increase in capital utilization. The magnitude of this correlation is the largest among the three groups of firms. Furthermore, notice that there appears to be a substitution effect between debt in current liabilities and long-term debt within the two-quarters range. While the former increases over the subsequent quarters, the latter decreases.

Figure 4.3: Dynamic Correlation Controlling for Size



Note. The panels show the dynamic correlation between the cyclical component of the capital structure variables and capital utilization segregated by firm size. The data ranges from 1980Q1 to 2017Q4. All series are seasonally adjusted by an X-13ARIMA-SEATS and detrended by an HP filter. Further detail is provided in Appendix B.2.

Table 4.3: Correlation of the Cyclical Components Controlled by Size

	Corr(CapUt$_t$, Variable$_{t+j}$)			
Size Class	Liabilities	Debt in Current Liabilities	Long-Term Debt	Total Equity
First Methodology				
$[0, 25]$	0.23	0.08	-0.08	0.26
$[25, 50]$	0.10	-0.29	0.16	0.51
$[50, 75]$	0.30	-0.16	0.22	0.57
$[75, 90]$	0.20	0.08	0.07	0.60
$[90, 95]$	0.34	0.29	0.01	0.47
$[95, 99]$	0.23	0.32	-0.20	0.51
$[99, 100]$	0.57	0.49	0.23	0.24
Winsorized Sample				
$[0, 95]$	0.33	0.20	0.08	0.61
$[0, 99]$	0.30	0.31	-0.08	0.58
All firms	0.54	0.49	0.22	0.49
Second Methodology				
$[0, 33]$	0.23	0.02	-0.03	0.29
$[33, 100]$	0.54	0.49	0.22	0.49
Third Methodology				
$[0, 33]$	0.23	0.02	-0.03	0.29
$[33, 75]$	0.27	-0.21	0.22	0.58
$[75, 100]$	0.54	0.49	0.21	0.47

Note. The table shows the correlation between capital utilization and the capital structure measures when controlling for firm size. The control is based on three different approaches. The first approach uses the methodology of Covas and Den Haan (2011). The second approach follows Frank and Goyal (2003), while the third approach consists in grouping the firms in three percentiles. All series are seasonally adjusted by an X-13ARIMA-SEATS and detrended by an HP filter. The full sample period ranges from 1980Q1 to 2017Q4.

Regression Analysis

Our previous stylized analyses provide suggestive evidence that firms' leverage and capital utilization are dynamically related. In this section, we proceed with a deeper investigation and run a regression analysis to verify if capital utilization is indeed a relevant factor explaining leverage.

Our regression analysis has two stages. In the first part, we regress the cyclical component of our leverage measures (i.e., Total Debt/Assets, Long-term/Assets, and Current Liabilities/Assets) on the broadest economic factor available: the cyclical component of the GDP. [1] The purpose of this regression is to remove possible competing economic factors that may interact with the explanatory variable (i.e., capital utilization). Succinctly, this procedure damps the effects of possible omitted variables. We run the regression

$$\mathrm{Y}_t = \beta \cdot \mathrm{GDP}_t + \varepsilon_t^Y, \tag{4.1}$$

where Y is the cyclical component of a leverage measure, β is the regression coefficient, GDP is the business cycle component of the GDP, and ε^Y is the error term of the regression. In fact, rewriting the error term as $\varepsilon^Y = \mathrm{Y} - \beta \cdot \mathrm{GDP}$, we can see that the residual ε^Y represents the leverage measure *net* of business cycle effects. By construction, our new variable ε^Y does not correlate with the business cycle component.

In the second stage, we regress our detrended leverage measures against five factors: lagged leverage, capital utilization, and three factors of Frank and Goyal (2009): size, growth, and profitability. We introduce the lagged leverage variable because the analyses in previous sections indicate that leverage is a highly persistent measure. Thus, this term helps reducing autocorrelation effects. [2] Capital utilization is our

[1] Similar to the other series, we extract the cyclical component of the GDP through the HP filter described in Appendix B.2.

[2] We thank an anonymous referee for suggesting including the lagged leverage term in the regres-

primary variable of interest since the purpose of this regression is to verify if the cyclical component of capital utilization has explanatory power over leverage. Lastly, the three factors of Frank and Goyal (2009) have been shown to have explanatory power over leverage measures. Thus, we include Frank and Goyal's factors to avoid the model misspecification and reduce omitted-variable bias. [3]

The second-stage regression is summarized as

$$\begin{aligned}\varepsilon_t^Y &= \beta_1 \cdot \varepsilon_{t-1}^Y + \beta_2 \cdot \text{CU}_{t-1} + \beta_3 \cdot \text{Size}_{t-1} + \beta 4 \cdot \text{Income}_{t-1} \\ &+ \beta_5 \cdot \text{Growth}_{t-1} + \text{Intercept} + \text{Error}_t. \end{aligned} \tag{4.2}$$

Size is proxied by the log of assets, Income is proxied by the ratio of operating income before depreciation to total assets, and Growth is proxied by the percentage change in total assets per quarter. As previously mentioned, a detailed description of the data construction and sources is provided in Appendix B.1.

Table 4.4 shows the result of this two-stage regression analysis. First, we observe that the lagged dependent variable is highly significant for all three measures of leverage, which confirms that leverage is a highly persistent variable. Second, the capital utilization coefficient for the total and long-term debt (first and second column) are not significant at the 10% level, indicating that the capital utilization does not have explanatory power over them. Third and more interestingly, the capital utilization coefficient in the regression for the short-term debt net of business cycle effects is still significant at the 5% level. Fourth, notice that after removing the business cycle component of the GDP, introducing the lagged variable, and controlling for capital

sion analysis.

[3] Frank and Goyal (2009) evaluate 25 potential factors in their empirical model of capital structure. The authors conclude that only six variables are relevant to explaining market leverage: log of assets, profits, market-to-book assets ratio, median industry leverage, tangibility, and expected inflation. Importantly, since we remove the business cycle component from the three leverage definitions, the economic variables related to business cycles, such as inflation, are already controlled for. Lastly, since industry conditions are not the focus of this paper, we do not test median industry leverage or tangibility.

utilization, none of Frank and Goyal's factors is significant at the 10% level.

In summary, our two-stage regression analysis provides strong evidence in favor of our hypothesis that capital utilization is a critical economic channel that propagates short-term business cycles shocks to the firm's leverage at the *aggregate level*, making capital utilization and short-term debt positively correlated. In addition, after controlling for the cyclical component of the GDP, autocorrelation, and the factors of Frank and Goyal (2009), we observe that the regression coefficient of long-term debt is negative, although not significant at the 10% level, showing that capital utilization has no explanatory power over long-term debt.

In the next section, we investigate whether the same patterns observed at the *aggregate level* still hold at the *firm level*.

4.2.2 Firm-level Analysis

In contrast to aggregate analyses that generally rely on the TCU to proxy capital utilization, performing firm-level analyses is a more delicate task because a large number of firms do not report data on workweek hours. Thus, we need to construct a proxy for firm-level capital utilization that is broad enough to encompass the majority of firms in our dataset and still reflects the main concept of capital utilization that is capturing the available amount of physical capital that can be utilized by workers. For this reason, we proxy the firm-level capital utilization measure as the ratio of employees over the capital expenditure on property, plant, and equipment. [4] By construction, when firms hire more employees while keeping the same physical level of capital, the workweek hour per capital increases, and the intensity of capital utilization follows. In short, more workers using a given number of machines increases capital utilization.

[4]See Appendix B.1 for a detailed explanation on the COMPUSTAT series used to compute the firm-level capital utilization.

Table 4.4: Regression Analysis

	$\varepsilon^Y(t)$		
	Total Debt/Assets (t)	Long-term Debt/Assets (t)	Current Liabilities/Assets (t)
Constant	0.0242	**0.0486*** **	-0.0140
	(0.0202)	(0.0151)	(0.0094)
$\varepsilon^Y(t-1)$	**0.8941*** **	**0.8138*** **	**0.9443*** **
	(0.0344)	(0.0467)	(0.0207)
Capital Utilization $(t-1)$	0.00027	-0.0001	**0.0002** **
	(0.0001)	(0.0001)	(0.0001)
Size $(t-1)$	**-0.005* **	0.0004	-0.0017
	(0.0030)	(0.0017)	(0.0018)
Income Ratio $(t-1)$	-0.8321	-0.1577	-0.0675
	(0.5941)	(0.3163)	(0.3380)
Growth $(t-1)$	0.00008	-0.00007	0.00008
	(0.0001)	(0.00007)	(0.00006)
Adjusted R^2	0.912	0.811	0.979
Observations	151	151	151

Note. The table shows the regression analysis for three different measures of leverage: Total Debt/Assets, LongDebt/Assets, and Current Liabilities/Assets. In addition to the factors of Frank and Goyal (2009), we include capital utilization and the lagged dependent variable as predictors. All series are seasonally adjusted by an X-13ARIMA-SEATS, and the sample frequency is quarterly data from 1980Q1 to 2017Q4. The factor *Size* is the logarithm of total assets over GDP, *Growth* is the growth of assets per quarter, and *Income Ratio* is the operating income before depreciation. Significance levels are indicated by *, **, and *** for 10%, 5%, and 1%, respectively. Standard errors are shown in parenthesis.

