

# MANAGER ATTENTION AND LEVERAGE DYNAMICS

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## ABSTRACT

I examine the relation between firm-level financial decisions and the focuses of executive managers of the company, by creating and analyzing two novel indices of executive attention, as revealed through the language used in quarterly earnings call transcripts. Corporations are critically sensitive to both the macroeconomic environment and firm-specific challenges, and executives must correspondingly choose to allocate finite time and attention between these topics. By using natural language processing, I create a new method to consistently assess the information content of this dialog quantitatively. The attention capacity and attention allocation measurements are time-varying and associated with firm characteristics (size, profitability, tangibility and market to book ratio), as well as macroeconomics (economic growth and uncertainty). Managers have a two-step decision process. They first decide attention capacity and attention allocation before making financing decisions. Managerial attention capacity increases in response to rising uncertainty in the environment. An increase of volatility in either macro or firm-specific component has both substitution and scale effects to the other component. Empirically, the scale effect increases the firm's leverage ratio, while the substitution effect lowers it. Theoretically,

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I allow a representative manager to make endogenous information choices before optimizing firm's financial structure. Using an optimal static capital structure model with a contingent claim setup, I show that the model reproduces the key phenomenology.

Keywords: capital structure, information rigidity, natural language processing, macro and firm-specific shocks

## 1. Introduction

The recent nonfinancial business leverage has mounted to record-high levels<sup>1</sup>. The co-occurrence of aggregate leverage peak and economy pledge opens up new research possibilities. The impact of macroeconomics on firm financial decisions is addressed (Duffie et al., 2003; Fama, 1986; Hackbarth et al., 2006). Besides, corporate finance literature traditionally explains the leverage variation with firm characteristics, liquidity, adjustment cost and policy<sup>2</sup>. Despite the efforts, volatility and heterogeneity in firm-level leverage remains partially unexplained<sup>3</sup>. This paper aims to address the unexplained parts by introducing behavioral factors.

The approaches above assume that decision makers either have perfect information or don't have a learning process at all. When a manager process perfect information, she knows the exact future outcomes. When a manager doesn't pay attention, she estimates future cash flows with uncertainty. Being partially attentive is more prevalent. Indeed, limited attention are ubiquitous in business. Countless issues, either about inner communication (Robson and Tourish, 2005) or about external environment (Hassan et al., 2019; Baker et al., 2016), are attention requiring. The managers don't always have enough information or don't have time to collect information to make the best decision. Managers need to prioritize timing over optimization occasionally. Inefficient attention allocation is even more common. Projects can be ordered by urgency instead of importance. A task can take longer than expected, leaving other decisions made without deliberation. As a result, limited attention can cause frictions, which deviate a firm from the greatest value. These frictions caused by managers' cognitive bias is known as information rigidity in macroeconomics and financial investment. But using information-theoretic ideas in corporate finance is still awaiting for initial attempts. To investigate the role of information channel, this paper introduces endogenous information decision making process into a static optimal financial structure model. Managers choose the attention capacity and attention allocation before making optimal financial decisions.

Research about information rigidity commonly treats attention capacity and atten-

<sup>1</sup>The U.S. non-financial corporate business's debt securities and loans over GDP reach 52% in Quarter four, 2020. See Board of Governors of the Federal Reserve System (US), Non-financial Corporate Business; Debt Securities and Loans; Liability, Level [BCNSDODNS], retrieved from FRED, Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org/series/BCNSDODNS>, June 30, 2021.

<sup>2</sup>See Hackbarth et al. (2006), Karpavičius and Yu (2017), Faccio and Xu (2015), Heider and Ljungqvist (2015), Leary (2009) and Jordà et al. (2020). Faccio and Xu (2015) and Heider and Ljungqvist (2015) found a significant positive correlation between tax rate and leverage ratio.

<sup>3</sup>Lemmon et al. (2008) points out that firm-level leverage has an unobserved time-varying unexplained. Graham and Leary (2011) makes the same argument of cross-section leverage variations

tion allocation as constant. That is to say, the agent's ability to learn from new information and the attention ratio allocated to each field are assumed constant over time. Does managerial attention capacity stay constant? What factors do managers consider when optimizing information decisions? Does limited attention affect firm-level capital structure? Can managerial attention help explaining the unprecedented high level of business leverage?

To answer the questions, this paper first seeks to measure and analyze the information channel of managers' financial decision making. The raw material that I used to construct the measurements are the earnings call transcripts. Public listed firms are required by U.S. Securities and Exchange Commission (SEC) to host quarterly earnings call conference to reveal information about company operations and exchange information with investors. During the conference, the executive managers present and discuss a company's current and future operation, revenue, cash flow and financing status. The documented text thus reveals managers' attention and work priorities. With the adequate raw text, I construct two novel firm-level attention measurements for 3481 firms and exam the quantity and the priority of managers' attention. Attention capacity, which is the sum of attention payed to macroeconomic and firm-specific components, measures the amount of information that a manager processed to make the financial decision. Attention allocation describes a ratio of attention that a manager distributed to each component. After discussing the construction and validation of the attention measures, I use the new time series of firm-level attention to document a number of new findings. Details about the measurements can be found at section two.

At the aggregate level, attention capacity is counter cyclical while attention allocation to macroeconomics has an upward trend. The cross-section distribution variances of both indexes are larger during recessions. Further analysis documents that managers' attention capacity is positively correlated with firm size, profitability, tangibility, market to book value and leverage. Attention allocation is positively related with firm size and profitability while it is negatively correlated with the market to book value, tangibility and leverage. Attention capacity is time-variant and affected by uncertainty in the business environment. The uncertainty comes from two parts, macro and firm-specific components, in which the mechanism of information work in the same way. When the uncertainty in both component changes simultaneously, it's difficult to analyze. To simplify the process, I keep the firm-specific volatility constant while make the macro volatility variant for most cases throughout this paper. The effect stays the same vice versa.

There are two key findings in the empirical analysis. First, attention capacity increases leverage ratio, while attention allocation towards macroeconomics decreases leverage ratio. I conclude this finding as the scale and substitution effects of managers being

attentive to macroeconomics. Suppose the firm-specific volatility stays constant, higher macro volatility leads to an increase in managerial attention to macroeconomics and improved attention capacity. With increased attention capacity, managers gain more information about the fundamental economy and thus improve precision of estimated optimal financial structure. Managers can risk a higher leverage by being more aware of their own financing situations. On the other hand, paying attention to macroeconomics can crowd out the attention allocated to firm-specific issues, resulting in a lower estimation precision, making managers conservative about borrowing decisions. I found that the substitution effect is higher than the scale effect with both empirical evidence and theoretical setup. This finding is robust when considering firms' financial constraints and industrial cyclical sensitivity. The second finding documents that the information channel represented by attention capacity and attention allocation can amplify the effect of business cycle on leverage ratio. Recession is featured with low economic growth rates and high uncertainty. Motivated by high macro uncertainty, managers choose to pay more attention to macroeconomics and increase the weight of macro factors when making an optimal financing decision. I also found that when adding an aggregate uncertainty measurement, the coefficient of GDP growth rate becomes insignificant, suggesting that the information channel connects the macro environment through the second moment instead of the first moment.

The findings in the empirical part motivate the design of my theoretical model. Following the theory of rational inattention, I assume that agents have limited attention and cannot process all the available information. Managers' attention capacity and attention allocation is inertial in financial decision making, because it determines managers' beliefs about internal and external environment and estimation precision of future conditions. Three major elements are incorporated into firm's financial decisions. First, a representative firm chooses optimal information decision before maximizing the value of the firm. The information decision consists of attention capacity, the amount of information, and attention allocation, which is how to allocate limited attention between macroeconomics and firm-specific issues. Second, the decisions of attention capacity is based on the total volatility of the company. Third, the attention allocation is determined by both the attention capacity and comparative variances of macro versus firm-specific components. The information choice is time-varying.

This paper makes three contributions. First, by using quarterly earnings call transcripts and Natural Language Processing (NLP), I construct two novel firm-level measurements of managers' attention: attention capacity and attention allocation. Attention capacity measures the amount of effective information that managers acquired. Attention allocation measures how much managers pay attention to macroeconomic environment out of the total attention capacity. Both the measurements are time-varying, indicat-

ing that managers' attention capacity and attention allocation are correlated with other time-varying factors. Consistent with information rigidity theory, the agent's attention capacity index is positively correlated with the variance of related variables. For example, the attention capacity is higher during recession, when the economic uncertainty is high. Second, I investigate if the time-varying attention measurements help explain the variance and heterogeneity of firm-level leverage ratio. With these two measurements, I document that managers' leverage ratio decision is positively correlated with their attention capacity and negatively correlated with attention allocation towards macroeconomics. To interpret the correlations, paying attention to macroeconomics has both substitution and scale effects on managerial financial decisions using firm-specific information. By looking at the role of the business cycle, I further document that managerial attention to macroeconomics amplifies the effect of the business cycle on firm-level leverage ratio. Finally, I build a theoretical model integrating rational inattention theory and corporate finance. The rational inattention theory is extended to Geometric Brownian Motion. The model aims at making managerial information choice endogenous based on the precision of past estimation. The model reproduces the same phenomenology as found in empirical analysis.

**Related Literature** This paper relates to three strands of literature. The first addresses the role of macroeconomics in a firm's financial decision. The second literature highlights the role of information rigidity in agents' decision making process. The last strand of literature attempts to use machine learning techniques and text data to measure abstract concepts in economics, such as uncertainty, risk and attention.

Since the seminal work of Modigliani and Miller (1958), economists have made efforts to understand firms' financing policy quantitatively. Traditional studies of corporate finance focus more on firm-specific conditions<sup>4</sup>. A heightened volume of research appearing in the past 20 years highlights the role of macroeconomics in determining capital structure<sup>5</sup>. Business cycles can affect a firm's financial choice with default risk, credit risk, liquidity and cash flow<sup>6</sup>. Several discrepancies remain in both theoretical and empir-

<sup>4</sup>Titman and Wessels (1988), Rajan and Zingales (1995), Hovakimian et al. (2001) and Hovakimian et al. (2004) provide evidence that various firm characteristics are related to firm's leverage ratio.

<sup>5</sup>Choe et al. (1993) first show that macroeconomics are important factors to a firm's financing choices. Levy and Hennessy (2007) and Brunnermeier and Krishnamurthy (2020) share the same idea. Indeed the three major theories (trade-off, pecking-order, and market timing) of a firm's financing decisions all emphasize the role of macroeconomics.

<sup>6</sup>Fama (1986), and Duffie et al. (2003) provide evidence that business cycles impact the probability of default. Hackbarth et al. (2006) study the role of credit risk. Faulkender and Petersen (2006) firstly document the role of the supply-side of liquidity. Firms that have access to public bond markets choose to have more leverage

ical results. First, theoretical studies yield both pro-cyclical and counter-cyclical patterns of leverage ratio<sup>7</sup>. A large variation and heterogeneity in firm's leverage choice<sup>8</sup> remains unexplained.

This paper makes an contribution to the corporate finance literature in the following three ways: 1) I introduce rational inattention as a new factor that influences firm-level leverage variations. Corporations are critically sensitive to both the macroeconomic environment and firm-specific challenges. Being attentive to macroeconomics increases the firm's leverage ratio by expanding the attention capacity. Paying attention to macroeconomics, on the other hand, lowers the leverage ratio by crowding out managers' focus on firm-specific issues. 2) I study the information channel, through which the business cycle influences leverage ratio. The results further point out that the aggregate uncertainty contributes the influence instead of the first moment. 3) I introduce time-varying attention capacity and attention allocation into a static optimal capital structure model. Before making firm value maximizing decisions, managers make optimal information decisions.

This paper also closely connects with information rigidity literature. As Gabaix (2019) points out, "Traditional rational economics assumes that we process all the information that is freely available to us". Numerous research shows that agents' attention level is roughly halfway between paying attention and not paying attention (Gabaix, 2019). A new wave of studies investigate the role of agent's attention in decision making process. Most research focuses on the real economic activity, such as consumer decisions, manager's decisions on real production and hiring, professional forecaster's behavior on forecasting (Maćkowiak et al., 2009; Maćkowiak and Wiederholt, 2015; Coibion and Gorodnichenko, 2015; Flynn and Sastry, 2021; Andrade et al., 2021; Chen et al., 2021). Recent findings show that managers treat information from macro and micro sources differently<sup>9</sup>.

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<sup>7</sup>Hackbarth et al. (2006) reported a counter-cyclical leverage. Similar results are found in Levy and Hennessy (2007) with less financially-constrained firms, Chen (2010) with firm's actual leverage ratio, Halling et al. (2016) with target leverage ratio, and Erel et al. (2012) with financially unconstrained firms. Oppositely, Bhamra et al. (2010) found the capital structure pro-cyclical using a consumption-based asset-pricing model. Chen (2010) found the firm's target leverage ratio pro-cyclical. Erel et al. (2012) found the capital raising of non-investment grade borrowers pro-cyclical.

<sup>8</sup>Korajczyk and Levy (2003) document that macroeconomic conditions affects financially unconstrained firm's capital structure choice but not for financially constrained firms. Begenau and Salomao (2019) note that big and small firms use different financing policy over the business cycle.

<sup>9</sup>Meyer et al. (2021), Chen et al. (2021) and Candia et al. (2021) show that comparing to firm-specific issues, managers pay less attention towards macro conditions. Candia et al. (2021) further points out that the inflation expectations of U.S. managers appear far from anchored. U.S. managers are largely uninformed about recent aggregate inflation dynamics or monetary policy. Maćkowiak et al. (2009) point out that decision-makers in firms pay significantly more attention to sector-specific conditions than to aggregate conditions. Similar findings see Zhang (2017)

A few papers shed lights on information rigidity in finance. Efforts are mostly made in explaining an investor's investment behavior. Kacperczyk et al. (2016) investigate if mutual fund managers allocate attention rationally. They use an attention allocation model and find that some investment managers have skill and that attention is allocated rationally. Sicherman et al. (2016) exam investors' financial attention by using novel panel data on daily investor online account logins. They find that investor attention declines when VIX arises. Hirshleifer and Sheng (2021) study firm-level earnings announcements. They find that aside from substitution effects, there is also a complementary relationship between macro and micro news. Dessein and Santos (2021) build a theoretical model and focus on the allocation of managerial attention. They yield that a manager's behavior matters more in a complex environment. Hirshleifer and Teoh (2003) point out investors have limited attention and ability to process information. Hirshleifer et al. (2009) demonstrate that limited attention results in market reactions to relevant news. Overall, there is a good amount of theoretical paper. Comparatively, empirical research on attention has been slowly developed because of measurement challenges. Peng and Xiong (2006) discover that investors' limited attention leads to category-learning behavior. Investors allocate more attention to market and sectoral information than to firm-specific information. Other related paper includes Peng (2005) and Van Nieuwerburgh and Veldkamp (2010).