Our proxy of capital utilization relates to other *industry-level* measures proposed in the literature. For instance, Basu *et al.* (2006) propose adding capital's workweek and labor efforts to Hall (1989)-style regression to control for unobserved changes in capital utilization. As explained by Basu *et al.* (2013), the idea behind this regression is that a firm seeking to minimize costs try to cut margins on both observable and unobservable factors. As a result, changes in the capital's workweek and labor efforts also reflect changes in unobserved capital utilization. Shapiro (1986) proposes the average workweek of capital, defined as the weighted average of numbers of workers in the first, second, and third work shifts as a proxy for capital utilization for firms in the manufacturing sector. Gorodnichenko and Shapiro (2011) use the Survey of Plan Capacity (SPC) to construct three series of capital utilization per industry based on average plant hours per week, average plants hours per day, and the average number of plant days in operation per week. Filbeck and Gorman (2000) employ different methods to capture asset utilization, such as fixed asset turnover ratio, net sales/inventory, and inventory turnover.

Naturally, our empirical measure has its shortcomings as well. First, data on the number of employees is only available at the annual frequency. Thus, our measure cannot capture short-term variations on capital utilization and its propagation to firms' capital structure. However, since we focus on the cyclical components of capital utilization and leverage, this drawback does not significantly impact our results. Second, similar to the proxies of Shapiro (1986) and Basu *et al.* (2006), our measure cannot capture the effects of unobserved changes in capital utilization, such as temporary plant closings or the hire of temporary workers. Nevertheless, we argue that the short-term effect of these events should not substantially impact the cyclical component of capital utilization we aim to capture.

For the firm-level analysis, we rely on the annual COMPUSTAT datasets. The total number of observations is 47,591, with a total number of cross sections of 4,817. The time period is the same as before, and it ranges from 1980 to 2017. Since COMPUSTAT does not have information on the workweek hours per capital, we proxy the firm-level capital utilization by the ratio of the number of employees (EMP) over Capital Expend Property, Plant and Equipment Schd V (CAPXV). CAPXV represents the amount spent for constructing and/or acquiring property, plant, and equipment (see Appendix B.1 for details). The three measures of leverage are the same as described in Section 4.2.1.

With the described dataset, we run a panel regression for our three measures of leverage (current liabilities/assets, long-term debt/assets, total debt/assets). In addition to capital utilization, we follow Frank and Goyal (2009) and add the log of total assets, profits, tangibility, and market-to-book ratio to control for firm-specific effects. We run the panel data regression with three different specifications: (1) with individual/cross-section (firm) effects only, (2) with time effects only, and (3) with both effects (two-way effects). The panel data regression model is represented by

$$y_{it} = w_{it}^{\top}\beta^{w} + f_{i}^{\top}\beta^{f} + \alpha_i + \varepsilon_{it}, \qquad i = 1, ..., n, \quad t = 1, ..., T, \tag{4.3}$$

where y_{it} is the leverage measure of firm i, w_{it} is the vector of time-varying regressors containing capital utilization, log of total assets, profits, tangibility, and market-to-book ratio, f_i is the vector of time invariant regressors, α_i represents the individual and unobservable effects, and ε_{it} is the error term.

Table 4.5 presents the results of the panel data regression described in (4.3). First, we observe that capital utilization is statistically significant at the 1% level to explain all three measures of leverage, with the exception of the current liabilities over assets with firm effects is significant only at 10%. Surprisingly, even proxying leverage by long-term debt over assets yields highly significant capital utilization coefficients. This contrast with our results in the aggregate-level analysis that indicates that the cyclical component of the aggregate capital utility does not have explanatory power over long-term debt. Second, notice that the relevance of capital utilization in explaining leverage is irrespective of whether we control for firm and time effects or not. Overall, the results indicate that capital utilization is an important economic channel that has explanatory power over leverage at the firm level.

Our findings of Sections 4.2.1 and 4.2.2 can be summarized as follows. At the aggregate level, we find that capital utilization has explanatory power over short-term debt but has no predictive ability over long-term debt. In addition, we show that capital utilization is procyclical with equity and short-term debt.

At the firm level, we find that capital utilization has strong explanatory power over both short- and long-term debt. As we demonstrated with our panel data regression analysis, the relationship survives even when we control for fixed and time effects separately and simultaneously. To our knowledge, we are the first to document these facts in the literature.

4.3 A DSGE Model with Capital Utilization and Capital Structure

While the empirical analysis of Section 4.2 shows capital utilization has a critical role in explaining short-term debt both at the aggregate and firm level, our econometric analysis does not explain *how* this relationship emerges. Another unanswered question that econometric models do not shed light on is the role of capital utilization in propagating real and financial shocks to assets. Does capital utilization act as a financial accelerator by amplifying financial shocks to economic factors, or does it act as a buffer mechanism by smoothing these shocks and preventing a ripple effect on the economic factors?

To answer these critical questions, we construct a DSGE model in the spirit of

Table 4.5: Panel Data Regression

	Current Liabilities/Assets			Long-term Debt/Assets			Total Debt/Assets		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Capital Ut	0.00130*	0.00546***	0.00188***	0.00823***	0.00563***	0.00731***	0.00953***	0.01109***	0.00920***
	(0.00067)	(0.00060)	(0.00067)	(0.00147)	(0.00157)	(0.00146)	(0.00155)	(0.00168)	(0.00153)
Log(Assets)	−0.00183***	−0.00086***	0.00288***	0.02662***	0.01787***	0.03870***	0.02480***	0.01700***	0.04158***
	(0.00033)	(0.00016)	(0.00045)	(0.00073)	(0.00042)	(0.00099)	(0.00077)	(0.00045)	(0.00104)
Profits	−0.07557***	−0.07402***	−0.08331***	−0.22615***	−0.23205***	0.24751***	−0.30172***	−0.30607***	−0.33082***
	(0.00335)	(0.00307)	(0.0034)	(0.00732)	(0.00798)	(0.00739)	(0.00773)	(0.00853)	(0.00775)
Tangibility	0.00883***	−0.02033***	-0.00163	0.17431***	0.20185***	0.14420***	0.183146***	0.18152***	0.14258***
	(0.00287)	(0.0014)	(0.00291)	(0.00626)	(0.00363)	(0.00633)	(0.0066)	(0.00389)	(0.00663)
MtB ratio	0.00046***	0.00031***	0.00072***	0.00501***	0.00234***	0.00590***	0.00547***	0.00266***	0.00662***
	(0.00011)	(0.00011)	(0.00011)	(0.00024(	(0.00029)	(0.00025)	(0.00026)	(0.00032(	(0.00026)
Intercept	0.02312	0.04252***	-0.00108	−0.09287***	0.07502***	−0.1366***	−0.06974**	0.11755***	−0.13769***
	(0.0161)	(0.00244)	(0.0161)	(0.0351)	(0.00634)	(0.035)	(0.037)	(0.00678)	(0.0367)
Firm effects	✓			✓			✓		
Time effects		✓			✓			✓	
Two-way			✓			✓			✓

Note. The table displays estimation results of panel data model for three specifications: (1) with only individual/cross-section (firm) effects, (2) with only time effects, and (3) both effects (two-way effects). The sample is annual data between 1980 and 2017 with 47,591 observations and 4,817 firms. Profits is calculated as Operating Income Before Depreciation (OIBDP) over Total Asset (AT), tangibility is calculated as Total Plant and Equipment (PPENT) over Total Asset (AT), Market-to-book ratio (MtB ratio) is computed as market value over book value. Significance levels are indicated by *, **, and *** for 10%, 5%, and 1%, respectively. Numbers in parentheses below estimated coefficients are standard errors. The factor *Size* is the logarithm of total assets over GDP, *Growth* is the growth of assets per quarter, and *Income Ratio* is the operating income before depreciation. Significance levels are indicated by *, **, and *** for 10%, 5%, and 1%, respectively. Standard errors are shown in parentheses.

Jermann and Quadrini (2012). Specifically, we introduce capital utilization and leverage in an RBC model with financial frictions. Since the primary focus of our study is understanding the *aggregate* effects of capital utilization on leverage (proxied by short-term debt), we use a DSGE model with a single representative firm and household. As a result, while our theoretical model can elucidate how capital utilization acts as a transmission channel propagating real shocks to financial variables and financial shocks to economic variables, it cannot address questions related to firms' heterogeneity. For instance, questions about the role of capital utilization on the leverage of labor-intensive firms or capital-intensive industries cannot be answered by our model since it describes a representative single firm.

We introduce the economy in the next section.

4.3.1 Firms

We assume the firm's technology has the following Cobb-Douglas representation

$$F(z_t, k_t, h_t, n_t) = z_t(h_t k_t)^{\theta} n_t^{1-\theta}, \tag{4.4}$$

where the production inputs are the capital utilization h_t, the stock of capital k_t, and labor n_t. The parameter θ represents the elasticity of capital used in total production. The output in (4.4) represents the firm's revenue as well. Furthermore, the firm's productivity z_t follows an AR(1) process, described as

$$\ln(z_t/z_{ss}) = \rho_z \ln(z_{t-1}/z_{ss}) + \mu_{z,t},$$

where z_{ss} is the shock steady state, ρ_z is the shock's persistence, and $\mu_{z,t}$ is a productivity shock with a stochastic behavior.

Leverage. The firm finances its operations with equity s_t and debt b_t. We assume the firm issues equity only once, in the beginning of time, but the price of equity varies over time. Thus, we normalize the equity supply s_t to one. As a result, the variable driving the leverage ratio is the debt b_t. Motivated by our findings in Section 4.2, we assume that (short-term) debt matures in one period (a quarter).

Accounting equations. Earnings before interest and taxes (EBIT) is expressed as revenue minus labor cost

$$EBIT_t = F(z_t, k_t, h_t, n_t) - w_t n_t,$$

where w_t is the wage function. Furthermore, profits π_t are calculated as the after-tax difference between the EBIT and the debt payment (including the principal)

$$\pi_t = (1 - \tau)(EBIT_t - R_{t-1} b_{t-1}),$$

where R_t is the gross interest rate (i.e., $R_t = 1 + r_t$).

The retained earnings RE_t is calculated by deducting the payment of dividends d_t (with their respective adjustment costs) from profits

$$RE_t = \pi_t - \varphi(d_t). \tag{4.5}$$

We adopt the same functional form of Jermann and Quadrini (2012) for the adjustment cost of dividends $\varphi(\cdot)$ and assume that

$$\varphi(d_t) = d_t + \kappa(d_t - d_{ss})^2,$$

where d_{ss} corresponds to the steady-state value of dividends and κ is the dividend adjustment cost coefficient.

Last, investment is only financed by retained earnings and new debt

$$i_t = RE_t + b_t.$$

Capital accumulation. The firm's capital accumulation is represented by

$$k_{t+1} = (1 - \delta(h_t))k_t + v_t i_t (1 - S(i_t, i_{t-1})). \tag{4.6}$$

The functional form of the endogenous depreciation is based on Jaimovich and Rebelo (2009) and given by

$$\delta(h) = \delta_0 + \delta_1 \left(\frac{h^{1+\chi} - 1}{1 + \chi} \right),$$

where the parameter $\delta_1 > 0$ represents the exposure of depreciation to capital utilization and χ is the sensitivity of depreciation to capital utilization. Since $h \in [0, 1]$, a higher value of χ implies that the effect of capital utilization on depreciation is lower. Thus, χ can be interpreted as the flexibility of capital utilization as well. Additionally, we assume that capital utilization h_{ss} is one in the steady-state, implying that the depreciation in the steady-state is $\delta_{ss} = \delta_0$.

The term v_t in (4.6) represents a shock to investment, commonly referred to as the MEI shock in the economic literature. Positive MEI shocks increase the firm's capacity to transform one unit of investment into new capital. As customary in the literature, we assume v_t follows an AR(1) process with representation

$$\ln(v_t/v_{ss}) = \rho_v \ln(v_{t-1}/v_{ss}) + \mu_{v,t}.$$

The parameter ρ_v is the shock's persistence, v_{ss} is the MEI shock steady state, and $\mu_{v,t}$ is a shock with stochastic behavior.

Last, changes in the investment plan generate a cost $S(i_t, i_{t-1})$ that depends positively on the current investment level and negatively on the previous investment level. Following Justiniano *et al.* (2010), the adjustment cost function is

$$S(i_t, i_{t-1}) = \frac{\phi}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2,$$

where ϕ is the investment adjustment cost parameter.

Enforcement constraint. As in Jermann and Quadrini (2012), we assume the firm requires intraperiod loans to finance the working capital. This working capital is necessary at the beginning of every period because the realization of the revenues takes place only at the end of each period. The working capital covers investment expenses, wage payroll, equity payout, debt, and payment of taxes. Assuming that the intraperiod loan l_t does not generate interest payments and is fully repaid at the end of the period, the working capital constraint satisfies

$$l_t = i_t + \varphi(d) + w_t n_t + R_{t-1} b_{t-1} + \tau(F(z_t, k_t, h_t, n_t) - w_t n_t R_{t-1} b_{t-1}) - b_t. \quad (4.7)$$

We assume that the firm's ability to borrow is limited by an enforcement constraint. In essence, the constraint requires that the outstanding loan amount be lower than the residual equity value (i.e., the difference between assets available and debt payments). Thus, the enforcement constraint is represented by

$$\xi_t(k_{t+1} - b_t) \geq l_t, \quad (4.8)$$

where ξ_t is a stochastic innovation, referred to as a financial shock. Similar to Jermann and Quadrini (2012), we interpret the left-hand side of (4.8) as the fraction of residual equity value recovered by lenders when the firm defaults before the end of the period. Thus, a decrease in ξ_t reflects a deterioration of the firm's financial health and causes lenders to reduce the supply of loans, justifying the natural interpretation of ξ_t as a financial shock. On the other hand, an increase in ξ_t means that the firm has more assets to use as collateral to back the loans.

As before, we model financial shocks as an AR(1) with representation

$$\ln(\xi_t/\xi_{ss}) = \rho_\xi \ln(\xi_{t-1}/\xi_{ss}) + \mu_{\xi,t},$$

where ρ_ξ is the shock's persistence, ξ_{ss} is the financial shock steady state, and $\mu_{\xi,t}$ is a shock with stochastic behavior.

Firm's budget restriction. From the accounting equations for EBIT, profits, retained earnings, and financing investment, it follows that the firm's budget restriction can be written as

$$(1-\tau)(F(z_t,k_t,h_t,n_t)-w_tn_t-R_{t-1}b_{t-1})=i_t-b_t+\varphi(d_t).$$

When we consider the firm's budget restriction along with the enforcement constraint, the loan equals revenues (i.e., $l_t = F(z_t, k_t, h_t, n_t)$). As a result, condition (4.8) becomes

$$\xi_t(k_{t+1}-b_t)\geq F(z_t,k_t,h_t,n_t). \tag{4.9}$$

Recursive Formulation of the Firm's Problem

The firm maximizes its market value by choosing the equity payout d_t, labor demand n_t, capital utilization h_t, short-term debt b_t, investment i_t, and capital k_{t+1}, subject to its budget restriction, the capital accumulation equation, and enforcement constraint. In short, the firm's optimization problem can be written as

$$V(k_t,b_{t-1},i_{t-1};z_t,v_t,\xi_t)=\max_{d_t,n_t,h_t,b_t,i_t,k_{t+1}}\{d_t+\mathbb{E}_t\left[m_{t+1}V(k_{t+1},b_t,i_t;z_{t+1},v_{t+1},\xi_{t+1})\right]\},$$

subject to

$$(1-\tau)(F(z_t,h_t,k_t,n_t)-w_tn_t-R_{t-1}b_{t-1})=i_t-b_t+\varphi(d_t),$$
$$k_{t+1}=(1-\delta(h_t))k_t+v_ti_t(1-S(i_t,i_{t-1})),$$
$$\xi_t(k_{t+1}-b_t)\geq F(z_t,h_t,k_t,n_t),$$

where m_t is the stochastic discount factor further detailed in Section 4.3.2.

It follows that the first-order conditions from the optimization problem are

$$F_n(z_t,h_t,k_t,n_t)=\frac{w_t(1-\tau)}{1-\tau-\mu_t\varphi_d(d_t)}, \tag{4.10}$$
$$F_h(z_t,h_t,k_t,n_t)=\frac{q_t\delta_h(h_t)k_t\varphi_d(d_t)}{1-\tau-\mu_t\varphi_d(d_t)}, \tag{4.11}$$

$$\frac{1}{\varphi_d(d_t)} = \mu_t \xi_t + \mathbb{E}_t \left[m_{t+1} \frac{(1-\tau)R_t}{\varphi_d(d_{t+1})} \right], \tag{4.12}$$

$$\begin{aligned} q_t = & \mathbb{E}_t \bigg[m_{t+1} F_k(z_{t+1}, h_{t+1}, k_{t+1}, n_{t+1}) \left(\frac{1-\tau}{\varphi_d(d_{t+1})} - \mu_{t+1} \right) \\ & + q_{t+1}(1 - \delta(h_{t+1})) \bigg] + \mu_t \xi_t, \end{aligned} \tag{4.13}$$

$$\begin{aligned} \frac{1}{\varphi_d(d_t)} = & - \mathbb{E}_t \left[m_{t+1} q_{t+1} v_{t+1} i_{t+1} S_i(i_{t+1}, i_t) \right] \\ & + q_t v_t (1 - S(i_t, i_{t-1}) - i_t S_i(i_t, i_{t-1})). \end{aligned} \tag{4.14}$$

The first-order conditions give two Lagrange multipliers (LM): one associated with the capital accumulation equation, denoted by q_t (also known in the literature as Tobin's q) and another associated with the enforcement constraint, denoted by μ_t. Equation (4.10) represents the demand for labor that makes the marginal productivity of labor equal the marginal cost. Under this framework, the marginal cost is affected by the tightness of the enforcement constraint, measured by $\mu_t \varphi_d(d_t)$. Thus, a tighter constraint implies that $\xi_t(k_{t+1} - b_t) - F(z_t, h_t, k_t, n_t)$ tends to zero, resulting in an increase in the LM μ_t and a decline in labor demand.

Equation (4.11) shows the first-order condition for capital utilization h_t at the optimum. As illustrated, the marginal cost of capital corresponds to an increase in depreciation, which is determined by the tightness of the enforcement constraint. Thus, the tighter the constraint, the lower the capital utilization.

The optimality condition for the debt level is outlined in equation (4.12). First, notice that the endogenous cost of debt R_t is impacted by both economic shocks (through the marginal utility m_{t+1}) and financial shocks ξ_t. Second, when financial frictions are present, the cost of debt has the additional term $\mu_t \xi_t$ that produces a tighter constraint for debt issuance, resulting in a higher total cost of debt. On the other hand, the tax shield of debt induced by the presence of corporate taxes counteracts the increase in the total cost, which results in a net cost of debt issuance of $(1-\tau)R_t$. Consequently, the equity payout policy becomes stochastic and sensitive to changes in the debt policy.

Equation (4.13) reveals that, at the optimum, the marginal benefit of investment equals its marginal cost and that the present value of the marginal benefit of investment is composed of three elements. The first component is the marginal productivity of new capital after taxes net the cost of a tighter enforcement constraint μ_{t+1}. This term explicitly shows that financial shocks have a direct effect on the optimal capital decision. The second component represents the value of new capital after depreciation (i.e., $q_{t+1}(1-\delta(h_{t+1}))$). The third element $\mu_t \xi_t$ is the benefit generated by the new capital in terms of assets used as collateral in the enforcement constraint. Last, the marginal cost of investment is expressed in terms of the current value of capital q_t.