There are so far six ways to measure attention<sup>10</sup>: 1) deviations from an optimal action (Coibion and Gorodnichenko, 2015; Baker et al., 2020; An, 2019); 2) deviations from normative cross-partials; 3) physical measurement (e.g.eye-tracking); 4) surveys (Meyer et al., 2021; Canda et al., 2021); 5) imputations from the impact of attentional interventions ; 6) Natural Language Processing(Hassan et al., 2019, 2021; Flynn and Sastry, 2021). Each method has pros and cons. Using deviations from an optimal action provide accessible data but may cause misalignment issues. The microdata speaks about more of forecasters' attention instead of managers' attention. One need to be aware of this difference when using forecasters' expectations as the proxy of managers' actions. Survey data is straightforward, consistent and timely. The drawback of using survey data is that it costly and time consuming. This paper uses NLP method. NLP can directly measure managerial attention revealed by the raw text. It's efficient, objective and easy to replicate. It also opens up possibilities of related research questions. For example, do managers pay equal attention to each specific category of macroeconomics (inflation, unemployment, interest rate etc..)?

This paper differs from the literature in the following three ways: 1) I focus on firm-level managerial attention and exam both the quantity and the allocation of attention. I

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<sup>10</sup>This classification builds on Gabaix's (2019) and DellaVigna's (2009).

first study the factors that can influence managerial attention. The impact of managerial attention is also carefully estimated. 2) I provide novel quarterly measurements of attention capacity and attention allocation for around two decades. By using NLP, my measurements are objective, efficient and replicable. 3) I first incorporate the rational inattention model with a contingent claims paradigm. The possibility of using rational inattention model under Brownian motion is also explored.

This paper also relates to the application of machine learning and natural language processing in social science. Classic applications can be found in Baker et al. (2016), Hassan et al. (2019, 2021) and Flynn and Sastry (2021). “*Measuring attention is still a hard task*” (Gabaix, 2019). Measuring an abstract concept such as *attention* is challenging. This paper mainly follows the methodology introduced in Flynn and Sastry (2021) (hereafter FS), which uses the *Term Frequency-Inverse Document Frequency (TF-IDF)* and 10-Q documents to construct the macroeconomic attention. They focus on the aggregate level of informativeness and found that at the aggregate level, firm attention to macroeconomics is counter-cyclical.

This paper differs from the previous research in the following two ways: 1) I focus on the information perspective of the measurement using TF-IDF and provide rationalization that two independent measurements are additive; 2) I make the connection of empirical measurement with the rational inattention model based on information theory. Because both TF-IDF and rational inattention model are built on information theory and share the same unit - one bit of information.

This paper closely relates to and inspired by three papers. The first comes Flynn and Sastry (2021)(hereafter FS). They use similar NLP method to generate attention measurement to macroeconomics and investigate the impact of business cycles on firms’ producing decisions. My paper differs from FS in the following three ways. FS focus only on firm’s attention to macroeconomics, while I endogenize firm’s information decision. By considering managerial attention quantity and allocation choice, I emphasize the role of attention to macroeconomics differently. In FS, a firm make fewer mistakes by being attentive to macroeconomics. Whereas, I discover the substitution and scale effect of managers being attentive to macro environment. Second, on top of FS’s contribution of attention measurement using NLP, my paper further connects information theory with the measurement of TF-IDF. I prove mathematically that using TF-IDF on the same text, the managers’ attention to different aspects are additive. Thus, it opens up great possibilities to investigate managers’ attention distribution. Third, I focus on firm’s financing decision instead of producing decision. I first introduce RI into a static optimal capital structure model. My paper also closely related to Zhang (2017). We conclude from different methods that attention capacity is state-dependent. Zhang (2017) applies rMarkov-switching

factor-augmented vector autoregression (MS-FAVAR) analysis on disaggregate personal consumption expenditure (PCE). Whereas, I directly measure managers' attention using text data. Inspired by the empirical evidence, we make the same assumption, that information decisions depend on the variance of information from different aspects, in the theoretical models. Second, we both emphasize the role of attention to macroeconomics. But differently, I focus on firm-level evidence for financing decisions, while Zhang (2017) focuses on sectional evidence and producing decisions. The third closely related paper is Hirshleifer and Sheng (2021). This paper exams the sensitivity of stock market reactions to earnings news on days either with or without major macroeconomic announcements. Their result suggests a complementary relationship between macro news and firm-level news, while the existing theories suggest that macro and firm-level earnings news are attention substitutes. Similarly, my paper suggest both substitution and scale effects. This paper differs from Hirshleifer and Sheng (2021) with data and agents. Instead of investigating investors and focusing on earnings announcement, I emphasize managers' financial decisions and generate a direct measurement of managerial attention to both macro and firm-specific challenges.

The rest of the paper is structured as follows: Section 2 defines and introduces the measurement of managers' attention capacity and attention allocation, using quarterly earnings call transcripts and TF-IDF. I then discuss the factors that determine attention capacity and attention allocation. The findings reveals the time-varying and heterogeneity of the two measurements. Section 3 investigate the role of managerial attention in making financing decisions. I then exam the effect of business cycle on firm-level leverage ratio and present the evidence of both substitute and scale effects. Section 4 presents the robust test of empirical results with two sets of difference categorization using the main sample data. I focus on firm's financial constraints and cyclical sensitivity. Section 5 describes the theoretical model combined by rational inattention framework and optimal capital structure with contingent claims diagram. Section 6 concludes.

## ***2. Measuring C-Suite's Attention Capacity and Attention Allocation***

This section introduces the construction of the two key variables of this paper: attention capacity and attention allocation. I start this section with the definition of attention capacity and attention allocation. I then introduce the text data used to generate the variable, which are the quarterly earnings call transcripts and the textbooks. Next, I show the methods to prepare the documents. Finally, I demonstrate the TF-IDF algorithm in detail, the key terms selected for each attention category, and how to interpret the results.

## 2.1 Attention Capacity and Attention Allocation

Entering the big data era, we are fighting for limited attention and learning to optimally allocate our attention. The limited attention comes from three parts. First, we all have twenty-four hours per day, and we each decide how to make the best of it. Second, the most majority of us can only focus on one thing at a time(reference). Multitasking usually lowers one's work efficiency. Third, we have limited capacity for information processing. For example, human performs poorer in complicated computation compared to computers(reference). Sims (2006) points out that due to Shannon capacity, there is always an upper bound of information transaction rate between the input and the output. In this paper, I define managerial attention capacity as the upper bound of information transaction rate when a manager works. This is the key to understand the heterogeneity as well as that executive managers in big firms have on average higher attention capacity than the same level managers in small firms, as I will show in the empirical research part. Because first, acquiring knowledge about the macro environment is harder and more costly than firm-specific issues. Big firms can afford news terminals, such as Bloomberg, and macro consultancy services. Second, big firms usually have larger exposure to macroeconomics, making the cost of not paying attention higher. In another word, executive managers in smaller firms are rationally inattentive to macroeconomic information.

We are making attention allocation decisions all the time. The problem can come from, whether multitasking, to should I spend the time working, or have fun in nature. In this paper, I provide a narrow definition of attention allocation. Only considering executive managers' working time, I define attention allocation as the percent ratio of attention that an executive manager pays to macroeconomic information. Executive managers are known to have tight schedules. When making a decision, they need to consider both the outside environment and only firm-related issues. They also make an effort with both inner and outer communication. Sometimes a decision has to be made before thorough considerations. Thus, paying attention to macroeconomics can help managers collect useful information as well as distracts managers from focusing on tasks that are known critical to firm development.

## 2.2 the Quarterly Earnings call Transcripts

I use the quarterly Earnings Call Transcript<sup>11</sup> of publicly listed firms to construct manager's attention. I first measure managers' attention toward macroeconomic and

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<sup>11</sup>Also used in Hassan et al. (2019), Flynn and Sastry (2021) and Hassan et al. (2021)

firm-specific conditions separately.

An earnings call conference is held once every quarter before its 10-Q or 10-K available, in the form of teleconference or webcast. A public listed company uses the call as an opportunity to discuss the financial results, the cause, and the forecasting of future operations of a reporting period (quarterly). The calls usually happen when the stock market is closed so that all investors can have a chance to learn about this company's performance before trading. To make sure investors and analysts are informed about the calls, the notices of the earnings calls are usually announced a few days or weeks in advance. The notifications are usually posted on the firm's website under a section named Investor Relations or Investors. Of course, professional financial data providers such as Bloomberg, FactSet, and Thomson Reuters will remind analysts about the upcoming earnings call. For individual investors, brokers such as Robinhood, push the notifications too. Many companies provide the recordings or presentation slides from the calls for investors who missed the meeting. It is worth noting that though the vast majority of firms host the earnings call conference, some small firms with very few investors have the exemption not to host the earnings call. The call often starts with a safe harbor statement<sup>12</sup>, a presentation, and a discussion of the firm's financial result and a Q&A session. In the call, the C-Suite also discusses the details of its coming SEC Form 10-Q (quarterly report) or 10-K (annual report).

I choose earnings call transcripts over Form 10-Q for the following three reasons. 1) It consists of the executive manager's speaking, making sure that I'm measuring the manager's attention; 2) The statement updates more promptly than the risk part in Form 10-Q, where the same statements can repeat a few times; 3) The call transcripts include a Q& A session where the institutional investors and professional analysts can ask the executive team questions. With the question session, the chance that the executive managers intentionally hide information is smaller than in Form 10-Q and 10-K.

### **2.3 Textbooks**

During the term selection phase, I use three classic textbooks of Corporate Finance to select terms about firm-specific issues. *Essentials of Corporate Finance* by Ross, Stephen A., Randolph Westerfield, Bradford D. Jordan, and Ernest N. Biktashev, *Financial Reporting and Analysis* by Gibson, Charles H, *Principles of Corporate Finance*

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<sup>12</sup>A safe harbor statement is made to inform the audience that the discussion can consist of forward-looking statements, which are not factual statements

by Brealey, Richard A., Stewart C. Myers, Franklin Allen, and Pitabas Mohanty<sup>13</sup>. I use two classic textbooks of Macroeconomics to select terms about macroeconomic conditions. *Macroeconomics Principles and Policy* by Baumol, J. W., and S. A. Blinder. *Principles of Macroeconomics* by Mankiw, N. Gregory, Ronald D. Kneebone, Kenneth James McKenzie, and Nicholas Rowe<sup>14</sup>. I present the justification of using text to reference the most informativeness terms in the *Term Identification* section.

## 2.4 Preparing The Documents

After obtaining the transcripts from the FactSet database, I conduct the following steps for pre-processing<sup>15</sup>. 1) Each transcript consists of paragraphs and sentences, which are seen as strings in NLP. I perform string tokenization by simply split each document into words and use the Natural Language Toolkit (NLTK)<sup>16</sup> to drop stop words. 2) I use word stemming to normalize the words with the same root. In this way, words with the same word root can be aggregated. Otherwise, the frequency of the words can be underestimated and thus bias the measurement. The same steps apply to textbooks too.

The NLP algorithm that I use to conduct this measurement is called *Term Frequency-Inverted Document Frequency (TF-IDF)*. It measures whether a word is frequent in a given document, relative to its frequency in the entire corpus. Here, the single document could be a textbook or an earnings call transcript. The corpus is the set of call transcripts.

## 2.5 Introducing TF-IDF

I start the demonstration of *TF-IDF* with the definition of the symbols. In this section,  $w$  represents each individual term,  $d_{f,t}$  represents each individual document for firm  $f$  at quarter  $t$ , which can also be seen as a vector of  $w$ .  $D$  represents the set of earnings call transcript documents across all firms  $f$  and all quarters  $t$  and  $B$  represents the set of textbooks  $b$ .

The definition of *TF-IDF* is as follows. *term-frequency* can be seen as the occurrence

<sup>13</sup>The edition of the textbooks are 9<sup>th</sup>, 12<sup>th</sup> and 12<sup>th</sup> separately.

<sup>14</sup>The edition of the textbooks are 14<sup>th</sup> and 6<sup>th</sup> separately.

<sup>15</sup>Pre-processing refers to the process of converting data to something a computer can understand. Here the goal is to decompose a document into useful words, which serve as a unit.

<sup>16</sup>A common library in Python for Natural Language Processing

number of each term  $w$  over the total number of words in document  $d$ . Define  $N_d$  as the number of all terms in document  $d$ , and define  $n_{w,d}$  as the frequency of term  $w$  appear in document  $d$ .

$$tf(w, d) := \frac{n_{w,d}}{N_d} \quad (1)$$

*document-frequency* can be seen as the fraction of documents  $d_{f,t}$  in the set of documents  $D$ , that contains the term  $w$ . Define  $N_D$  as the number of documents in the set  $D$ , and define  $n_{w,D}$  as the number of documents  $d_{f,t}$  that contains the term  $w$ .

$$df(w, D) := \frac{n_{w,D}}{N_D} \quad (2)$$

$$idf(w, D) := \log\left(\frac{1}{df(w, D)}\right) \quad (3)$$

Putting together, the *tf-idf*, or *term-frequency-inverse-document-frequency*, measures the weighted occurrence of a term in a document relative to its weighted occurrence in the entire corpus:

$$tf\text{-}idf(w, d_{f,t}, D) := tf(w, d_{f,t}) \cdot idf(w, D) \quad (4)$$

Equation (1) indicates that  $0 \leq tf(w, d_{f,t}) \leq 1$ . Equation (2) implies that  $0 \leq df(w, D) \leq 1$ , thus, in equation (3),  $idf(w, D) \geq 0$ . According to information theory,  $tf(w, d_{f,t})$  is the probability of a term  $w$  appears in a random word in document  $d_{f,t}$ . Analogically,  $df(w, D)$  is the probability of  $w$  appears in in a random document  $d_{f,t}$ . Aizawa (2003) demonstrates a way to interpret *tf-idf* from the information theory perspective.  $idf(w, D)$  can be seen as the amount of information gain after observing the term  $w$  and  $tf(w, d_{f,t})$  represents the probability that the term  $w$  is observed. *tf-idf* can be the expected information gain of a term  $w$ .

## 2.6 An Example to Present TF-IDF Calculation

In Table 1 below, I present the *tf-idf* and the inter-median calculation process for four represented terms. Comparing *gdp* and *monetari*, *gdp* occurs more in both the textbook and the  $D$  corpus, thus *gdp* has higher *tf* and lower *idf*. As the value of *tf-idf* is a simple product of *tf* and *idf*, *gdp* ends up with a higher *tf-idf* value than *monetari*.

The term *use* is a very common word. Thus it has a higher frequency in both textbook and the corpus comparing to *monetari*. The *tf* value of *monetari* and *use* is the same, but *use* has a lower *idf*. It means that to my sample corpus, *use* is less informative than *monetari*. Thus, *use* has a much lower *tf-idf* value than *monetari*. *handicraft*, on the other hand, rarely occur in either textbook or my sample corpus. Though *handicraft* is very informative (with a high *idf*), it's misleading when expressing macroeconomics news. Thus, *handicraft* has a low *tf-idf* despite a high *idf*. To conclude, *idf* measures the *informativeness* of a term within the corpus, while *tf* measures the *relevance* of a term to a certain context, which in this paper, it's how much a term is relevant to macroeconomic or firm-specific conditions.