The firm's optimal investment decision is represented in equation (4.14). The right-hand side describes the marginal benefit of adding one unit of investment, while the left-hand side represents the marginal cost caused by a decrease of one unit of investment in the current period. It is worth noting that the derivative of the adjustment cost S with respect to its second argument is negative (i.e., $S_i(i_{t+1}, i_t) < 0$). Thus, this component corresponds to a benefit obtained from a lower cost of adjustment for a given variation in current investment. The second term represents the value of one additional unit of investment after taking into account the level and the marginal increase of the adjustment cost.

4.3.2 Households

We assume all households have the same preference and are subject to the same budget constraint. Therefore, the household sector is summarized by a representative agent with the following preference

$$u(c_t, n_t) = \frac{1}{1-\gamma}\left(\left(c_t - \frac{n_t^{1+\theta}}{1+\theta}\right)^{1+\gamma} - 1\right), \tag{4.15}$$

where γ represents the relative risk aversion parameter and θ is the elasticity of labor parameter. The representative household consumes capital at the rate c_t and supplies labor n_t to the firm at a competitive wage w_t. It is assumed that the labor and good markets are both competitive. The household owns the firm and obtains income from three sources: corporate bonds b_t, labor income $w_t n_t$, and the equity market (dividends d_t and capital appreciation). Additionally, taxes paid by the firm T_t are transferable to households (i.e., $T_t = \tau(EBIT_t - R_{t-1}b_{t-1})$).

Recursive formulation of the household problem

The representative household maximizes the expected lifetime utility of consumption and leisure $(1 - n_t)$, solving the following dynamic problem

$$V(b_{t-1}, s_t) = \max_{c_t, n_t, b_t, s_{t+1}} \{u(c_t, n_t) + \beta \mathbb{E}_t [V(b_t, s_{t+1})]\},$$

subject to the budget constraint

$$w_t n_t + R_{t-1}b_{t-1} + s_t(d_t + p_t) + T_t = b_t + s_{t+1}p_t + c_t,$$

where p_t represents the price of equity. The first-order conditions of the household's maximization problem give the labor supply and the optimal condition for the level of debt and the number of shares. They are

$$\begin{aligned} u_n(c_t, n_t) &= -u_c(c_t, n_t) w_t, \\ u_c(c_t, n_t) &= \beta \mathbb{E}_t \left[u_c(c_{t+1}, n_{t+1}) R_t\right], \\ p_t &= \mathbb{E}_t \left[\beta \frac{u_c(c_{t+1}, n_{t+1})}{u_c(c_t, n_t)}(d_{t+1} + p_{t+1})\right]. \end{aligned}$$

The first expression shows that the supply of labor is independent of the consumption level. As a result, the income effect is absent in the supply of labor. The advantage of this formulation is that it allows us to isolate the effect of capital utilization on the equilibrium expression for labor, providing a clear illustration of the mechanism. The last two equations are used to determine the interest rate and the price of equity, respectively.

As usual, the stochastic discount factor m_t is obtained via forward substitution in

$$p_t = \mathbb{E}_t \left[\sum_{j=1}^{\infty} \left(\beta^j \frac{u_c(c_{t+j}, n_{t+j})}{u_c(c_t, n_t)} \right) d_{t+j} \right],$$

implying that

$$m_{t+j} = \beta^j \frac{u_c(c_{t+j}, n_{t+j})}{u_c(c_t, n_t)}.$$

4.4 Quantitative Analysis

4.4.1 Calibration

The model parameters can be categorized into three groups: preference, production, and shocks. We detail the calibration for each group next.

Preference. In the steady state, the gross interest rate is the inverse of the discount factor:

$$1 + r_{ss} = R_{ss} = 1/\beta.$$

Thus, we choose β to match an annual interest rate of debt of 7.32%, as in Jermann and Quadrini (2012). We fix the intertemporal elasticity of substitution (IES) of labor supply $1/\theta_n$ at 1.1 (implying that $\theta_n = 0.9$), which falls within the range of sensible values $[0.3, 2.2]$, suggested by Greenwood *et al.* (1988). Following the same study, we adopt the coefficient of relative risk aversion γ of 2.

Production. In accordance with Jones (2016), we set the average share of capital in the total production θ at 0.36 and follow Graham (2000) to fix the tax corporate rate τ at 35%. The quarterly-steady state depreciation δ_0 is equal to 2.5%, resulting in the standard 10% annual depreciation rate of the business cycle literature. In addition, we assume that the capital utilization in the steady-state is one, which means that the firm uses its full capacity in the long-run equilibrium and implies $\delta_0 = \delta_{ss}$. The dividend adjustment cost parameter $\kappa = 0.146$ is taken from Jermann and Quadrini (2012), and the elasticity of marginal depreciation $\chi = 0.42$ is based on Greenwood *et al.* (1988). Last, the investment adjustment cost $\phi = 3$ comes from Justiniano *et al.* (2010), while the slope of the depreciation function is fixed at 0.008 to guarantee that the steady-state value of debt is positive.

Shocks. We use the estimated values of Jermann and Quadrini (2012) to calibrate the dynamics of productivity and financial shocks. In particular, we set the persistence and volatility of productivity shocks at 0.9457 and 0.0045, respectively. For financial shocks, we fix the persistence at 0.9703 and the volatility at 0.0098.

The most challenging part is to identify the evolution of MEI shocks to extract the persistence ρ_v and volatility σ_v. We obtain these parameters in three steps. First, based on the COMPUSTAT database, we construct the quarterly aggregate Tobin's q series using that

$$\text{Tobin's } q = \frac{\text{Total Assets} + \text{Market Value} - \text{Total Common and Ordinary Equity}}{\text{Total Assets}}.$$

Second, we use the fact that, in the steady-state, investment shocks are the inverse of Tobin's q. Thus, by inverting this series, we obtain the time series of MEI shocks. The last step consists of extracting the persistence and volatility from the new series, resulting in $\rho_v = 0.8287$ and $\sigma_v = 0.0521$. The model calibration is summarized in Table 4.6.

Table 4.6: Calibration

Group	Description	Symbol	Value
Preference	Time discount factor	β	0.9825
	Inverse of IES of labor	θ_n	0.9
	Relative risk aversion	γ	2
Production	Elasticity of utilized capital	θ	0.36
	Corporate tax rate	τ	0.35
	Dividend adjustment cost	κ	0.146
	Elasticity of marginal depreciation	χ	0.42
	Investment adjustment cost	ϕ	3
	Depreciation in SS	δ_0	0.025
	Depreciation exposure	δ_1	0.008
Shocks	Productivity persistence	ρ_z	0.9457
	Productivity volatility	σ_z	0.0045
	Financial persistence	ρ_ξ	0.9703
	Financial volatility	σ_ξ	0.0098
	MEI persistence	ρ_v	0.8287
	MEI volatility	σ_v	0.0521

Note. The table shows the parameter values at quarterly frequency.

4.4.2 Capital utilization as a transmission mechanism

This section contains one of the main results of our study. It illustrates how capital utilization acts as a transmission and amplification channel of two different types of shocks: (*i*) real (MEI) shocks and (*ii*) financial shocks. Since real and financial shocks affect different elements of a firm, capital utilization adjusts differently to the realization of those shocks. To isolate the impact of each of these shocks and understand the propagation mechanism induced by capital utilization, we investigate the impulse response function of MEI and financial shocks in a benchmark model *without* capital utilization and a counterpart *with* capital utilization. Next, we detail the concept of real and financial shocks and present the results.

MEI shocks. MEI shocks v_t are considered real shocks because they impact the firm's ability to transform investment in future capital stock, as shown in the capital accumulation equation outlined in (4.6). While a positive shock increases the firm's capacity to transform one unit of investment in new capital, a negative MEI shock reduces the firm's transformation capacity of investment relative to its steady-state value. A negative MEI shock might simply reflect a loss of efficiency in the investment process. As shown in equation (4.14), since investment adjustments are costly, a negative MEI shock forces the firm to reduce the level of investment, which produces lower capital in the next period. In addition, to keep the enforcement constraint binding, the firm reduces its labor demand, as shown by a substitution of the loan equation (4.7) into the enforcement constraint (4.8)

$$\frac{\xi_t}{1-\xi_t}\Big(k_{t+1} - i_t - \varphi(d) - w_t n_t - R_{t-1}b_{t-1} \\ - \tau(F(z_t, k_t, h_t, n_t) - w_t n_t - R_{t-1}b_{t-1})\Big) \geq F(z_t, k_t, h_t, n_t). \tag{4.16}$$

Since the reduction in the absolute value of capital in the next period is greater than the decline of the current investment, the enforcement constraint is binding. This mandates two alternatives for the firm: it adjusts either the dividend policy or the labor demand. Given that changes in the dividend policy are costly, the firm opts to reduce its labor demand, resulting in a decline of production and, therefore, EBIT and profits. Consequently, retained earnings drop below the steady-state value, limiting the financing of investments. As the firm reduces its investments, the demand for short-term financing declines, generating lower leverage ratios.