Table 1: An Example for Term-level *tf-idf* Calculation

Term	Term Frequency	tf	Document Frequency	idf	<i>tf-idf</i>
gdp	1080	0.006	11952	2.813	0.017
monetari	494	0.003	3340	4.088	0.011
use	501	0.003	199065	0.00001	0.000000028
handicraft	1	0.000006	1	12.201	0.000068

Note: This table shows an example of intermediate steps while calculating *tf-idf*. The data is extracted from  $W_{macro}$  term identification process using *Macroeconomics Principles and Policy* by Baumol, J. W., and S. A. Blinder.

## 2.7 Term Identification

The goal of this section is to select a set of terms  $w_{macro}$  and a set of terms  $w_{firm}$  which can represent the informativeness of macroeconomic and idiosyncratic conditions separately in the earnings call transcripts. Using each textbook  $b_i$ , where  $i$  represents textbooks of macroeconomics or corporate finance. I first calculate the  $tf(w, b_i)$  for each term  $w$  appears in  $b$ . Then for each term  $w$  in the earnings call transcript corpus  $D$ , I calculate the  $idf(w, D)$ . Finally, by combining  $tf(w, b_i)$  and  $idf(w, D)$ , I calculate  $tf-idf(w, b_i, D)$ . Terms that don't appear in  $b_i$  and  $D$ , will be dropped automatically at this step. I then take the top 200 terms with the highest  $tf-idf(w, b_i, D)$  values from terms in each textbook  $b_i$ , and take the *intersection*<sup>17</sup> to generate the candidate bag of words  $w_{macro}$  and  $w_{firm}$ <sup>18</sup>. It's possible that  $w_{macro}$  and  $w_{firm}$  contain the same terms that may bias the measurement, thus I exclude the mutual terms of the two-word sets from each

<sup>17</sup>This step helps to eliminate bias from any single textbook.

<sup>18</sup>For macroeconomics, I take intersection across terms of two textbooks, and for firm-specific conditions, I take intersection across terms of three textbooks.

bag of words. In the next section, I use  $w_{macro}$  and  $w_{firm}$  to construct the manager's attention toward macroeconomic and idiosyncratic conditions. Table 2 below shows the final terms for each category.

Table 2: Terms Selected with TF-IDF

Category	Terms
Macro	gdp, monetari, deficit, equilibrium, inflat, unemploy, polici, aggreg, multipli, economist, economi, suppli, wage, export, govern, recess, fed, nation, demand, expansionari, labor, phillip, stagflat, fiscal, consumpt, feder, bushel, nomin, surplu, econom, consum, employ, macroeconom, currenc, crisi, tariff, foreign, deflat, crowd, polit, policymak, boom, societi
Micro	bond, firm, dividend, stock, discount, creditor, bankruptci, equiti, return, financ, loan, yield, stockhold, asset, turnov, payment, inventori, matur, valuat, nyse, borrow, debt, liabil, paid, premium, payabl, flow, vote, tax, analysi, owner, pay, deprec, payout, mutual, default, yahoo, taxabl, worth, fix, principl, short, inflow

<sup>1</sup> I use the following three textbooks of corporate finance to select firm-specific terms. *Essentials of Corporate Finance* by Ross, Stephen A., Randolph Westerfield, Bradford D. Jordan, and Ernest N. Biktimirov, *Financial Reporting and Analysis* by Gibson, Charles H, *Principles of Corporate Finance* by Brealey, Richard A., Stewart C. Myers, Franklin Allen, and Pitabas Mohanty. I use the following two textbooks of Macroeconomics to select terms about macroeconomic conditions. *Macroeconomics Principles and Policy* by Baumol, J. W., and S. A. Blinder. *Principles of macroeconomics* by Mankiw, N. Gregory, Ronald D. Kneebone, Kenneth James McKenzie, and Nicholas Rowe.

## 2.8 Construct the Measurements

The firm-level attention to macroeconomic conditions and firm-specific conditions is defined as follows:

$$\text{AttentionToMacro}(f, t) := \sum_{w \in w_{macro}} \text{tf-idf}(w, d_{f,t}, D) \quad (5)$$

$$\text{AttentionToFirm}(f, t) := \sum_{w \in w_{firm}} \text{tf-idf}(w, d_{f,t}, D) \quad (6)$$

To construct the panel database of manager's attention capacity, I simply take the sum of  $\text{AttentionToMacro}(f, t)$  (hereafter ATM) and  $\text{AttentionToFirm}(f, t)$  (here-

after ATF). The simple summation operation is derived from the additivity of channel capacity<sup>19</sup>. To adjust for the scale for a better display, I also time the obtained value with 100. For attention allocation, I define it as the manager's attention allocating to macroeconomics. I time the value with 100 to present it in the percentage format.

$$\text{AttentionCapacity}(f, t) := (\text{AttentionToMacro}(f, t) + \text{AttentionToFirm}(f, t)) \times 100 \quad (7)$$

$$\text{AttentionAllocation}(f, t) := \frac{\text{AttentionToMacro}(f, t) \times 100}{\text{AttentionCapacity}(f, t)} \times 100 \quad (8)$$

In the following sections, I will mainly use *AttentionCapacity* and *AttentionAllocation* in empirical analysis as well as in theoretical model.

## 2.9 Presenting C-Suite's Attention

In this section, I use the constructed novel attention measurements to document the factors that determine managers' attention, specifically:

1. Managerial attention capacity is positively correlated with firm size, profitability, tangibility, market to book value and leverage;
2. Managerial attention capacity is dynamic and counter-cyclical at the aggregate level;
3. Managerial attention allocation to macroeconomics is positively correlated with firm size and profitability, while negatively correlated with tangibility, market to book value and leverage;
4. Managerial attention allocation to macroeconomics has a positive drift at the aggregate level;

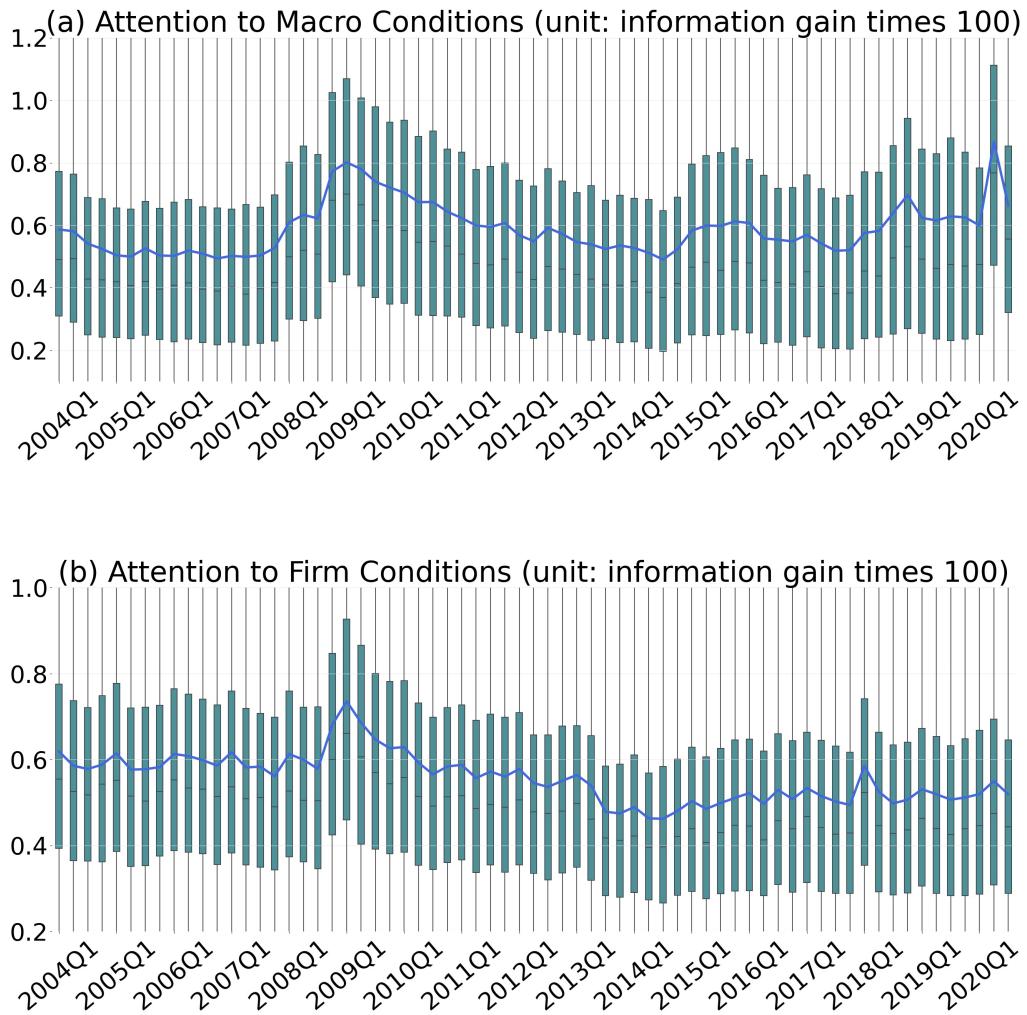
Figure 1 presents the aggregated C-Suite's attention towards macroeconomic and firm-level conditions. The manager's attention capacity is counter-cyclical and positively correlated with firm size and profitability. Intuitively, larger firms have more financial capacity to afford more information towards both macroeconomic and idiosyncratic shocks.

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<sup>19</sup>Defined in Shannon (1948), channel capacity is additive over independent channels

The counter-cyclical pattern in the managers' attention is mainly driven by their attention towards macroeconomics. The Covid-19 pandemic triggers more attention towards macroeconomics than the 2008 Financial Crisis. There is no cyclical pattern on attention towards idiosyncratic shocks. The Covid-19 pandemic brings more common shocks than idiosyncratic shocks. It could be that firms with higher exposure to macroeconomics will tend to pay more attention to macroeconomics. This finding is surprisingly consistent with Lemmon et al. (2008).

Figure 1: Aggregated Manager's Attention towards Macro and Idiosyncratic Conditions, 2004Q1 – 2020Q3



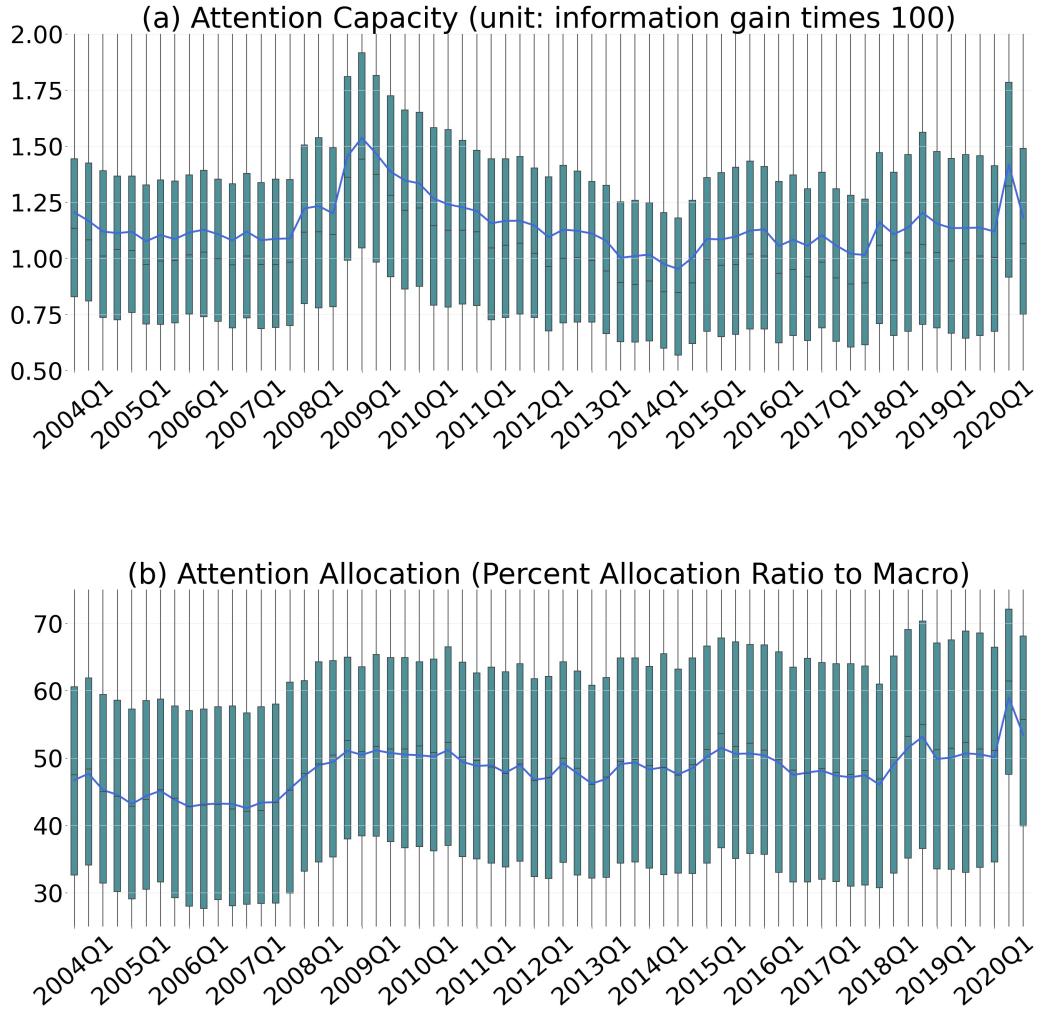
Note: This figure shows manager's attention to macroeconomic and firm-specific conditions. The Box-Whisker plots represent the distribution of firm's attention in each quarter. The line plot shows the aggregated attention.

These findings are consistent with rational inattention theory. When the shock is too big to ignore, meaning the cost of not paying attention becomes too big, the agents

will choose to pay attention. Firms expand more than 30% of their attention capacity towards macroeconomics during economic downturns.

Figure 2 shows the aggregated attention capacity and allocation, the key variables in this paper.

Figure 2: Aggregated Executive Manager's Attention Capacity and Allocation, 2004Q1 – 2020Q3



Note: This figure shows manager's attention capacity and attention allocation. The Box-Whisker plots represent the distribution of firm's attention in each quarter. The line plot shows the aggregated attention.

These findings are consistent with rational inattention theory. When the uncertainty of aggregate environment is high, agents pay more attention to optimize the information choices. Firms expand more than 30% of their attention capacity towards macroeconomics during economic downturns aggregatey.

### *Cross-sectional Heterogeneity and Managerial Attention*

A natural question comes that what factors determine the revealed attention capacity and attention allocation? Data shows that a manager's attention capacity is positively correlated with firm size, profitability, tangibility, market to book value, and leverage, while it is negatively correlated with the real GDP growth rate. Manager's attention allocation is positively correlated with firm size and profitability, while it is negatively correlated with the market to book value, tangibility, leverage, and real GDP growth rate. Table 3 presents the correlation matrix between managerial attention and other firm-level variables.