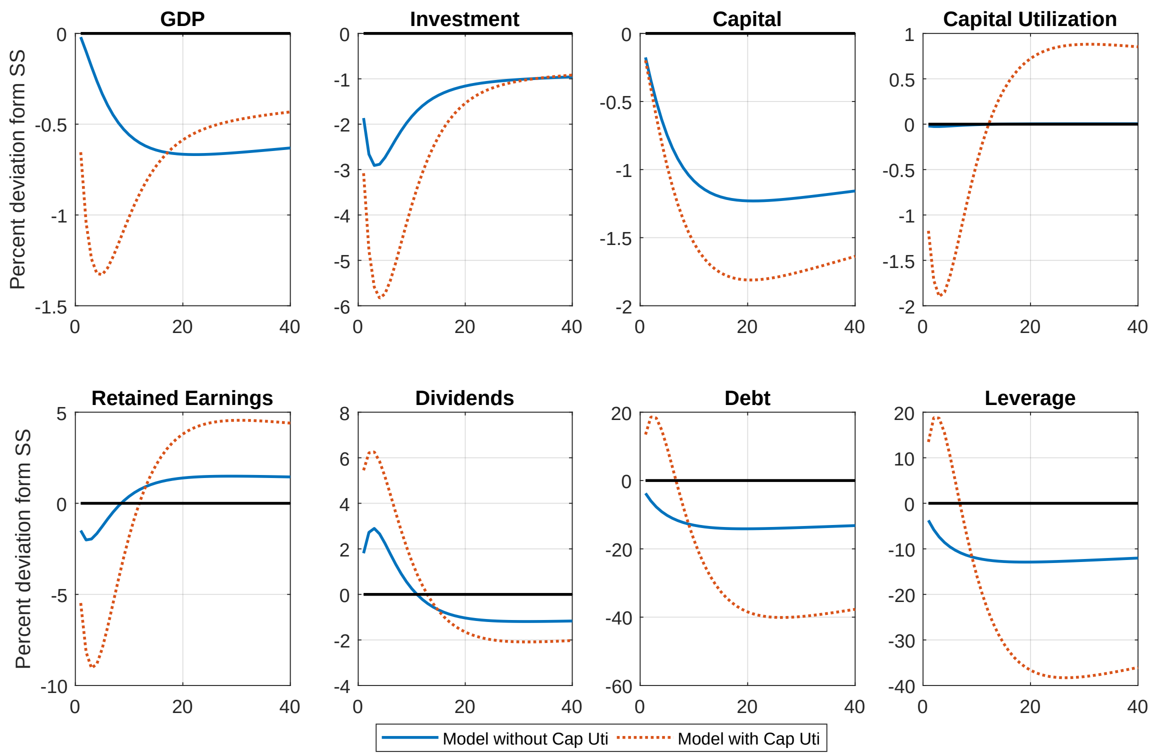
We highlight that capital utilization *amplifies* the effects generated by MEI shocks on real variables. As shown in equation (4.11), the optimal level of capital utilization is directly affected by MEI shocks through the induced changes in the marginal cost of investment, represented in (4.14). Thus, the firm's optimal response to a negative MEI shock is to reduce its capital utilization, pushing labor demand, output, EBIT, and profits down. This limits the firm's ability to fund investment, causing the firm to experience an additional reduction of capital. The lower levels of capital lead to lower levels of output and, consequently, profits, causing investment to plunge even further.

On the financial front, since the supply of debt is elastic (and represented by the coefficient of risk aversion), movements in demand for debt do not cause large fluctuations in the short-term interest rate. The same negative MEI shock that generates a decline in revenues causes the firm to optimally react by taking more debt to finance its dividend policy, raising both dividend and debt levels. Note that this result differs considerably from the benchmark case where the capital utilization mechanism is absent. In the latter case, the firm does not resort to short-term debt to finance its dividend policy but rather relies on its profits. Therefore, the level of debt drops, and the leverage ratio follows.

Figure 4.4 presents the impulse response functions of real and financial variables to an MEI shock. The solid line corresponds to the benchmark model without the capital utilization mechanism, while the dashed line represents the model with capital utilization. Two comments are in order. First, in the presence of capital utilization, the responses of the economic variables are considerably larger than in the benchmark case, illustrating the powerful amplification mechanism generated by capital utilization. Second, the two plots on the rightmost bottom show that capital utilization can change the direction of the impact caused by a negative MEI shock on debt and leverage because capital utilization alters the firm's financing decision on investment, as previously discussed.

Financial shocks. In our setting, a negative financial shock can be interpreted as a reduction in the probability that the lender will recover all the face value of the loan. The realization of these shocks has a direct impact in two critical equations: (*i*) the enforcement constraint in (4.9) and (*ii*) the optimal capital decision in (4.13). Nevertheless, capital utilization once more drives the spillover effects on other assets.

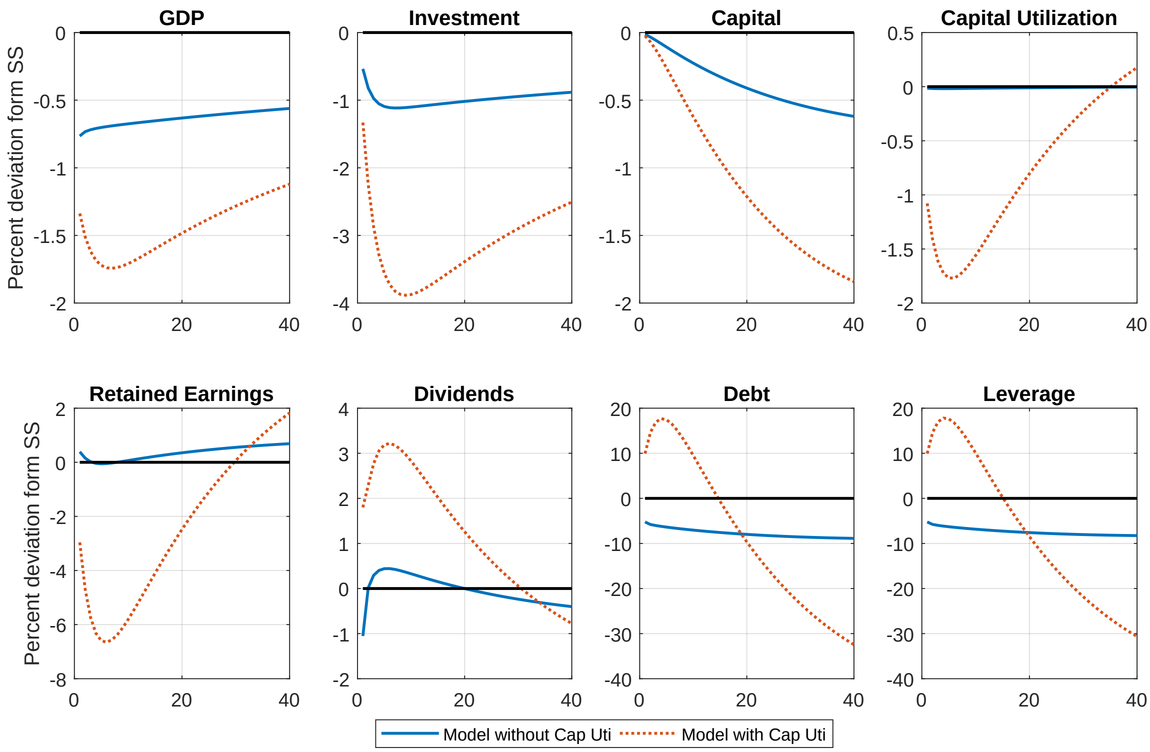
Figure 4.4: Impulse Response Function to a Negative Marginal Efficiency of Investment Shock



Note. The panels show the effect of a one-unit orthogonal MEI shock on output (GDP), investment, capital, capital utilization, retained earnings, dividends, short-term debt, and leverage. The solid (blue) line corresponds to the impulse response function of the benchmark case with no capital utilization, while the dashed (red) line is the response of the model with capital utilization.

As illustrated by the enforcement constraint in (4.16), the firm's optimal response to a negative financial shock is to reduce the level of investment, dividends, employment, or any combination thereof. Since the firm can reduce its capital utilization as an optimal response to a negative financial shock, production declines even further, causing retained earnings to follow. Once again, the elastic supply of debt leads the firm to rely on short-term debt to finance its dividend policy, driving the debt and leverage ratio up. Last, if capital utilization is absent, a negative financial shock limits the firm's ability to borrow, forcing the firm to finance its investment with retained earnings. In this scenario, an increase of retained earnings, illustrated in (4.5), can

Figure 4.5: Impulse Response Function to a Negative Financial Shock



Note. The panels show the effect of a one-unit orthogonal financial shock on output (GDP), investment, capital, capital utilization, retained earnings, dividends, short-term debt, and leverage. The solid (blue) line corresponds to the impulse response function of the benchmark case with no capital utilization, while the dashed (red) line is the response of the model with capital utilization.

only be achieved by a substantial reduction of the equity payout.

Figure 4.5 presents the impulse response functions of real and financial variables to a financial shock. As before, the solid line corresponds to the benchmark model without the capital utilization mechanism, while the dashed line represents the model with capital utilization. Similar to the results of Figure 4.4, capital utilization is the key mechanism not only amplifying the magnitude of shocks but also changing the firm's capital structure decision.

4.5 Conclusion

Our study presents a comprehensive analysis of the relationship between capital utilization and leverage, providing empirical evidence that these variables are procyclical. In particular, we show that the relationship between these variables is especially strong when leverage is proxied by the firm's short-term debt. We conduct several robustness tests, such as dynamic correlation analysis controlling for firm size; regression analysis controlling for established leverage predictors; business cycle components; and autocorrelation; and a firm-level panel data estimation that verifies the existence of the strong positive relationship between capital utilization and short-term debt at the firm levels.

After documenting this interesting finding, we create a DSGE model to understand how the procyclicality of capital utilization and leverage arises endogenously and how capital utilization acts as a propagation and amplification mechanism of real and financial assets to all assets in the economy. Our results show that the reason capital utilization is critical to explain leverage is that it alters the financing of investment away from retained earnings towards debt. In the absence of this mechanism, a real or financial negative shock leads the firm to reduce its debt and cut equity payout to increase retained earnings in order to finance investment. For all of these reasons, we argue that ignoring the capital utilization mechanism can lead researchers to underestimate the effects of real and financial shocks and derive misleading conclusions regarding the leverage decisions of firms.

Lastly, there several possible fruitful extensions of our model. A first natural extension is to allow for equity issuance and firm heterogeneity. Hennessy and Whited (2007) show that "for large (small) firms, estimated marginal equity flotation costs start at 5.0% (10.7%) and bankruptcy costs equal to 8.4% (15.1%) of capital." This suggests that equity issuance costs are economically significant and could potentially affect the firm's behavior. Taking this feature into consideration can result in interesting implications for the firm's capital structure. For instance, the high cost of equity issuance could, in theory, lead small firms to depend less on equity issuance and more on debt, driving small firms to a potential debt overhang. As a result, an increase in capital utilization in good times would prevent the firm from obtaining debt financing in the same period, which could eventually damp the procyclicality of capital utilization and short-term debt. In contrast, since large firms can easily increase their debt, equity issuance would ultimately strengthen the capital utilization mechanism for large firms since the risk of debt overhang for these firms is very low.

A second possible extension is to introduce the possibility for firms to default (see Hennessy and Whited (2007) and Nikolov and Whited (2014)). Considering an endogenous default option increases the cost of debt, especially for small firms. In good times, productivity shocks increase firms' capital utilization. As a result, firms increase debt to finance their short-term operations. However, with the introduction of the possibility of default, the amount of debt required by firms to finance their expenses could be significantly higher and more expensive. This could, in theory, weaken the capital utilization channel. This interesting extension of our model can shed light on the relationship between capital utilization and credit spreads.

Chapter 5

CONCLUSION

The state of the economy and the economic policy significantly affect firms' decisions. Therefore, a careful study of the connection between macroeconomics and corporate finance theories requires developing models in which we can evaluate the effects of economic policy on corporate investment and financing decisions. These kinds of models belong to the macro-finance area. In this dissertation, I develop three macro-finance models in three related essays. The first model is a firm dynamic with financial and real frictions to study the working capital channel of the monetary policy. The second is a constraint firm with corporate bond issuance in the context of the COVID-19 crisis to study the effects of the unconventional monetary policy on firms' decisions. Finally, the third model is a dynamic stochastic general equilibrium model to study how the physical capital utilization rate could affect the firm's capital structure. In this model, the firm decides the physical capital utilization rate endogenously and faces economic frictions.

The results of the first essay open a promising research agenda with the following questions: What is the magnitude of the working capital over the business cycle? Is the working capital channel represented by ϕ different for expansion and recessions? Is ϕ different for constrained and unconstrained firms? Or for small, medium, and large firms? Considering the magnitude of the working capital channel, how could monetary policy affect the firm's capital structure through this channel? Is this effect different due to the firm's characteristics? The answer to these questions will shed light on our understanding of the design of monetary policy and how its mechanisms are related to firms' optimal decisions.

Similarly, the conclusions of the second essay show that several research questions are still open and lead to future research. For instance, under what conditions firms are willing to use the funding from PMCCF to increase investment? In addition, what is the role of financial frictions such as equity/debt issuance costs in amplifying or moderating the effects of the UMP? Finally, what is the role of real frictions such as investment irreversibility on the efficacy of UMP? These questions will shed light on our understanding of the UMP and provide insights for a better policy design. Furthermore, from a theoretical perspective, studying this policy in a complete heterogeneous firms framework will be valuable since it could illuminate what kind of firms are more responsive to the UMP and why.

Finally, the third essay shows clearly that a theory of capital structure should seriously consider the firm's capital utilization which is missing in the current literature—additionally, there several possible fruitful extensions of our model. A first natural extension allows for equity issuance and firm heterogeneity and a second possible extension introduces the possibility for firms to default.

I plan to make progress in this macro-finance research agenda in future work.

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APPENDIX A

APPENDIX TO CHAPTER 2

A.1 Solution of the Base Model

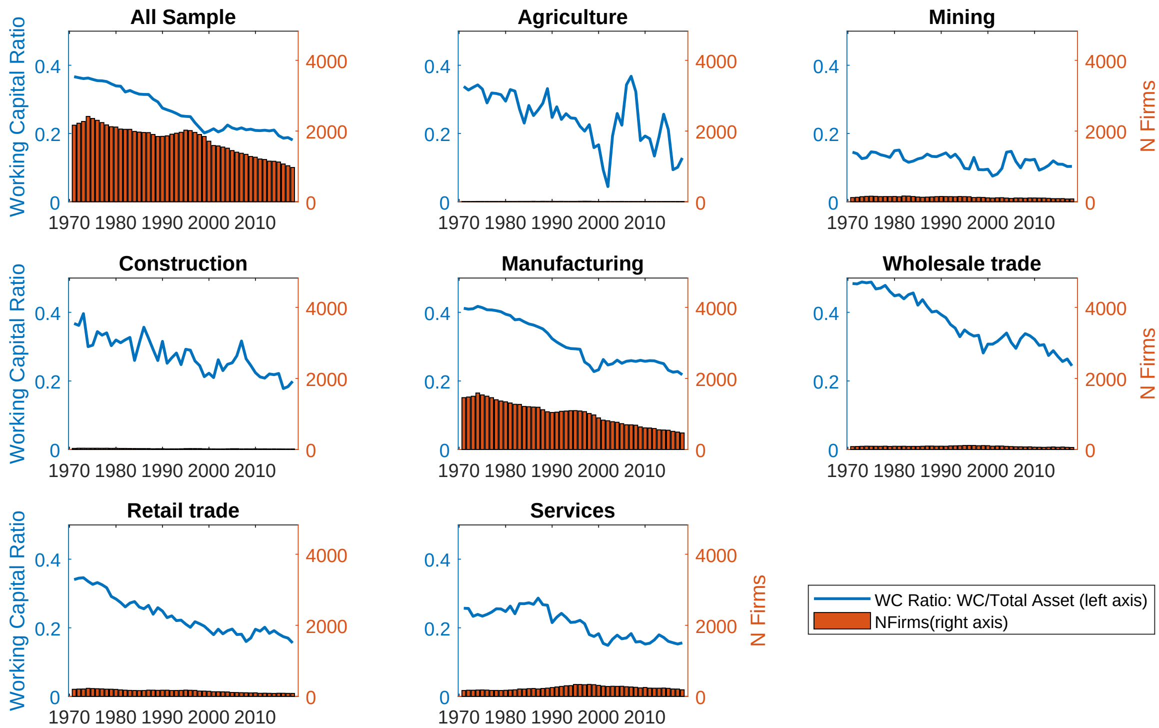
To find a numerical solution of the base model, I follow three steps.

1. **Steady state.** With the calibration, I find the steady-state value for all variables. For example, output ($Y_{ss} = 0.3380$), capital ($K_{ss} = 0.8588$), and investment ($I_{ss} = 0.0859$).

2. **Finite state space.** I specify a finite state space for the two state variables, k and ε. First of all, using the method in Tauchen (1986), I construct a grid for the interest rate shock ε. I consider 11 points in that grid centered in the steady-state value of gross interest rate ($R_{ss} = 1.04$). This procedure transforms the equation (2.3) into a discrete state Markov chain on the interval $[1, 1.08]$. Furthermore, I then construct a grid for k which contains 101 points centered at the steady-state capital stock (K_{ss}). From this procedure, I have that $k \in [\underline{k}, \overline{k}]$. The lower bound of this grid, $\underline{k}$, is 0.5 times the steady-state value of capital stock evaluated in the lower bound of ε. In the same way, the upper bound of k is the steady-state value of capital stock evaluated in the upper bound of ε. I follow the same strategy for n.

3. **Method to solve the model.** I solve the model using value function iteration on the Bellman equation (2.11), which generates the value function $V(k, \varepsilon)$ and the policy function $k', n' = g(k, n, \varepsilon)$. Additionally, other important policy functions are obtained such as profitability, investment rate, and working capital ratio. Michaelides and Ng (2000) find that good finite sample performance requires a simulated sample that is approximately 10 times as large as the actual data sample.

Figure A.1: What is the Fraction of Working Capital in the Total Asset of the Firm?



Note. This figure shows the average working capital ratio for the entire sample and for seven industries.