Table 3: Variable Correlation Matrix

	Leverage(market)	Leverage(book)	AttenCapacity	AttenAllocation
Firm Size	0.32	0.36	0.18	0.10
Profitability	0.06	0.07	0.18	0.10
Market to Book	0.04	0.36	-0.02	-0.03
Tangibility	0.37	0.27	0.15	-0.07
Leverage(market)			0.22	-0.09
Leverage(book)	0.79		0.15	-0.06

<sup>1</sup> This table presents correlation. All values are significant at 1% level

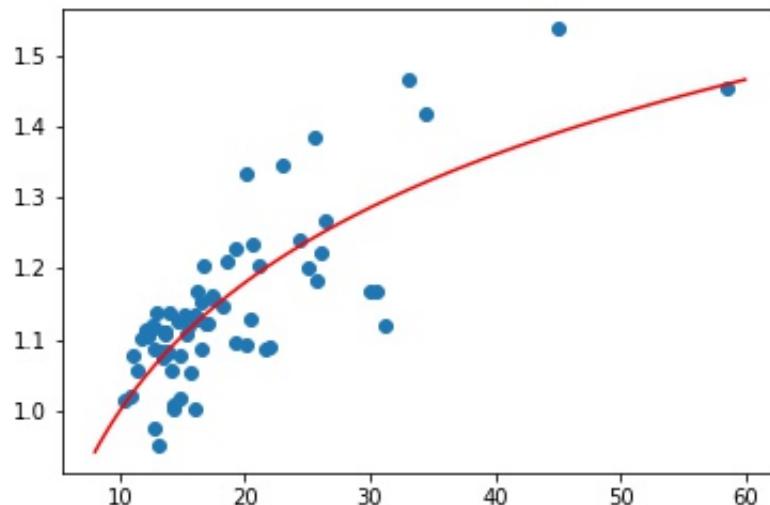
1. Managerial attention capacity (hereafter AC) and attention allocation (hereafter AA) towards macroeconomics are counter-cyclical, as macroeconomics news are more salient in recession than in expansion. See Figure A.1.
2. AC and AA are size-dependent. Big firms run business in different states and even different countries, thus they are more exposed to macroeconomic fluctuations than smaller firms. See Figure A.2.
3. For similar reasons, financially unconstrained firms have higher AC and AA because they attend the public bond market and are more exposed to common shocks than financially constrained firms<sup>20</sup>. See Figure A.3.
4. AC and AA are higher for firms with higher profitability. Because it is costly to understand macroeconomic news and policies. Thus, more profitable firms will be more likely to afford the expenses such as hiring an economist as a consultant and purchasing media services. See Figure A.4.

<sup>20</sup>In the later section, I define financially constrained firms as those who has bond ratings, while financially unconstrained firms don't have bond ratings

Whether financially constrained firms or unconstrained firms pay more attention to macroeconomics is ambiguous. There are two reasons with opposite directions. First, unconstrained firms are usually bigger firms and can afford to learn more about economic perspectives. Second, financially constrained firms are more aggressively obtaining cheap credits during expansion and choose to default during economic contractions. For this reason, financially constrained firms should also have incentives to pay attention to business cycles. Without a measurement of attention, the overall effect is unclear. Figure A.3 shows that the first effect dominates.

Attention capacity is a function of uncertainty. In section 5, I provide an explicit function of attention capacity. Here, I present a plot of aggregate attention capacity and a fitted function of equation (47),  $\kappa_t = \kappa_0 + \theta \log(\sigma_{x,t})$ . Figure 3 shows the aggregated attention capacity in response to VIX.

Figure 3: Aggregated Manager's Attention Capacity and A Fitted Line, 2004Q1 – 2020Q3



Note: This dots shows manager's attention capacity at the aggregate level. The red line shows the fitted line of equation (47),  $\kappa_t = 1.0 + 0.26 \times \log(\sigma_{x,t})$ . The vertical axis shows the aggregated attention capacity of my measurement. The horizontal axis shows the VIX.

### 3. Empirical Analysis

#### 3.1 Data and Sample Selection

The primary sample includes firms in the quarterly Compustat database. I first restrict the sample to the firms that are listed on the major US Stock Exchange – the New York Stock Exchange (NYSE), and National Association of Securities Dealers Automated Quotation (NASDAQ). I then exclude firms that are in Finance, Insurance, and Real Estate (SIC Codes 6000-6799), regulated division (SIC Codes 4000-4999) and Non-classifiable division(SIC Codes 9900-9999). Table A.1 provides more information on the SIC code and corresponding Divisions. I further drop the firms that last less than two years (eight quarters) as young firms have different financing policies. Finally, to mitigate the effect of outliers and eradicate errors in the data, I trim all variables at the upper and lower 0.5 percentiles. The earnings call transcripts are obtained from the FactSet database and written in English. When indexing the quarter of each call transcript file, I use the quarter when the call happens instead of the quarter to which the discussion applies. In this way, each transcript documents the C-Suite's belief of that time with less than one quarter forward-looking horizon. After merging the two databases, the sample consists of 127678 documents covering the period from 2004Q1 to 2020Q3 for 3481 firms.

Following Welch (2011), I define financial debt (FD) over capital (CP) as the leverage ratio, where capital equals to financial debt plus equity. Welch (2011) points out that the widely-used leverage ratio defined as financial debt over total assets is biased, as this definition ignores the role of non-financial liabilities. He argues that when using FD over total Asset (AT) as the leverage ratio, the leverage ratio becomes lower when a firm has more equity, and when it has more non-financial liabilities. In effect, non-financial liabilities are counted the same as equity. Under this definition, there are two ways to define capital: book value of capital (BCP) and market value of capital (MCP). Other variables are shown in Table 3. Table 4 shows the summary of variables.

Figure A.5 shows the industry distribution of the sample.

Table 4: Variable Construction using the Compustat Sample (Quarterly)

Variable Name	Variable Construction
Financial Debt (FD)	long-term debt (DLTTQ)+debt in current liabilities (DLCQ)
Market value of capital(MCP)	Financial Debt (FD)+market value of equity (MEQ)
Market value of equity (MEQ)	close price (PRCCQ)×common share outstanding (CSHOQ)
Book value of capital (BCP)	Financial Debt (FD) + Book value of equity (BEQ)
Book value of equity (BEQ)	Stock-holders equity (SEQQ)+non-controlling interests (MIBTQ)
Firm size	log(assets(ATQ)), where assets are deflated by the GDP deflator
Profitability	Operating income before depreciation(OIBDPQ)/Assets (ATQ)
Market-to-Book ratio	Market value of equity (MEQ)/Book value of equity (BEQ)
Tangibility	Net Property Plant and Equipment (PPENTQ)/Asset (ATQ)
AttentionToMacro	author calculation
AttentionToFirm	author calculation
AttentionCapacity	(AttentionToMacro + FirmAttention)*100
AttentionAllocation	((AttentionToMacro*100)/AttentionCapacity)*100

<sup>1</sup> The capitalized abbreviations in parenthesis follow the Compustat mnemonics when not otherwise defined. The definition of the leverage follow Welch (2011) and his website (the part of Notes on Debt Ratios). In Compustat raw data, DLC can be negative, I treat it as missing value (na). These firm characteristics are commonly used in corporate finance literature.

Table 5: Variable Definition and Transformation

Variable	Transformation	Mean	Standard Error	Median
Leverage(book)	FD <sup>1</sup> /BEQ <sup>2</sup>	0.32	0.28	0.29
Leverage(market)	FD/MEQ	0.19	0.20	0.13
Firm Size	$\log(bookassets^3)$	9.20	1.77	0.75
Profitability		0.02	0.05	0.03
Tangibility		0.23	0.23	0.15
Market to Book	MEQ/BEQ	9.09	33.76	2.53
ATM	ATM times 100	0.59	0.49	0.47
ATF	ATF times 100	0.55	0.34	0.48
AttentionCapacity		1.14	0.64	1.03
AttentionAllocation		48.42	21.15	48.94

<sup>1</sup> FD stands for Financial Debt<sup>2</sup> BEQ is the book value of equity = stockholders'equity + noncontrolling<sup>3</sup> deflated with GDP deflator

### 3.2 Variance Decomposition

To find the dominance of the firm-level leverage changes, I decompose the variation in leverage changes into its common (aggregate), industrial and idiosyncratic components using the panel variance decomposition methods<sup>21</sup>. The variance decomposition follows a two-stage panel regression strategy. At the first stage, the aggregate component is uncovered by regressing market leverage ratio (or leverage ratio growth rate) on time dummies and clustering standard errors at the firm level. At the second stage, the regression takes the residual series from the first stage and regress on the interaction of time dummies and sector dummies. From the second stage, the residual series were separated into a sector (SIC division) component and an idiosyncratic component. The result shows that the idiosyncratic component is the most volatile. The relative standard deviation of the idiosyncratic component (0.20) is 5 times bigger than that of the aggregate component (0.04) and 6.7 times bigger than that of the sector-specific component (0.03). It further suggests that the aggregate component and the sector-specific component play a similar role. Whereas, the literature agrees that industry characteristics can play an important role in explaining corporate leverage. This gives me the guidance in designing the role of macroeconomy and sector in the empirical analysis.

I applied the same variance decomposition exercise with the manager's attention towards macro conditions. The standard deviation of the idiosyncratic component (0.005) is 5.5 times that of aggregated component (0.0009), and is 10 times than sector component.

Table 6: The Managerial Attention

	size	profitability	M_to_B	tangibility	lev_m	lev_b	gdp
leverage_m	0.32	0.05	-0.01	0.38			-0.04
leverage_b	0.34	0.04	0.11	0.27			-0.01
attention_cap	0.19	0.15	-0.01	0.15	0.23	0.15	-0.06
attention_allo	0.09	0.07	-0.01	-0.08	-0.1	-0.06	-0.04

<sup>1</sup> This table presents correlation. All values are significant at 1% level.

The manager's attention capacity is counter-cyclical and size-dependent. Larger firms have more financial capacity to afford more information towards both macroeconomic and idiosyncratic shocks. The counter-cyclical pattern in the managers' attention capacity is mainly driven by their attention towards macroeconomics. The Coronavirus

<sup>21</sup>It was proposed by Carlsson and Skans (2012) and then used in Meyer et al. (2021). Lemmon et al. (2008) made a similar decomposition for firm-level leverage ratio change.

pandemic triggers more attention towards macroeconomics than the 2008 Financial Crisis. There is no cyclical pattern on attention towards idiosyncratic shocks. The Coronavirus pandemic brings more common shocks than idiosyncratic shocks. It could be that firms with higher exposure to macroeconomics will tend to pay more attention to macroeconomics.

### 3.3 C-Suite's Attention as A Factor of Leverage Dynamics

The variations and dynamics in a firm's leverage ratio haven't been well explained (Graham and Leary, 2011). This section aims at introducing managers' attention capacity and attention allocation as two important factors in a firm's leverage ratio.

$$\text{leverage}_{i,t} = \delta_i + \delta_t + \alpha_1 \times \text{AttentionCapacity}_{i,t} + \alpha_2 \times \text{AttentionAllocation}_{i,t} + \gamma \times Z_{i,t} + \varepsilon_{i,t} \quad (9)$$

where  $\text{leverage}_{i,t}$  is market leverage,  $\delta_i$  and  $\delta_t$  stand for firm fixed effect and time fixed effect.  $Z_{i,t}$  is a vector of control variables, including firm size, profitability, market to book ratio, and tangibility.

Table 7 presents the regression result using the firm-level panel data. There are two findings I would like to highlight. First, at the firm level attention capacity has a significantly positive effect on market leverage ratio. Second, attention allocation towards macroeconomics has a significantly negative effect on the manager's leverage decisions. Both results hold even after controlling for firm characteristics, time, and firm fixed effects, comparing columns (4) and (6). Besides, by including attention capacity and attention allocation, I obtain the regression with the best adjusted R-square, shown in column (6). After considering the business cycle, measured by the real GDP growth rate, my result is still robust and significant.

The results suggest that a manager's attention towards macroeconomics have both substitution and scale effect on leverage ratio. When a manager pays attention to macroeconomics, the attention capacity increases, motivating more information collection. Higher information volume will help a manager make better decisions (scale effect). On the other hand, paying attention to macroeconomics may distract a manager from focusing on issues that are important for the firm.

Table 7: Panel Regression, Leverage and Manager's Attention

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Attention Capacity	1.69*** (0.07)		2.01*** (0.07)		1.93*** (0.07)		2.79*** (0.07)	2.09*** (0.07)
Attention Allocation		-5.53*** (0.21)	-6.39*** (0.21)		-6.11*** (0.20)	-4.06*** (0.21)	-4.77*** (0.20)	
Firm Size				4.29*** (0.07)	4.34*** (0.07)	5.93*** (0.07)	6.07*** (0.07)	
Profitability				-64.1*** (1.13)	-62.5*** (1.12)	-69.5*** (1.12)	-67.9*** (1.15)	
Market to Book Value				0.01*** (0.00)	0.01*** (0.00)	0.02*** (0.00)	0.02*** (0.00)	
Tangibility				23.8*** (0.51)	23.9*** (0.51)	30.0*** (0.51)	28.7** (0.51)	
Real GDP Growth Rate					-0.10*** (0.00)	-0.001 (0.01)		
VIX						0.22*** (0.00)		
Constant	19.3*** (0.03)	17.4*** (0.09)	22.0*** (0.10)	20.1*** (0.12)	-24.7*** (0.69)	-24.4*** (0.70)	-42.2*** (0.63)	-46.5*** (0.63)
Time Fixed Effect	YES	YES	YES	YES	YES	YES	NO	NO
Firm Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Observations	124617	124617	124617	124617	120444	120444	120444	120444
Adjusted $R^2$	0.75	0.75	0.75	0.75	0.76	0.77	0.75	0.76

Note: Standard errors in parentheses. \*\*\* $p < 0.01$ . I present the coefficient of Market to Book Value as 100 times the original values. The attention allocation is in decimal format instead of percentage for coefficient presentation purpose.

The interaction of macro news versus micro news, and how it affects an agent's decision, has not yet developed in the corporate finance field. In recent investor behavior literature, Peng and Xiong (2006) propose that investors see the macro news and firm-level news as substitutes, and they process macro and sector news first, then turn to firm-specific information. Hirshleifer and Sheng (2021) first find that macro news and micro news can be complementary too.

### 3.4 C-Suite's Attention as An Amplifier of Business Cycles

It's well researched that the economic state affects the firm-level leverage ratio. But the channel through which the business cycle transmits to a firm's capital structure is still underdeveloped. I demonstrate that executive managers' attention can amplify the effect of the business cycle on a firm's financial decisions. To uncover this relationship, I add interaction terms of attention capacity times real GDP growth rate and attention allocation times real GDP growth rate into the baseline equation (9). run the following regression.

$$\begin{aligned} \text{leverage}_{i,t} = & \delta_i + \alpha_1 \times \text{AttentionCapacity}_{i,t} + \alpha_2 \times \text{AttentionAllocation}_{i,t} + \\ & \beta_1 \times \text{realGDPgrowthrate}_t + \beta_2 \times \text{realGDPgrowthrate}_t \times \\ & \text{AttentionCapacity}_{i,t} + \beta_3 \times \text{realGDPgrowthrate}_t \times \text{AttentionAllocation}_{i,t} \\ & + \gamma \times Z_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (10)$$

where  $\text{leverage}_{i,t}$  is market leverage,  $\delta_i$  stand for firm fixed effect.  $Z_{i,t}$  is a vector of control variables, including firm size, profitability, market to book ratio, and tangibility.

In Table 8, column (3) shows that the interaction term of attention capacity and real GDP growth rate is negative. It suggests that during a recession, when the real GDP growth rate is negative, the firm-level leverage increases, and more than half of the effect work through the attention capacity channel. When executive managers have rising awareness of the uncertainties, they tend to take actions to offset them. Here, the action is to increase leverage ratio to cope with economic downturns. This acts as the amplifier of business cycles. Column (4) shows that the interaction term of attention allocation and real GDP growth rate is positive. It suggests that during the recession, when the real GDP growth rate is negative, paying attention to macroeconomics can be a distraction for managers to evaluate what is a proper leverage ratio, which includes rising credit risk.

Managers may downplay the effect of firm-specific conditions and choose to lower the leverage ratio.

Table 8: Panel Regression, Manager's Attention as An Amplifier of the Business Cycle on Leverage

	(1)	(2)	(3)	(4)	(5)
Attention Capacity	1.93*** (0.07)	2.79*** (0.07)	2.84*** (0.07)	2.80*** (0.07)	2.87*** (0.07)
Attention Allocation	-6.11*** (0.20)	-4.06*** (0.21)	-4.04*** (0.21)	-4.39*** (0.21)	-4.50*** (0.21)
Firm Size	4.34*** (0.07)	5.93*** (0.07)	5.92*** (0.07)	5.93*** (0.07)	5.93*** (0.07)
Profitability	-62.5*** (1.12)	-69.5*** (1.15)	-69.5*** (1.15)	-69.4*** (1.15)	-69.3*** (1.15)
Market to Book Value	0.013*** (0.00)	0.018*** (0.00)	0.018*** (0.00)	0.018*** (0.00)	0.018*** (0.00)
Tangibility	23.9*** (0.51)	30.0*** (0.51)	30.0*** (0.51)	30.0*** (0.51)	30.0*** (0.51)
Real GDP Growth Rate		-0.098*** (0.00)	-0.037*** (0.01)	-0.19*** (0.02)	-0.15*** (0.02)
AttentionCapacity × Real GDP Growth Rate			-0.047*** (0.01)	-0.064*** (0.01)	
Constant	-24.4*** (0.70)	-42.2*** YES	-42.2*** NO	-42.1*** (0.63)	-42.1*** (0.63)
Time Fixed Effect				NO	NO
Firm Fixed Effect				YES	YES
Observations	120444	120444	120444	120444	120444
Adjusted $R^2$	0.77	0.75	0.75	0.75	0.75

Note: Standard errors in parentheses. \*\*\* $p < 0.01$ . I present the coefficient of Market to Book Value as 100 times the original values. The attention allocation is in decimal format instead of percentage for coefficient presentation purpose.

#### **4. Robustness Checks**

To investigate the heterogeneity in the firm-level leverages and whether executive managers' attention plays a major role for all of them, I apply a series of robustness checks in this section. The first comes with the liquidity supply faced by individual firms. The second part includes the studies of cyclical industries and non-cyclical industries.

##### **4.1 Role of Financial Constraint**

To categorize firms into financially constrained and financially non-constrained groups, I look at if a firm has access to the public debt market. Specifically, I use the bond rating from S&P 500<sup>22</sup>. I then merge the data with the accounting data from Compustat using the firm's stock ticker, resulting in 114923 observations. I first add a term *liquidity* into equation (9) and then run the same regression with the financially constrained group as well as the financially unconstrained group separately. The term *liquidity* is a dummy variable. *liquidity* equals 1 when a firm has access to the public debt market. Otherwise, it equals 0. Table 9 presents the results and they are robust across the whole sample and groups with different liquidity.

Column (2) shows that with better liquidity, a firm chooses to have a higher leverage ratio. To further compare the financially constrained group and financially unconstrained group, I separate the sample firms into two groups and present the exercise results in columns (3) and (4) separately. While it yields a robust result, the coefficients also show that financially unconstrained firms are affected by attention allocation more. Financially constrained firms are affected by attention capacity more.

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<sup>22</sup>The data is fetched from the WRDS Bond Returns database. I choose the rating from S&P 500 instead of Moody's and Fitch, because of data availability.

Table 9: Manager's Attention to Firm-level Leverage, considering liquidity

	(1)	(2)	(3)	(4)
Attention Capacity	1.94*** (0.07)	1.95*** (0.07)	1.47*** (0.15)	1.92*** (0.08)
Attention Allocation	-5.69*** (0.21)	-5.69*** (0.21)	-6.72*** (0.48)	-5.00*** (0.22)
Firm Size	4.34*** (0.07)	4.14*** (0.07)	3.68*** (0.22)	3.93*** (0.08)
Profitability	-59.2*** (1.13)	-58.5*** (1.13)	-127.5*** (3.53)	-49.5*** (1.17)
Market to Book Value	0.015*** (0.00)	0.014*** (0.00)	0.015*** (0.00)	0.013*** (0.00)
Tangibility	23.4*** (0.52)	23.2*** (0.51)	22.7*** (1.28)	23.0*** (0.56)
Liquidity		4.33*** (0.15)		
Constant	-24.7*** (0.70)	-23.7*** (0.70)	-12.9*** (2.51)	-21.8*** (0.72)
Time Fixed Effect	YES	YES	YES	YES
Firm Fixed Effect	YES	YES	YES	YES
Financially Constrained			NO	YES
Observations	114923	114923	20585	94152
Adjusted $R^2$	0.76	0.77	0.80	0.76

Note: Standard errors in parentheses. \*\*\* $p < 0.01$ . I present the coefficient of Market to Book Value as 100 times the original values. The attention allocation is in decimal format instead of percentage for coefficient presentation purpose.

## 4.2 Cyclical vs Non-cyclical Industry

Empirical results in Section 3 document that both managerial attention capacity and attention allocation follow a counter-cyclical pattern. To investigate the heterogeneity of cyclical sensitivity, I introduce a binary variable “cyclical” in the empirical study. For the eleven sectors recognized in Table A.1, I assign Construction, Manufacturing, Wholesale Trade, and Retail Trade as cyclical sensitive sectors<sup>23</sup>. Other sectors are not cyclical sensitive sectors. When a firm is more cyclical sensitive, the managers pay more attention to macroeconomics.

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<sup>23</sup>This categorization is based on Berman and Pfleeger (1997).

Table 10: Manager's Attention to Firm-level Leverage, Considering Cyclical Sensitivity

	(1)	(2)	(3)
Attention	2.79***	3.06***	2.27***
Capacity	(0.07)	(0.09)	(0.12)
Attention	-4.06***	-4.73***	-2.96***
Allocation	(0.21)	(0.26)	(0.35)
Firm	5.93***	6.52***	5.06***
Size	(0.07)	(0.09)	(0.10)
Profitability	-69.5***	-65.9***	-80.2***
	(1.15)	(1.36)	(2.16)
Market to	0.02***	0.02***	0.01***
Book Value	(0.00)	(0.00)	(0.00)
Tangibility	30.0***	32.9***	26.2***
	(0.51)	(0.67)	(0.81)
Real GDP	-0.10***	-0.10***	-0.10***
Growth Rate	(0.00)	(0.01)	(0.01)
Constant	-42.2***	-48.4***	-32.5***
	(0.63)	(0.82)	(1.01)
Time Fixed Effect	NO	NO	NO
Firm Fixed Effect	YES	YES	YES
Cyclical Sensitive	-	YES	NO
Observations	120444	77481	42963
Adjusted $R^2$	0.75	0.72	0.79

Note: Standard errors in parentheses. \*\*\* $p < 0.01$ . I present the coefficient of Market to Book Value as 100 times the original values. The attention allocation is in decimal format instead of percentage for coefficient presentation purpose.

In Table 10, column (2) and (3) present the empirical exercise in equation (9) for the whole sample, the cyclical sensitive industries and cyclical insensitive industries. Both scale effect and substitute effects are robust. Comparing results of cyclical sensitive industries (column (2)) and cyclical insensitive industries (column (3)), managerial attention has greater effects on the leverage ratio for cyclical sensitive industries.

## 5. Theoretical Model

The empirical results from section 3 and section 4 indicate that managerial information rigidity has non-trivial quantitative implications in financing decisions. To address the impact of information rigidity on a manager's financial decision, I introduce rational inattention (henceforth RI) into a contingent claims model with optimal static capital

structure. Following the established “noisy information model” proposed by Sims (2003, 2006, 2010), I assume that for a representative firm, the manager’s attention capacity and attention allocation are endogenous. RI has been well developed in macroeconomics and financial investment. Embedding RI in corporate finance is quiet a challenge mainly due to, in my opinion, the different statistics assumption as well as the modeling complication in capital structure models.

To merge the frameworks of RI and corporate finance, I first keep the assumption in baseline corporate finance model that the cash flow follows a Geometric Brownian Motion (GBM). This is the fundamental difference from the popular AR(1) assumption of shocks in RI. To keep the linear function of state variable, I assume that the cash flow consists of two independent components: macro and firm-specific components. To make this integration attempt straightforward, I apply an optimal static capital structure model under the contingent claims paradigm. The advantage of using this model provide two advantages. First, one can simply apply comparative statics to yield the differences between firm’s decisions with perfect attention and with rational inattention. Second, I can exam the difference between liquidity default (financial constrained firms) and optimal default (financial unconstrained firms) two scenarios. Section 5.1 mainly constructs the framework of optimal static capital structure with standard. For readers that are familiar with these model can jump to section 5.2. I introduce a new information decision process for managers. A manager’s financing decision is setup into two steps. At the beginning of the period, the manager makes optimal information decision according to the information she gained from last period. In this step, the manager chooses attention capacity and allocate attention. At the end of the period, the manager makes optimal financing decisions using the attention capacity and attention allocation decisions made from step 1.

## 5.1 Optimal Static Capital Structure

In this section, I introduce the standard optimal static capital structure framework with contingent claim paradigm. This setup serves the second step of a manager’s decision. As in the classic real options investment model, a representative firm generate cash flow  $X$  at time  $t$  from the assets owned by the firm. I suppose the cash flow  $X$  consists of macro and firm-specific components with a linear function:

$$X_t = \log m_t + \log f_t \quad (11)$$

where  $m_t$  represents the aggregate component of cash flows and  $f_t$  represents the firm-specific component of cash flows. Both components are stochastic GBMs and satisfy the

following stochastic differential equations (SDEs):

$$dm_t = \mu_m m_t dt + \sigma_m m_t dW_t^m. \quad (12)$$

$$df_t = \mu_f f_t dt + \sigma_f f_t dW_t^f. \quad (13)$$

where  $\mu_m$  and  $\mu_f$  are constant percentage drifts.  $\sigma_m$  and  $\sigma_f$  are constant percentage volatility. The drift terms are to model deterministic trends, while the volatility terms are to model a set of unpredictable events occurring during the motion.  $W_t^m$  and  $W_t^f$  are independent Brownian motions.

Given the arbitrary initial value  $m_0$  and  $f_0$ , the above SDEs have analytic solutions (under the Ito's interpretation):

$$m_t = m_0 \exp\left(\left(\mu_m - \frac{\sigma_m^2}{2}\right)t + \sigma_m W_t^m\right) \quad (14)$$

$$f_t = f_0 \exp\left(\left(\mu_f - \frac{\sigma_f^2}{2}\right)t + \sigma_f W_t^f\right) \quad (15)$$

where  $m_0$  and  $f_0$  are the initial values of  $m_t$  and  $f_t$ . By writing it with a natural Lagrangian format,  $m_t$  and  $f_t$  can transform to:

$$\log m_t = \log m_0 + \left(\mu_m - \frac{\sigma_m^2}{2}\right)t + \sigma_m W_t^m \quad (16)$$

$$\log f_t = \log f_0 + \left(\mu_f - \frac{\sigma_f^2}{2}\right)t + \sigma_f W_t^f \quad (17)$$

where  $\log m_t \sim N(\log m_0 + (\mu_m - \frac{\sigma_m^2}{2}t), \sigma_m^2 t)$ , and  $\log f_t \sim N(\log f_0 + (\mu_f - \frac{\sigma_f^2}{2}t), \sigma_f^2 t)$ . Combining the macro and the firm-specific components, I write the cash flow of the firm as:

$$X_t = \log m_t + \log f_t = \log(X_0) + \left(\mu_x - \frac{\sigma_x^2}{2}\right)t + \sigma_x W_t^{x24} \quad (18)$$

The distribution of  $X_t$  can be derived accordingly:  $N(\log(X_0) + (\mu_x - \frac{\sigma_x^2}{2}t), \sigma_x^2 t)$ . I assume a firm's investment and financing decision are independent, so that cash flows is not affected by investment nor operating costs. The cash flow  $X_t$  then is equivalent to earnings before interest and taxes (EBIT). Assuming perpetuity cash flows, I calculate

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<sup>24</sup> $X_0 = m_0 f_0$ ,  $\sigma_x = \sqrt{\sigma_m^2 + \sigma_f^2}$ ,  $\mu_x = \mu_m + \mu_f$ . See the calculation in Appendix B.

the equity value of an unlevered firm at any time  $t$  as discounted cash flows after tax:

$$S_t = \frac{(1 - \tau)X_t}{r - \mu_x} \quad (19)$$

where  $\tau$  is the tax rate charged at as a fraction of a firm's EBIT. No income tax is considered.

Consistent with the trade-off theory, issuing corporate debt provides "tax shield" to the company. The interest payments are considered as expenses, which are excluded from the taxation. I assume a simple perpetual debt with a constant coupon flow  $c$ . The total gain from the tax benefits to debt thus is  $\frac{\tau c}{r - \mu_x}$ . The cost of issuing corporate debt is the default. I assume two different types of default plan: optimal default and liquidity default. These two different default options represent two categories of firms that I would like to focus on in this paper: the firms without financial constraints and firms with financial constraints. This setup provides a natural comparison of the effect of limited attention and liquidity constraint and hence address the question of the degree of impact from attention side.

Since  $X_t$  is the only state variable, the two default options indicate different default thresholds, denoted as  $X_D$ . In the case of liquidity default, the company choose the default threshold  $X_D = c$ . In the case of optimal default, the company choose a threshold  $X_D < c$ . In both senerios, the companies choose to default when the cash flow reaches the threshold the first time from above. The default threshold is determined by the managers to maximize the equity value. The effective assumption here is that the equity holders have "deep pockets", meaning they can find other sources to provide liquidity to cover the coupon payments. In this case  $X_D < c$ . In the case of liquidity default, the default occurs when  $X_t$  becomes sufficiently low. I interpret this default time as the default threshold  $X_D$  equals the coupon payment  $c$ .