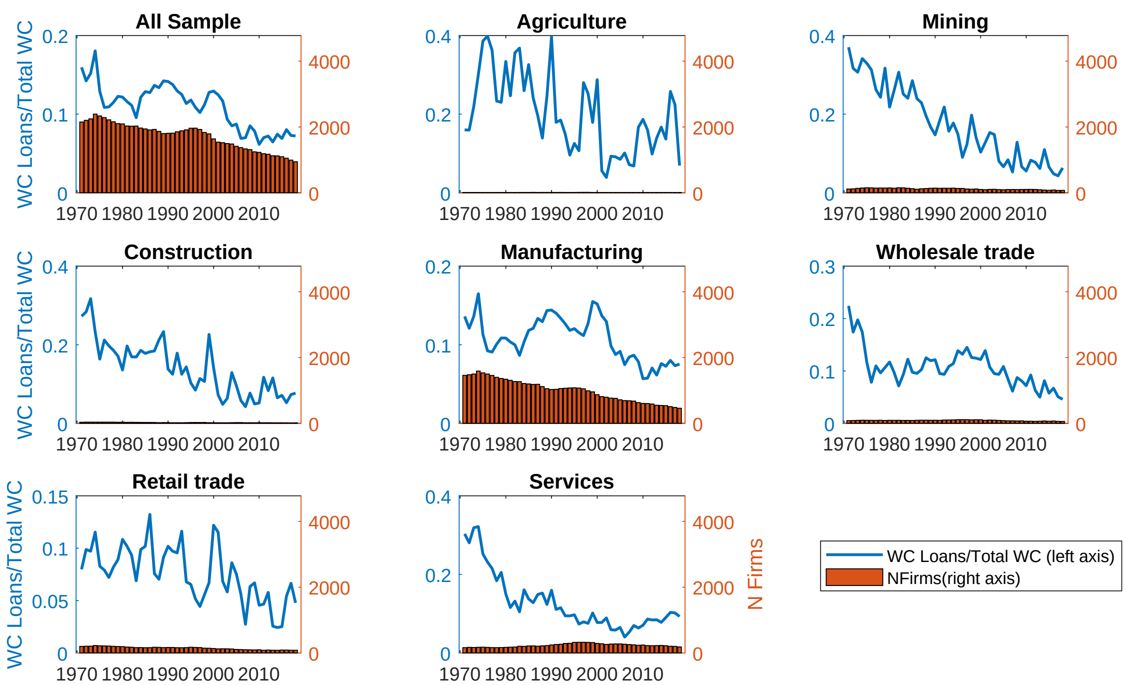
Table A.1: Descriptive Statistics

		Mean	SD	25%	50%	75%	Obs
All sample	prof.	0.115	0.133	0.079	0.129	0.180	86,911
	inv.	0.065	0.059	0.025	0.048	0.085	86,911
	wc	0.062	0.089	0.010	0.030	0.075	86,911
Manufacturing	prof.	0.123	0.125	0.087	0.135	0.185	49,290
	inv.	0.057	0.046	0.026	0.046	0.075	49,290
	wc	0.063	0.086	0.011	0.032	0.079	49,290
Services	prof.	0.090	0.177	0.063	0.116	0.174	12,171
	inv.	0.062	0.068	0.018	0.038	0.081	12,171
	wc	0.062	0.095	0.007	0.026	0.071	12,171
Retail Trade	prof.	0.135	0.101	0.092	0.141	0.190	7,434
	inv.	0.079	0.061	0.035	0.064	0.106	7,434
	wc	0.054	0.085	0.007	0.022	0.061	7,434
Mining	prof.	0.098	0.142	0.059	0.114	0.167	6,029
	inv.	0.124	0.090	0.054	0.103	0.178	6,029
	wc	0.053	0.079	0.007	0.026	0.066	6,029
Wholesale Trade	prof.	0.101	0.133	0.068	0.114	0.164	4,328
	inv.	0.045	0.046	0.016	0.032	0.059	4,328
	wc	0.084	0.114	0.010	0.034	0.110	4,328
Construction	prof.	0.093	0.100	0.053	0.096	0.143	1,741
	inv.	0.042	0.050	0.008	0.025	0.059	1,741
	wc	0.088	0.115	0.014	0.043	0.114	1,741
Agriculture*	prof.	0.090	0.090	0.036	0.102	0.150	430
	inv.	0.064	0.061	0.025	0.048	0.085	430
	wc	0.074	0.095	0.012	0.039	0.106	430

Note. This table presents descriptive statistics for the main variables used in the estimation for the entire sample and for every industry except for utilities, finance, and public administration firms. The sample is based on Compustat Annual Industrial Files. Moreover, the sample covers the period from 1971 to 2018 at an annual frequency. *SD* means *Standard Deviation* and *Obs* means the *number of observations.* 25%, 50%, and 75% represent percentiles.

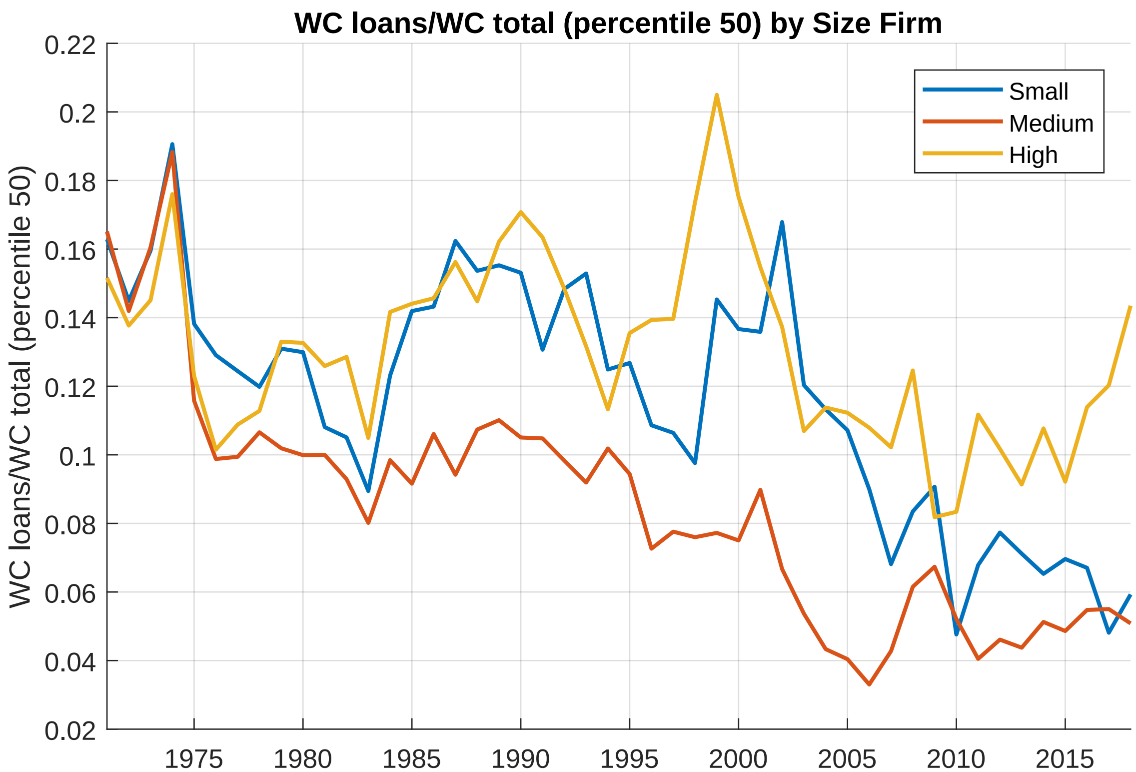
*This industry includes forestry and fishing as well.

Figure A.2: What is the Fraction of Working Capital Loans in Total Working Capital That the Firm Needs?



Note. This figure shows the median of WC loans/Total WC for all the sample and for seven industries. Working capital loans is represented by WCL and total working capital by TWC.

Figure A.3: Is the Working Capital Loans over the Total Working Capital Different Across Firm's Size?



Note. This figure shows the median of WCL/TWC for small, medium, and large firms. This figure considers the entire sample. Small firms are defined as those whose total assets are below the percentile 33, medium firms have total assets between percentile 33 and 66, and large firms have total assets above percentile 66. Every percentile is calculated for every year based on the year sample.

APPENDIX B

APPENDIX TO CHAPTER 4

B.1 Data

In this section, we present all datasets used in our aggregate- and firm-level analyses. The first dataset is quarterly COMPUSTAT data of publicly listed firms (excluding financial firms and utilities), from the first quarter of 1980 to the fourth quarter of 2017. All firm-level series come from this dataset.

From the Federal Reserve Bank of St. Louis (FRED), we collect the Capacity Utilization: Total Index (TCU) and the Real Gross Domestic Product (GDP). We transform the monthly data to quarterly frequency by averaging the monthly values of every quarter to match the frequency of the COMPUSTAT dataset. Last, equity prices come from CRSP. We list below the variables and regressors used in the empirical analysis of Section 4.2.

1. **Capital utilization.**

   Aggregate level. We use monthly data on the Capacity Utilization: Total Index (TCU) obtained from FRED.

   Firm level. The firm-level capital utilization is proxied by the ratio of the number of employees (EMP) to Capital Expend Property, Plant and Equipment Schd V (CAPXV). CAPXV represents the amount spent for constructing and/or acquiring property, plant, and equipment.

2. **Capital structure variables.**

   Total liabilities. We collect the series of total liabilities from COMPUSTAT at both quarterly (symbol LTQ) and annual (symbol LT) frequencies.

   Debt in current liabilities. We collect the series of debt in current liabilities from COMPUSTAT at both quarterly (symbol DLCQ) and annual (symbol DLC) frequencies.

   Long-term debt We collect the series of long-term debt from COMPUSTAT at both quarterly (symbol DLTTQ) and annual (symbol DLTT) frequencies.

   Total equity. With COMPUSTAT data, we construct total quarterly equity as the sum of total common/ordinary equity (CEQQ) plus the total preferred/preference stock (PSTKQ). The annual series is obtained by repeating the procedure with the series CEQ and PSTK.

   Total Assets. We collect the series of total assets from COMPUSTAT at both quarterly (symbol ATQ) and annual (symbol AT) frequencies.

   Liabilities and stockholders' equity. We collect the series of liabilities and stockholders' equity from COMPUSTAT at both quarterly (symbol LSEQ) and annual (symbol LSE) frequencies.

   Stockholders' equity. We collect the series of stockholders' equity from COMPUSTAT at both quarterly (symbol SEQQ) and annual (symbol SEQ) frequencies.

   Preferred stock. We collect the series of total preferred stock from COMPUSTAT at both quarterly (symbol PSTKQ) and annual (symbol PSTK) frequencies.

Common/ordinary equity. We collect the series of total common/ordinary equity from COMPUSTAT at both quarterly (symbol CEQQ) and annual (symbol CEQ).

Current liabilities/Assets. We construct quarterly (annually) current liabilities/assets as DLCQ/ATQ (DLC/AT).

Long-term debt/Assets. We construct quarterly (annually) long-term debt/assets as DLTTQ/ATQ (DLTT/AT).