Considering an Arrow-Debreu claim at any time prior to the time of default, the value of the default as an option is:

$$A(X_t, X_D) = \left(\frac{X_t}{X_D}\right)^{\xi_1} \quad (20)$$

where  $\xi_1$  is the negative root of the fundamental quadratic equation:

$$\xi_1 = -\frac{1}{\sigma_x^2} \left( \mu_x - \frac{\sigma_x^2}{2} + \sqrt{\left( \mu_x - \frac{\sigma_x^2}{2} \right)^2 + 2\sigma_x^2 r} \right) \quad (21)$$

For any date prior to default, the value of levered equity can be written as:

$$S(X_t) = \left( \frac{X_t}{r - \mu_x} - \frac{c}{r} \right)(1 - \tau) + A(X_t, X_D) \left( -\frac{X_D}{r - \mu_x} + \frac{c}{r} \right)(1 - \tau) \quad (22)$$

where in the equation, the first term  $(\frac{X_t}{r - \mu_x} - \frac{c}{r})(1 - \tau)$  represents the after-tax levered equity value in perpetuity when default doesn't happen. The second term  $A(X_t, X_D) \left( -\frac{X_D}{r - \mu_x} + \frac{c}{r} \right)(1 - \tau)$  considers the scenario of default, when shareholders give up future cash flows in exchange for discontinuing interest payments. To find the optimal level of  $X_D$ , we apply the smooth-pasting condition:

$$\frac{\partial S(X_t)}{\partial X_t} \Big|_{X_t=X_D} = 0 \quad (23)$$

By solving the condition equation, the optimal default boundary is:

$$X_D = \frac{\xi_1}{\xi_1 - 1} \frac{r - \mu_x}{r} c \quad (24)$$

Denote  $\gamma_D = \frac{\xi_1}{\xi_1 - 1} \frac{r - \mu_x}{r}$ , thus  $X_D = \gamma_D c$ . One can easily prove that  $\xi_1 < 0$  and  $\gamma_D < 1$ . This indicates that with the default option, the manager chooses to keep the firm running with the cash flow less than the coupon payment  $c$ . The manager needs to find other financial sources to avoid default. Thus, one can interpret  $\gamma_D = 1$  as the liquidation default case.

Given coupon  $c$  and default threshold  $X_D$ , the value of debt which applies liquidation in the case of default, is:

$$D(X_t) = \frac{c}{r} - A(X_t, X_D) \frac{c}{r} + A(X_t, X_D)(1 - \alpha)(1 - \tau) \frac{X_D}{r - \mu} \quad (25)$$

To interpret this equation, I suppose the first term  $\frac{c}{r} - A(X_t, X_D) \frac{c}{r}$  as the perpetuity value of risk-free debt. The second term  $A(X_t, X_D)(1 - \alpha)(1 - \tau) \frac{X_D}{r - \mu}$  is the percent value of interest payments which the debt-holders lose when the firm chooses to default. The last term represents the present value of assets that debt-holders recover in liquidation.

Under the framework of static capital structure environment, the decision to issue debt is made only once, which is at date 0. Shareholders consider maximizing the total value of future equity and debt. Because this is a decision about commit ex ante to maximizing the firm value, shareholders will internalize the value of future debt-holders' claims. Thus, I define the firm value at date 0 as the sum of equity value at date 0 and the debt value at date 0:  $V(X_0) = S(X_0) + D(X_0)$ . Considering equation (22) and (25),

I can rewrite the firm value at date 0 as:

$$\begin{aligned} V(X_0) = & \left( \frac{X_0}{r - \mu_x} - \frac{c}{r} \right) (1 - \tau) + A(X_0, X_D) \left( -\frac{X_D}{r - \mu_x} + \frac{c}{r} \right) (1 - \tau) + \\ & \frac{c}{r} - A(X_0, X_D) \frac{c}{r} + A(X_0, X_D) (1 - \alpha) (1 - \tau) \frac{X_D}{r - \mu} \end{aligned} \quad (26)$$

To decide a financial structure aiming at maximizing the firm value, the shareholders need to choose an optimal coupon  $c$ :

$$\frac{\partial V(X_0)}{\partial c} = 0 \quad (27)$$

Solving this equation, the optimal coupon payment is:

$$c^* = \frac{1}{\gamma} \left[ \frac{1}{1 - \xi_1} \frac{\tau}{(1 - \tau)\alpha\gamma \frac{r}{r - \mu_x} + \tau} \right]^{\frac{1}{\xi_1}} X_0 \quad (28)$$

Both empirical and theoretical research tend to use financial leverage rate upon cross-firm comparison. Because coupon rate is related to the firm size and not interpreted as a main proxy for financial policy.

I apply quasi-market leverage ratio:

$$QML(X_t) = \frac{D(X_0)}{D(X_0) + S(X_t)} \quad (29)$$

## 5.2 Introducing Managerial Information Rigidity

Now I turn to managerial information decisions. At the beginning of each period  $t$ , managers make the optimal information decision by deciding the attention capacity and attention allocation. Recall equation (16) and (17) are the real processes of cash flow's macroeconomic and firm-specific components. Following information rigidity pioneered by Sims (2003), I assume managers observe the macroeconomic and firm-specific components with a noise. Suppose  $s_{m,t}$  ( $s_{f,t}$ ) is the observed macroeconomic (firm-specific) component at time  $t$  about  $t+1$  dynamics:

$$s_{m,t} = \log m_{t+1} + \epsilon_{m,t} \quad (30)$$

$$s_{f,t} = \log f_{t+1} + \epsilon_{f,t} \quad (31)$$

where  $\epsilon_{m,t} \sim N(0, \eta_{m,t}^2)$ , and  $\epsilon_{f,t} \sim N(0, \eta_{f,t}^2)$  are *iid* idiosyncratic shock and are independent from the fundamental shocks  $(m_{t+1}, f_{t+1})$  hitting the economy. When a manager allocate more attention to a factor, the signal of that factor becomes more precise.  $\epsilon_{m,t}$  and  $\epsilon_{f,t}$  are endogenous noise determined by managerial finite attention capacity and attention allocation.

Both macro component process  $\log m_{t+1}$  and the noise follow Gaussian distribution, the joint distribution  $s_{m,t}$  also follows Gaussian distribution  $N(\log m_0 + (\mu_m - \frac{\sigma_m^2}{2})t, \sigma_m^2(t+1) + \eta_{m,t}^2)$ . Similarly, the noisy signal for the firm component  $s_{f,t}$  follows Gaussian distribution  $N(\log f_0 + (\mu_f - \frac{\sigma_f^2}{2})t, \sigma_f^2(t+1) + \eta_{f,t}^2)$ . Given the noisy signal  $s_{x,t}$ , a manager can update his belief about the cash flow according to the Bayes rule. The manager forms a posterior belief with the conditional distribution of the macro component  $m_{t+1}|s_{m,t} \sim N(\hat{m}_t, \hat{\omega}_{m,t}^2)$ , and the firm-specific component  $f_{t+1}|s_{f,t} \sim N(\hat{f}_t, \hat{\omega}_{f,t}^2)$ , where  $\hat{m}_t$  and  $\hat{f}_t$  are the conditional mean, and  $\hat{\omega}_{m,t}^2$  and  $\hat{\omega}_{f,t}^2$  are the conditional variance. According to the Bayes rule:

$$\frac{1}{\hat{\omega}_{m,t}^2} = \frac{1}{\sigma_m^2(t+1)} + \frac{1}{\eta_{m,t}^2} \quad (32)$$

$$\frac{1}{\hat{\omega}_{f,t}^2} = \frac{1}{\sigma_f^2(t+1)} + \frac{1}{\eta_{f,t}^2} \quad (33)$$

Recall the entropy of unconditional  $m_{t+1}$  is:

$$\mathcal{H}(m_{t+1}) = \frac{1}{2} \log_2(2\pi e \sigma_m^2(t+1)) \quad (34)$$

The entropy of conditional  $m_{t+1}|s_{m,t}$  is:

$$\mathcal{H}(m_{t+1}|s_{m,t}) = \frac{1}{2} \log_2(2\pi e \hat{\omega}_{m,t}^2) \quad (35)$$

Thus, the amount of information contained in  $s_{m,t}$  about  $m_{t+1}$  can be expressed by the reduction in the entropy of  $m_{t+1}$  after acknowledge about  $s_{m,t}$ :

$$I(m_{t+1}; s_{m,t}) \equiv \mathcal{H}(m_{t+1}) - \mathcal{H}(m_{t+1}|s_{m,t}) = \frac{1}{2} \log(\sigma_m^2(t+1)/\hat{\omega}_{m,t}^2) = \lambda_{m,t} \kappa_t \quad (36)$$

similarly, the amount of information contained in  $s_{f,t}$  about  $f_{t+1}$  can be expressed by the reduction in the entropy of  $f_{t+1}$  after acknowledge about  $s_{f,t}$ :

$$I(f_{t+1}; s_{f,t}) \equiv \mathcal{H}(f_{t+1}) - \mathcal{H}(f_{t+1}|s_{f,t}) = \frac{1}{2} \log(\sigma_f^2(t+1)/\hat{\omega}_{f,t}^2) = \lambda_{f,t} \kappa_t \quad (37)$$

where  $\kappa_t$  is the manager's information channel capacity (also called as attention capacity in section 3 and 4).  $\kappa_t$  also imposes an upper bound on the manager's information flow, which is defined as the uncertainty reduction as the mutual entropy of historical information and new information. From equation (31) and (35), the perceived variances of macro component and firm-specific component noises are:

$$\eta_{m,t}^2 = \frac{\sigma_m^2(t+1)}{e^{\lambda_{m,t}\kappa_t} - 1} \quad (38)$$

$$\eta_{f,t}^2 = \frac{\sigma_f^2(t+1)}{e^{\lambda_{f,t}\kappa_t} - 1} \quad (39)$$

Inspired by the empirical results, I assume the information capacity  $\kappa_t$  is variant instead of constant. As I assume the managerial information decision of macro and firm-specific components are independent,

$$I(X_{t+1}; s_{x,t}) = I(m_{t+1}; s_{m,t}) + I(m_{t+1}; s_{f,t}) \leq \kappa_t \quad (40)$$

$$\lambda_{m,t}\kappa_t + \lambda_{f,t}\kappa_t \leq \kappa_t \quad (41)$$

$$\lambda_{m,t} + \lambda_{f,t} \leq 1 \quad (42)$$

After acquiring the noise signal, the manager updates his belief of the macro component  $logm_{t+1}$  based on the Bayes rule with mean and variance of belief as:

$$\hat{m}_t = \bar{m}_t + (1 - e^{-\lambda_{m,t}\kappa_t})(s_{m,t} - \bar{m}_t)^{25} \quad (43)$$

$$\hat{\omega}_{m,t}^2 = \sigma_m^2(t+1)e^{-\lambda_{m,t}\kappa_t} \quad (44)$$

where  $(1 - e^{-\lambda_{m,t}\kappa_t})$  is the responsiveness of  $\hat{m}_t$  to the signal, increases with both attention allocation rate  $\lambda_{m,t}$  and attention capacity  $\kappa_t$ . Similar distribution can be found with the firm-specific component:

$$\hat{f}_t = \bar{f}_t + (1 - e^{-\lambda_{f,t}\kappa_t})(s_{f,t} - \bar{f}_t)^{26} \quad (45)$$

$$\hat{\omega}_{f,t}^2 = \sigma_f^2(t+1)e^{-\lambda_{f,t}\kappa_t} \quad (46)$$

### 5.3 Manager's Information Decision

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<sup>25</sup> $\bar{m}_t = logm_0 + (\mu_m - \frac{\sigma_m^2}{2})t$

<sup>26</sup> $\bar{f}_t = logf_0 + (\mu_f - \frac{\sigma_f^2}{2})t$

To make an efficient inter-temporal financing decision, the manager decide the attention capacity first, then attention allocation to factors that can affect the decision. I assume the attention capacity as a function of the cash flow standard deviation:

$$\kappa_t = \kappa_0 + \theta \log(\sigma_{x,t}) \quad (47)$$

where  $\kappa_0 > 0$  and  $0 < \theta < 1$  adjusts the relative scale.  $\kappa_0 > 0$  because intuitively, a manager should always be attentive to cash flow dynamics.  $0 < \theta < 1$  because the attention capacity should also increases as cash flow variance increases, while the slope decreases.

The objective of a manager's information decision is to minimize the variance of his belief about each period's cash flow.

$$V_t = \min_{\lambda_{m,t}, \lambda_{f,t}} \text{Var}_t(X_{t+1} | s_{m,t}, s_{f,t}) = \min_{\lambda_{m,t}, \lambda_{f,t}} \sigma_m^2(t+1)e^{-\lambda_{m,t}\kappa_t} + \sigma_f^2(t+1)e^{-\lambda_{f,t}\kappa_t} \quad (48)$$

Manager's information decision can be further transformed problem into

$$V_t = \min_{\lambda_{m,t}, \lambda_{f,t}} \sigma_m^2(t+1)e^{-\lambda_{m,t}\kappa_t} + \sigma_f^2(t+1)e^{-\lambda_{f,t}\kappa_t} \quad (49)$$

with three constraints:

$$\lambda_{m,t} + \lambda_{f,t} \leq 1 \quad (50)$$

$$0 \leq \lambda_{m,t} \leq 1 \quad (51)$$

$$0 \leq \lambda_{f,t} \leq 1 \quad (52)$$

Solving equation (49) and (50) with Lagrange multiplier gives:

$$\lambda_{m,t} - \lambda_{f,t} = \frac{2}{\kappa_t} \log\left(\frac{\sigma_{m,t}}{\sigma_{f,t}}\right) \quad (53)$$

$$\lambda_{m,t} = \frac{1}{2} + \frac{1}{\kappa_t} \log\left(\frac{\sigma_{m,t}}{\sigma_{f,t}}\right) \quad (54)$$

$$\lambda_{f,t} = \frac{1}{2} - \frac{1}{\kappa_t} \log\left(\frac{\sigma_{m,t}}{\sigma_{f,t}}\right) \quad (55)$$

This result indicates that a manager's attention allocation depends on the relative size of standard deviation between macro component and firm-specific component. A manager's attention allocation towards one component is positively correlated with the component's own variance. When the variance of macro component increases, the manager increases attention allocation to macroeconomics.

Meanwhile, equations (51)-(52) and (54)-(55) provide the binding of attention capacity via providing the constraints on the volatility. When  $\sigma_m$  and  $\sigma_f$  are constrained by maximum values  $\sigma_m^{max}$  or  $\sigma_f^{max}$ , the attention capacity  $\kappa_t$  has a maximum.

Manager's financing decision in the rise of macro volatility is a major concern in this paper. When macroeconomic volatility  $\sigma_m^2$  increases while keeping the volatility of firm-specific component  $\sigma_f^2$  constant, a manager's attention capacity  $\kappa_t$  first increases. The manager's attention to macroeconomic and firm-specific components can be described as:

$$AttentionToMacro_t(ATM_t) = \lambda_{m,t} \times \kappa_t = \frac{1}{2}\kappa_t + \log \frac{\sigma_m}{\sigma_f} \quad (56)$$

$$AttentionToFirm_t(ATF_t) = \lambda_{f,t} \times \kappa_t = \frac{1}{2}\kappa_t - \log \frac{\sigma_m}{\sigma_f} \quad (57)$$

where  $\frac{1}{2}\kappa_t$  represents the scale effect and  $\log \frac{\sigma_m}{\sigma_f}$  represents the substitute effect<sup>27</sup>. As a result, a manager's attention to macroeconomics certainly increases, while the attention to firm-specific component remains uncertain. Both the first term  $\frac{1}{2}\kappa_t$  and the second term  $\log \frac{\sigma_m}{\sigma_f}$  increase, and which term increase more requires further analysis. Taking the first derivative of  $ATF_t$  in response to  $\sigma_m$  yields:

$$\frac{\partial ATF_t}{\partial \sigma_m} = \frac{(\frac{\theta}{2} - 1)\sigma_m^2 - \sigma_f^2}{\sigma_m(\sigma_m^2 + \sigma_f^2)} \quad (58)$$

As  $0 < \theta < 1$ ,  $\frac{\partial ATF_t}{\partial \sigma_m} < 0$ , suggesting that the substitution effect is always larger than the scale effect.

#### 5.4 Manager's Financing Decision under Information Friction: Comparative Statics

A manager's posterior belief with the conditional distribution of the cash flow  $X_{t+1}|s_{m,t}, s_{f,t} \sim N(\hat{X}_t, \hat{\omega}_{x,t}^2)$ . Since macro component and firm-specific components are independent<sup>28</sup>,

$$\begin{aligned} \hat{X}_t &= \hat{m}_t + \hat{f}_t \\ &= \bar{m}_t + \bar{f}_t + (1 - e^{-\lambda_{m,t}\kappa_t})(s_{m,t} - \bar{m}_t) + (1 - e^{-\lambda_{f,t}\kappa_t})(s_{f,t} - \bar{f}_t) \\ &= \bar{X}_t + (1 - e^{-\lambda_{m,t}\kappa_t})(s_{m,t} - \bar{m}_t) + (1 - e^{-\lambda_{f,t}\kappa_t})(s_{f,t} - \bar{f}_t) \end{aligned} \quad (59)$$

<sup>27</sup>See Appendix B for math details.

<sup>28</sup> $\bar{X}_t = \log X_0 + (\mu_x - \frac{\sigma_x^2}{2})t$

$$\hat{\omega}_{x,t}^2 = \sigma_m^2(t+1)e^{-\lambda_{m,t}\kappa t} + \sigma_f^2(t+1)e^{-\lambda_{f,t}\kappa t} \quad (60)$$

Recall that in section 5.1, equation (28) indicates the coupon payment under perfect information, where the unconditional distribution of  $X_{t+1}$ :  $N(\log(X_0) + (\mu_x - \frac{\sigma_x^2}{2})(t+1), \sigma_x^2(t+1))^{29}$ . Equation (21) indicates that  $\xi_1$  is a function of cash flow's mean and variance. The conditional distribution of the cash flow indicates a lower variance than the unconditional case. But the relative size of conditional mean versus unconditional mean is uncertain.

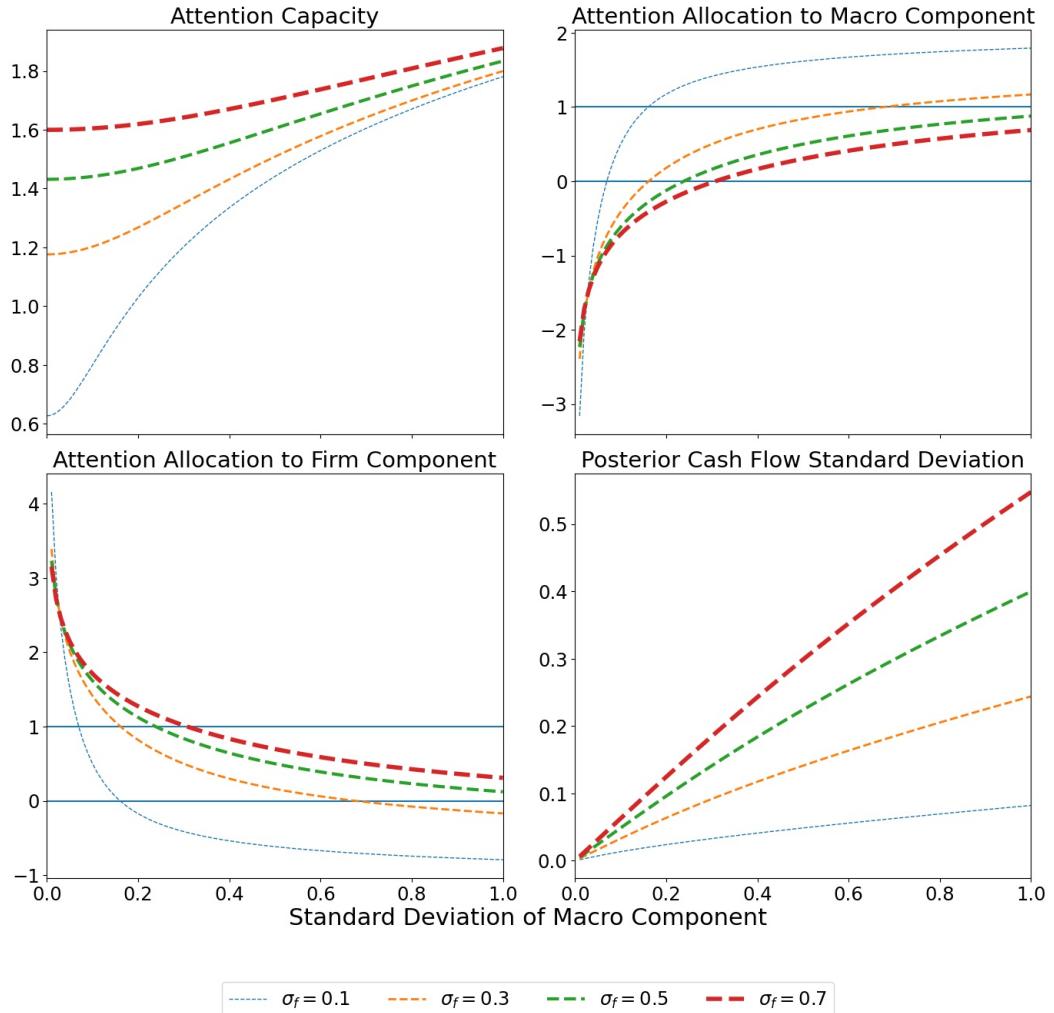
When considering the information friction, the dynamics of optimal coupon payment becomes too complicated. It is not easy and straight forward to provide an analytical analysis. I use a comparative statics to demonstrate the dynamics. Figure 3 illustrates the comparative statics of managerial attention capacity and attention allocation. Equation (47), (52) and (53) indicates that the volatility of both macro and firm-specific components can determine a manager's attention capacity and allocation, I exam both components in Figure 4. The  $x$  axis represents for the volatility of macro component, and the four line plots in each graph shows different level of volatility of firm-specific component.

Figure 5 presents the comparative statics of the optimal static capital structure model under no attention (classic attention) and limited attention. The dotted blue line and grey line present the leverage dynamics under optimal static capital structure model without information decision. The red and orange lines show the leverage dynamics with information decision process. First, with attention consideration, the optimal leverage ratio is higher than the case without attention consideration for all volatility level of macroeconomic component.

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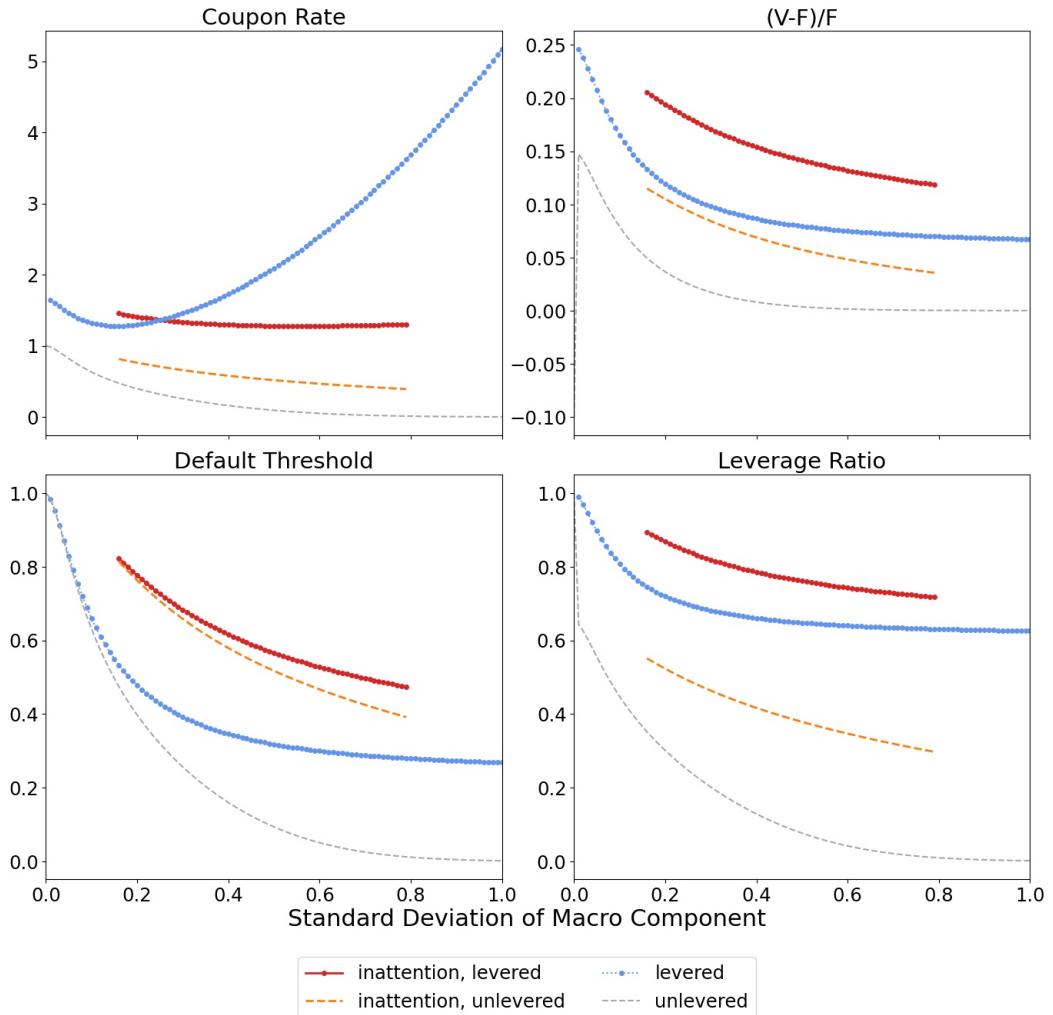
<sup>29</sup>  $X_0 = m_0 f_0$ ,  $\sigma_x = \sqrt{\sigma_m^2 + \sigma_f^2}$ ,  $\mu_x = \mu_m + \mu_f$

Figure 4: Optimal static capital structure model. Comparative statics with respect to Macro volatility



Note: This figure shows manager's attention capacity  $\kappa$ , attention allocation rate to macroeconomic and firm-specific conditions. The benchmark set of parameters is:  $k_0 = 0.8$  and  $\theta = 0.5$ .

Figure 5: Optimal static capital structure model. Comparative statics with respect to Macro volatility



Note: This figure shows the comparative statics of the optimal coupon rate,  $c$ , the default boundary,  $X_D$ , optimal leverage,  $L$ , and the difference in values between levered and unlevered firms,  $\frac{V-F}{F}$ , all with respect to macroeconomic volatility,  $\sigma_m$ , in the optimal static capital structure model. The benchmark set of parameters is:  $r = 0.05$ ,  $\mu = 0.02$ ,  $\sigma = 0.25$ ,  $\tau = 0.2$ ,  $X_0 = 1$  and  $\alpha = 0.1$ ,  $\sigma_m = 0.2$ ,  $\sigma_f = 0.3$ ,  $\eta_m = 1$ ,  $\eta_f = 1$ .

## *6. Conclusion*

Managers are confronted with stimuli from both macroeconomic and firm-specific issues. To introduce managerial efforts of learning about the environment into financing decision making process, I quantify managerial limited attention with attention capacity and attention allocation. Using the new measurements, I demonstrate that firm characteristics and the business cycle can affect the dynamics of managerial attention capacity and allocation.

Using public-listed firms' quarterly earnings call transcript and NLP, I first quantify managerial attention capacity and attention allocation. I have three findings regarding managerial attention: First, attention capacity and allocation are related to firm characteristics. Big firm size, high profitability, access to the credit market, and growth opportunities will make the managers expand attention capacity and allocation more attention to macroeconomics. Second, both attention capacity and attention allocation are counter-cyclical. They increase during a recession mainly due to increasingly salient macroeconomic information. Third, on average managers allocate more than half attention towards macroeconomics.

I also look into the role of managerial attention in explaining the unprecedented high level of business leverage. Attention capacity is stimulated from the surrounding's uncertainty. Both macroeconomic and firm-specific components play a central role in this process. To simplify the analysis, I assume the firm-specific volatility remain constant while allow the macroeconomic volatility variant. The results show that paying attention to macroeconomics provides both substitution and scale effects. Paying attention to macroeconomics concurs with attention capacity, which significantly increases a firm's leverage ratio by 1.69. Meanwhile, paying more attention to macroeconomics coincides with higher attention allocation towards macroeconomics, supplanting attention paid to firm-specific issues. This, in turn, results in a lower leverage ratio. My finding is robust after controlling for the business cycle, firm characteristics, and consideration of liquidity supply. The finding is also robust with different leverage ratio measurements.

I further investigate the role of managerial attention in amplifying the leverage cycles. By adding intersection terms of managerial attention and business cycles, I find that since attention capacity and attention allocation are counter-cyclical, they amplify the effect of the business cycle on firm level financial decisions. During a recession, the economic downturn will put pressure on a firm's leverage ratio. My estimation shows that expanded attention capacity doubles the effect from macroeconomics.

My attention measurements as well as the findings of substitution and scale effect point to some questions for future work. Is managerial attention nature or nurture? Does

managerial attention affect financial information release to investors? How do managerial attention impact business cycle dynamics, or long-run innovation, creative destruction, and growth?