Total debt/Assets. We construct quarterly (annually) total debt/assets as (DLCQ +DLTTQ)/ATQ ((DLC+DLTT)/AT).

3. **Aggregate regressors.**

   Size. We construct the variable Size as the logarithm of total assets (AT) over GDP. Total assets per quarter is the sum of AT across all firms.

   Income ratio. We construct the quarterly income ratio as the ratio between operating income before depreciation (OIBDPQ) and total assets (ATQ). We aggregate the series OIBDPQ and ATQ across firms compute the ratio OIBDPQ/ATQ.

   Growth. We construct the quarterly variable Growth as the percentage growth of assets per quarter (i.e. $\text{ATQ}_t/\text{ATQ}_{t-1} - 1$). Total assets per quarter is the sum of ATQ across firms.

4. **Panel data regressors.**

   Log assets. We construct the log assets series as the logarithm of the AT series.

   Profit. We construct the profit series as OIBDP over AT.

   Tangibility. We construct the tangibility series as the ratio between PPENT (Property, Plant and Equipment - Total (Net)) and AT.

   MtB ratio. We compute the market-to-book ratio (MtB ratio) as the ratio between the absolute value of the market price per share (PRC) and the book value per share (BKVLPS). We collect PRC from CRSP.

B.2 Econometric Techniques

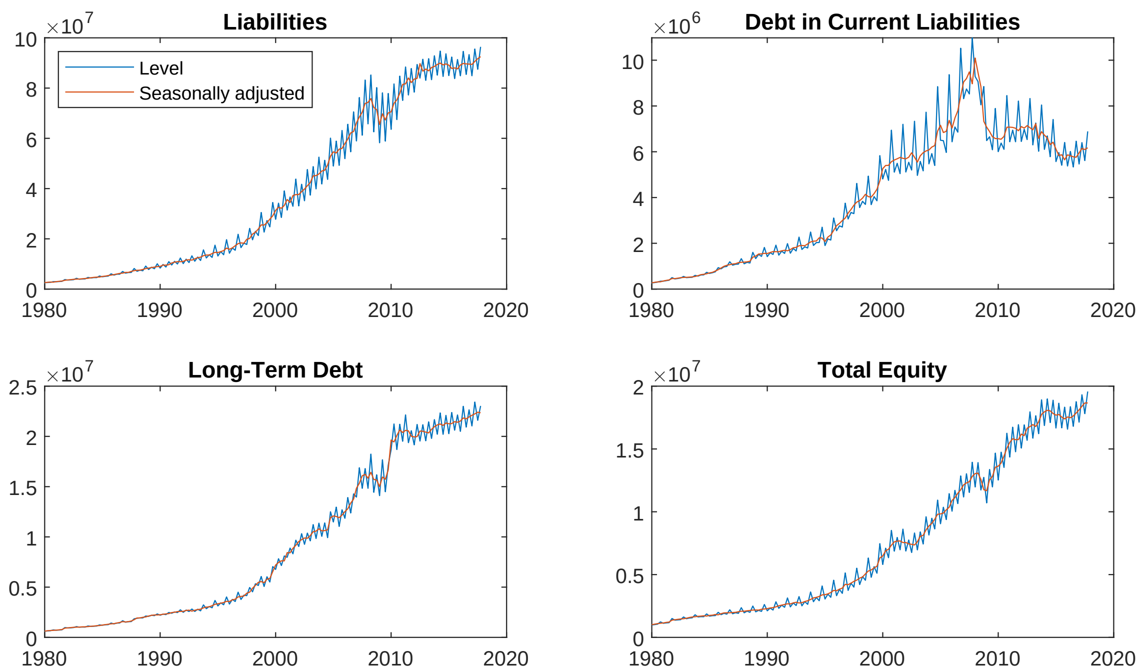
In this appendix, we explain the two econometric techniques (the seasonal adjustment X-13ARIMA-SEATS and the Hodrick-Prescott filter) used in the paper to construct our variables of interest. We also added more details about the computation of dynamic correlations.

B.2.1 X-13ARIMA-SEATS

Economic and financial variables usually contain a seasonal component that can affect the estimation procedure. A standard seasonal adjustment procedure to remove seasonal components is the X-13ARIMA-SEATS (see Gomez and Maravall (2001) and Maravall A. (2012)). Essentially, the seasonal adjustment of X-13ARIMA-SEATS consists of decomposing the target variables into a product of a trend, seasonal, and residual components. After fitting the original series with an ARIMA(p,d,q), the original series is divided by the estimated seasonal component of the econometric model. [1]

To illustrate the effect of the time-series smoothing procedure, we show in Figure B.1 the level of both the unadjusted and the seasonally-adjusted series for four variables: liabilities, debt in current liabilities, long-term debt, and total equity. A quick inspection reveals the presence of a seasonal component (blue line) in all four series. Notice that after we apply the X-13ARIMA-SEATS filter, the seasonally-adjusted variables (red line) behave smoothly. We apply this technique to all variables in our empirical analysis.

Figure B.1: Unadjusted and Seasonally-adjusted Variables (1980q1 - 2017q4)



B.2.2 Hodrick-Prescott Filter

To extract the cyclical components of capital utilization and leverage, and study their short-run movements, we rely on the filter developed by Hodrick and Prescott (1997). In a nutshell, the authors assume that we can decompose every time-series y_t in a trend component τ_t and a cyclical component c_t:

$$y_t = \tau_t + c_t. \tag{B.1}$$

Hodrick and Prescott (1997) suggest that the trend of a time-series can be obtained by minimizing the squared deviations of the original series from its trend (i.e. the cyclical

[1] For additional details on the methodology, see the webpage of the U.S. Census Bureau at https://www.census.gov/srd/www/x13as/.

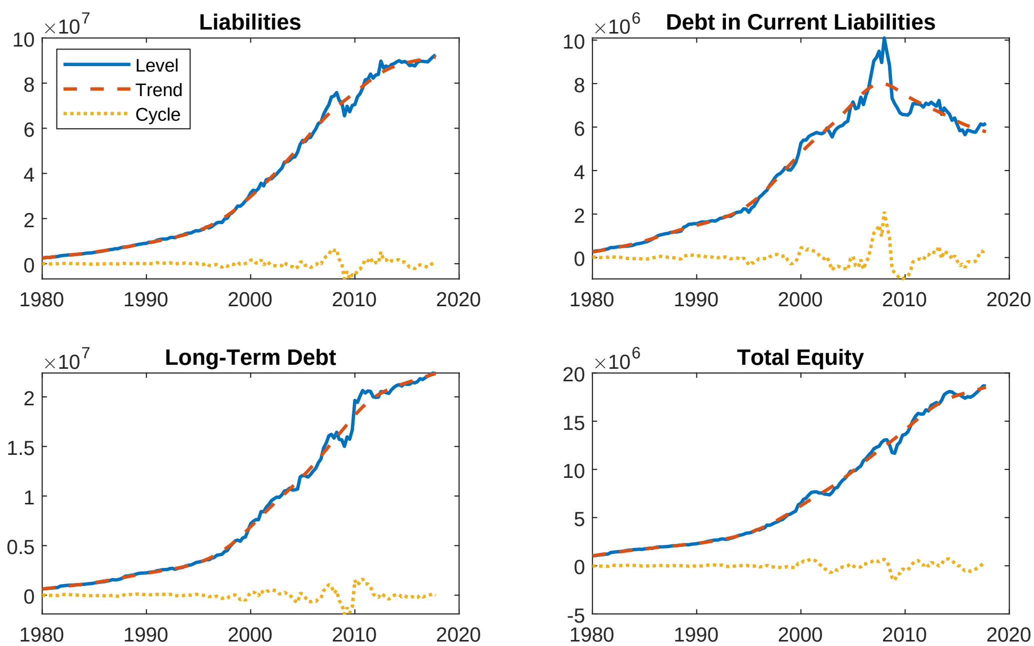
component), penalized by deviations of the growth rate of the trend component. In mathematical terms, the HP filter solves the following minimization problem:

$$\min_{\tau} \sum_{t=1}^{T} (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} (\tau_{t-1} + \tau_t)^2 \, ,$$

where λ is the penalization parameter, set at $\lambda = 1600$ by Hodrick and Prescott (1997). Naturally, the cyclical component c_t is recovered by simply taking the difference between the original series y_t and the trend component τ_t. We apply this procedure to all series investigated in our study.

To better illustrate the effect of this procedure on the variables of interest, we plot in Figure B.2 the original series (solid blue line), the trend component (dashed red line), and the cyclical component (dotted yellow line). All our empirical analyses in the paper are based on the cyclical component (i.e., the yellow dotted line), since our primary focus is in investigating *how the cyclical component of capital utilization and short-term debt are related.*

Figure B.2: Level, Trend, and Cycle Components (1980q1 - 2017q4)



B.2.3 Dynamic Correlations

Table 4.2 shows the dynamic correlation between (the cyclical components of) capital utilization and other financial variables. The main idea of the dynamic correlation is to evaluate the comovement between the capital utilization and the j-period lag or lead of the financial variables. Table 4.2 shows the standard Pearson's correlation coefficient for the lag-adjusted series. The reason why this analysis is worth investigating is that some financial variables could react before or after the capital utilization movements. In this case, using the dynamic correlation to understand the movements of financial variables at times $t \pm 1$ of $t \pm 2$ with capital utilization at time t can be very informative.

APPENDIX C

CO-AUTHORSHIP STATEMENT

Chapter 4 of this dissertation, titled Leverage and Capital Utilization, forms the core of a paper of the same name, co-authored with Dr. Alexis Montecinos and Dr. Diogo Duarte and included in this document with their permission.