## ***Appendix A***

Table A.1: Standard Industrial Classification (SIC) Manual

Range of SIC Codes	Division
0100-0999	Agriculture, Forestry and Fishing
1000-1499	Mining
1500-1799	Construction
2000-3999	Manufacturing
4000-4999	Transportation, Communications, Electric, Gas and Sanitary service
5000-5199	Wholesale Trade
5200-5999	Retail Trade
6000-6799	Finance, Insurance and Real Estate
7000-8999	Services
9100-9729	Public Administration
9900-9999	Non-classifiable

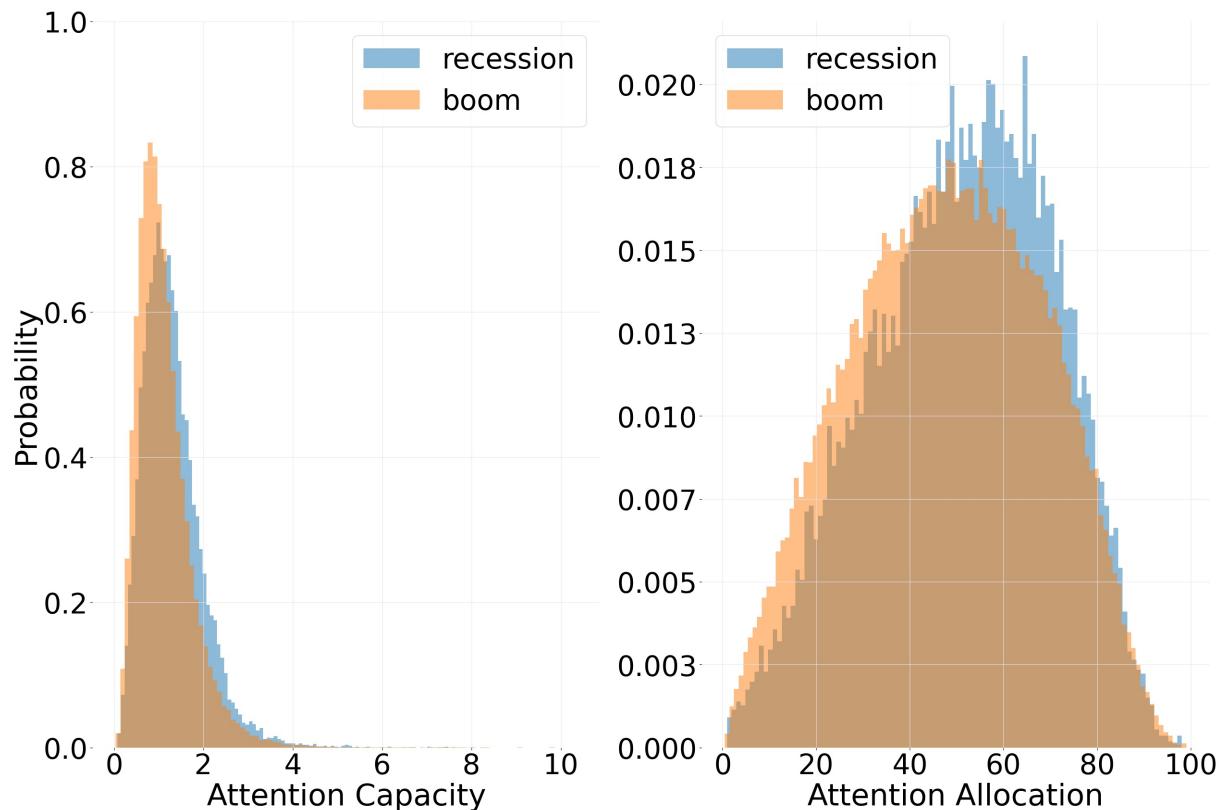
<sup>a</sup> This table is reproduced from the United States Department of Labor website. The SIC codes 1800-1999 are not used.

Table A.2: Comparative Statics of the Optimal Static Capital Structure Model

Variable	$\mu_x$	$\sigma_x$
<b>Endogenous case</b>		
$\gamma_D$	—	-/+
c	+. —	—
L	+	—
$X_D$	+	—
$\frac{V(X_0) - F(X_0)}{F(X_0)}$	+	—
<b>Exogenous case</b>		
c	-/+	—
L	—	—
$X_D$	-/+	—
$\frac{V(X_0) - F(X_0)}{F(X_0)}$	—	—

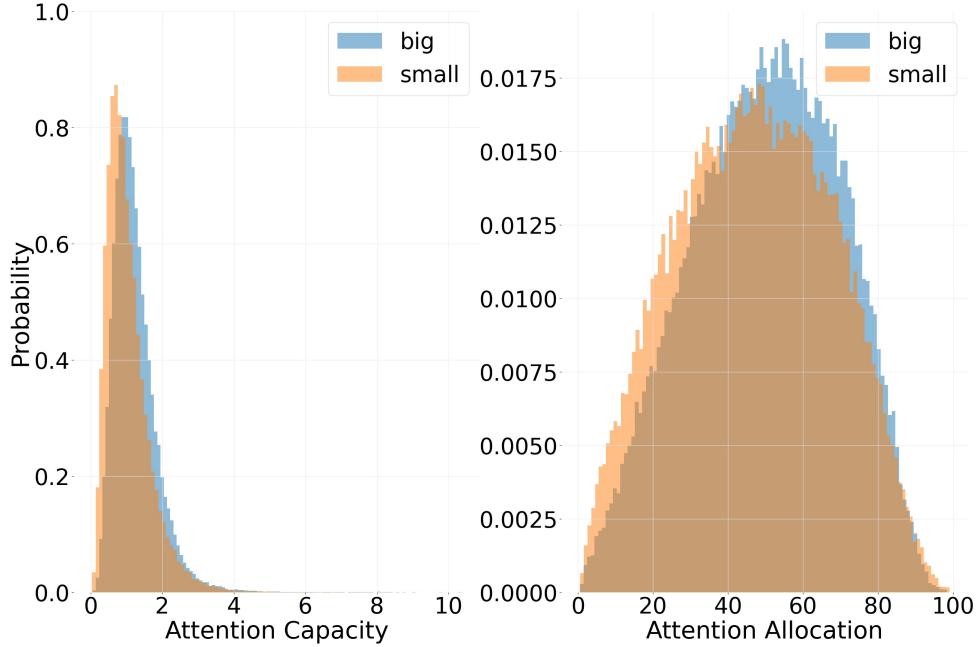
Note:  $\mu_x$  represents the mean of cash flow  $X$  and  $\sigma_x$  is the standard error of  $X$ . This table is reproduced from Strelalaev and Whited (2011).

Figure A.1: Manager's Attention is State-dependent



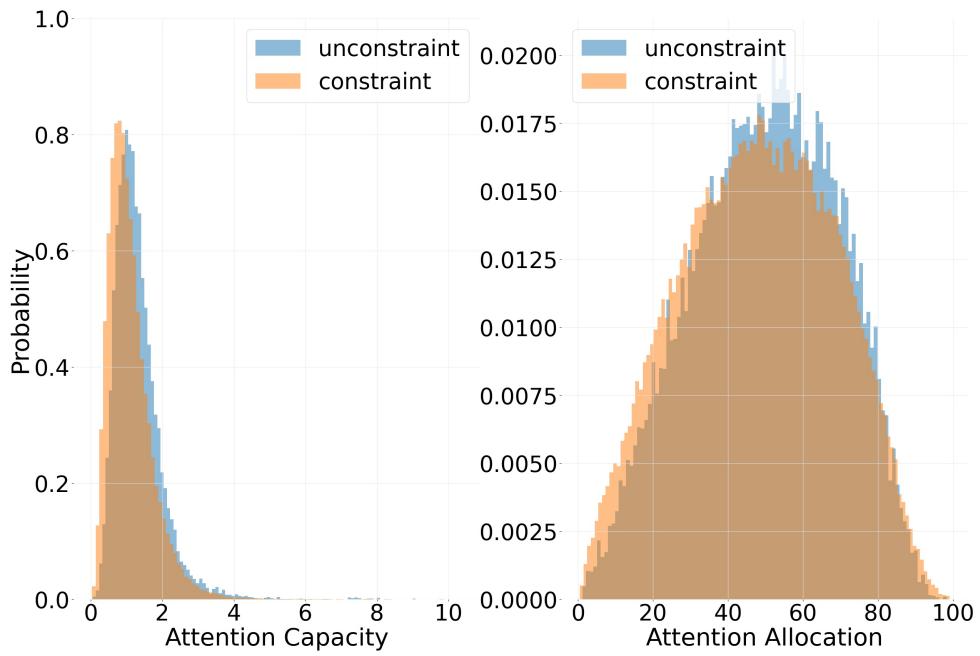
Note: This figure shows that managerial attention capacity and attention allocation towards macroeconomics are counter-cyclical. In recession, managers have higher attention capacity and attention allocation.

Figure A.2: Manager's Attention is Size-dependent



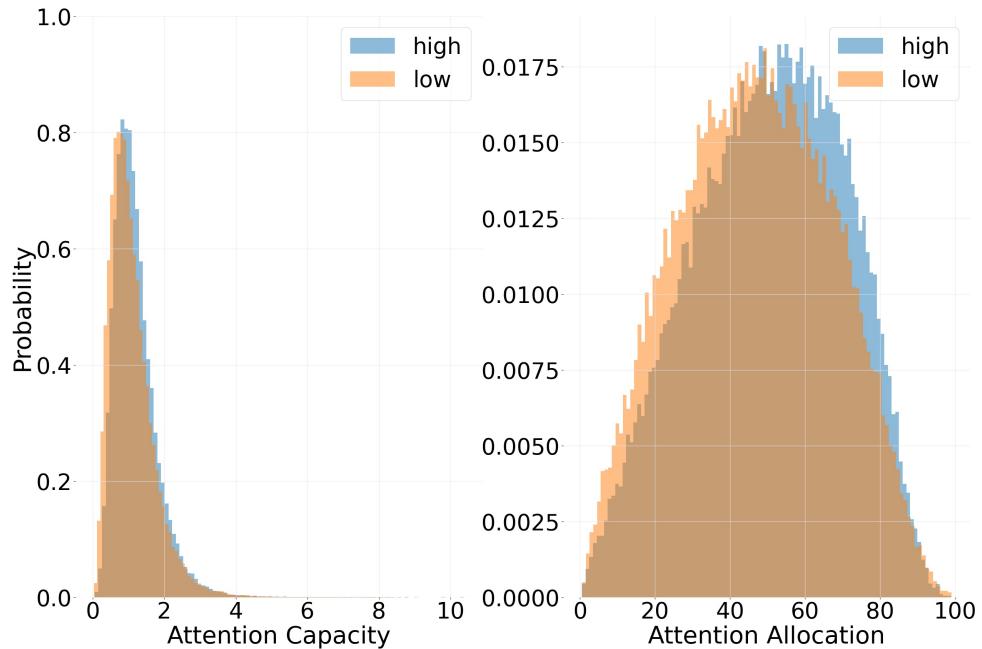
Note: This figure shows that managerial attention capacity and attention allocation towards macroeconomics are higher for bigger firms.

Figure A.3: Manager's Attention is Liquidity-dependent



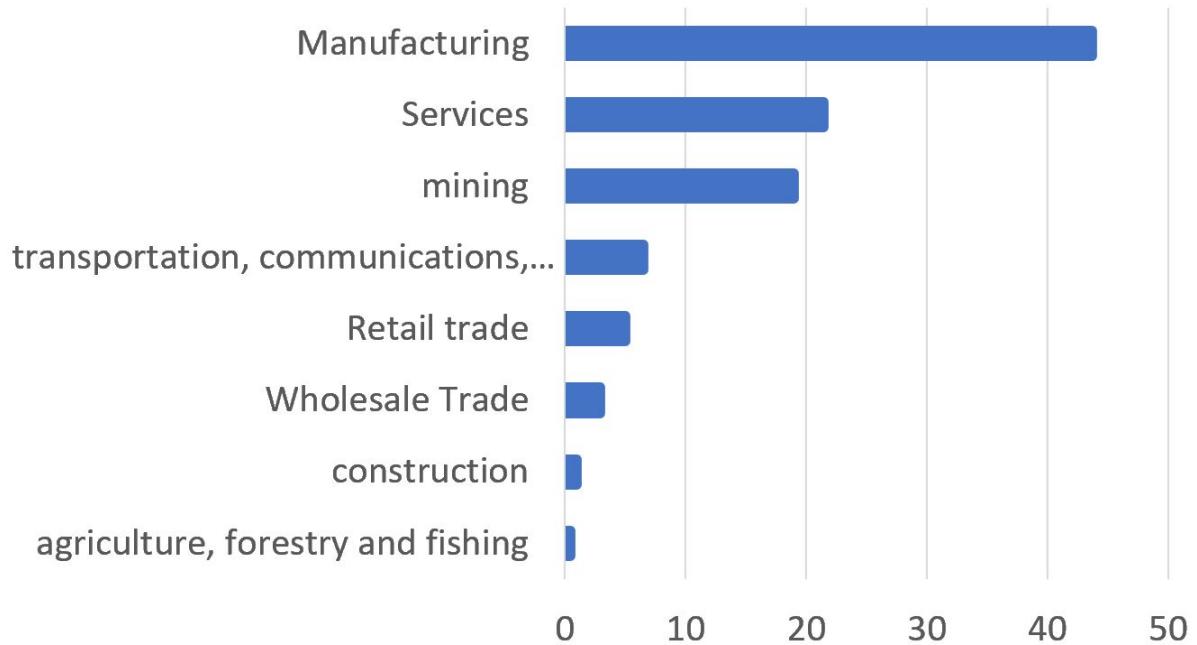
Note: This figure shows that managerial attention capacity and attention allocation towards macroeconomics are higher for financially unconstrained firms. Here I define financially unconstrained firms as those who have access to public debt market.

Figure A.4: Manager's Attention is Profitability-dependent



Note: This figure shows that managerial attention capacity and attention allocation towards macroeconomics are higher for firms with higher profitability.

Figure A.5: Sample Industry Distribution (percent)



## Appendix B

Derive the sum of two Brownian Motions. Define  $G_t = \sigma_a W_t^a + \sigma_m W_t^m$ .

$$\begin{aligned}
Var(G_t - G_s) &= Var((\sigma_a W_t^a + \sigma_m W_t^m) - (\sigma_a W_s^a + \sigma_m W_s^m)) \\
&= Var((\sigma_a W_t^a - \sigma_a W_s^a) + (\sigma_m W_t^m - \sigma_m W_s^m)) \\
&= Var(\sigma_a(W_t^a - W_s^a) + \sigma_m(W_t^m - W_s^m)) \\
&= \sigma_a^2 Var(W_t^a - W_s^a) + \sigma_m^2 Var(W_t^m - W_s^m) \\
&\quad + 2Cov(\sigma_a(W_t^a - W_s^a), \sigma_m(W_t^m - W_s^m)) \\
&= \sigma_a^2 Var(W_t^a - W_s^a) + \sigma_m^2 Var(W_t^m - W_s^m) + 0 \\
&= (t - s)(\sigma_a^2 + \sigma_m^2)
\end{aligned} \tag{61}$$

Thus,  $\frac{G_t}{\sqrt{\sigma_a^2 + \sigma_m^2}}$  is also a Brownian Motion, which I denote as  $W_t^x$ . I also assign  $\sigma_x^2 = \sqrt{\sigma_a^2 + \sigma_m^2}$ .

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