Around the Clock: Sleep Deprivation and Financial Analysts Performance *

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Abstract

Issues pertaining to the grueling working hours and resultant sleep deprivation of financial professionals have received increasing attention from regulatory bodies and the public. Using an innovative dataset sourced from PDF time stamps, this study constructs a novel measure to identify the occurrence and degree of sleep deprivation among individual financial analysts. I next examine whether analysts' sleep deprivation affects their job performance and find that sleep loss is significantly associated with diminished job performance. I then revisit the "protected-weekend" policy in the investment banks and find the policy exacerbates the sleep problem and impairs the performance of analysts with *ex-ante* severe sleep deficits.

Keywords: Sleep deprivation, Financial analysts, Working Performance

JEL Codes: G24, G41, D83

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1 Introduction

In 2013, a Bank of America intern tragically passed away after working continuously for 72 hours, prompting widespread concern about the extreme working hours within investment banks. Although a number of investment banks have implemented policies to improve analysts' work-life balance (e.g., the "protected weekend" policies), the situation appears to have seen little improvement in the past ten years. In 2023, Wall Street Oasis, an online community for financial professionals, initiated a survey on investment banking working conditions.[1] The survey results show that financial analysts are logging nearly 80 hours of work per week, with an average of six hours of sleep per night. Notably, analysts at Goldman Sachs are averaging a mere 4.9 hours of sleep per day.[2] These statistics highlight the prevailing condition of analysts who are taking on excessive workloads at the expense of their sleep.

Although sleep deprivation has become a prevalent issue among financial analysts, related economics research exploring the relationship between inadequate sleep and job performance remains limited. The primary limitation stems from the fact that sleep patterns among analysts become inherently unobservable once removed from controlled laboratory settings. While clinical or experimental environments allow direct sleep monitoring and data collection, achieving a comparable design in empirical research based on archival data is highly challenging. In this paper, I address the challenge by constructing a measure of sleep deprivation based on the metadata in analysts' PDF reports and then investigate the effect of sleep deprivation on sell-side financial analysts' performance.

Using a unique dataset that tracks the creation time of analysts' reports, this study introduces a novel measure to identify the occurrence and degree of sleep deprivation among analysts, specifically, their late-night work. To construct the measure, I first collect analysts'

[1] Over the 600 participants, 66% identified themselves as financial analysts. See https://www.wallstreetoasis.com/files/2023%20WSO%20IB%20Working%20Conditions%20Survey%20.pdf

[2] This is not the only survey concerning analysts' extreme working conditions. Also see https://www.bloomberg.com/news/newsletters/2021-03-18/money-stuff-goldman-analysts-work-too-hard

reports generated by human analysts at investment banks covering US public firms from Investext. Most analyst reports are authored and distributed in PDF format, and the metadata within these PDF files provides us with information regarding the document's generation. Next, I extract the creation date, creation time, modification date, modification time, and the corresponding time zone from the metadata. This data enables me to identify at what times analysts create their reports and to determine whether they work late hours, which could imply sleep deprivation (or circadian disruption). Finally, I aggregate the number of reports completed by an analyst during late-night hours (e.g., 12 a.m. to 5 a.m.) as my measure of the analyst's sleep deprivation. The greater number of reports completed late into the night implies the more severe the sleep deprivation.

My PDF reports sample consists of 874,548 documents generated by 3,756 distinct analysts covering 5,453 US public firms between 2008 and 2021. In this sample, 12.95% of the reports are generated during the 12 a.m. and 5 a.m. period. For the time interval between the 10 p.m. of the previous day and 7 a.m. of the day, this figure skyrockets 32.29%. Due to the popularity of PDF format among financial analysts and the comprehensive coverage of my sample, this statistic shows that a considerable amount of analysts trade sleep for work.

Prior research suggests that adequate and regular sleep holds paramount significance for financial professionals keeping a daily work routine. Related sleeping research shows that sleep plays a pivotal role in aiding energy restoration, thermoregulation, and tissue repair (Maquet, 2001). While individual variations do exist, it is generally accepted that obtaining less than seven hours of sleep is considered sleep deprivation for an adult between the ages of 18 and 60 (Cooper et al., 2018). Physiology and chronobiology research emphasizes that sleep deprivation exerts a pronounced negative impact on cognitive performance (Alhola and Polo-Kantola, 2007; Harrison and Home, 2000). This encompasses a decline in attention and working memory, impairment in long-term memory functions, as well as deterioration in decision-making abilities. [3] The diminished physiological and mental faculties resulting from sleep loss inherently influence the labor's working performance (Swanson et al., 2011b).

Given the various adverse effects of sleep loss, this study next examines whether sleep deprivation impairs financial analysts' working performance. To that end, analysts' forecast accuracy (PMAFA) and informativeness (CAR) are employed as proxies to gauge analysts' job performance. While the former measures an analyst's accuracy relative to their peers, the latter captures market reactions to their forecast revisions. As expected, I document a significant negative relationship between analysts' sleep deprivation and their job performance. In particular, analysts forecast accuracy and the market's responsiveness to forecast revisions decrease with the number of reports created by an analyst during late-night hours. In economic terms, I find that, within the same analyst-company pair, each additional report completed during late-night hours translates into a 1.3% decrease in the accuracy of their following day's earnings forecast and a 0.12% reduction in the market's corresponding reaction, which is meaningful given the mean values of the two variables are 1.7% and 3.535% respectively.

Although I include multiple analyst attributes and incorporate extensive fixed effects, it is still possible that individual analysts' sleep patterns and working performance are endogenously determined by unobservable factors such as analysts' abilities, workload, and the specific corporate culture of their investment banking environment. To further mitigate this endogeneity concerns, I next exploit the staggered implementation of investment banks' "protected weekend" policies (PWP) as an exogenous shock to test whether PWP affects analysts with high vs. low sleep deprivation levels differently. Following the tragic incident of the intern's death in 2013, certain investment banks introduced PWP to safeguard analysts' rest time. The implementation of PWP could, on the one hand, draw attention

[3] Sleep deprivation impacts our cognitive and emotional abilities because it disrupts the normal functioning of various neural networks in the brain. Specifically, research has shown that sleep deprivation can lead to alterations in attention and working memory, as well as impairments in the processing and recognition of emotions. These changes are thought to be due to disruptions in the activity of higher-order emotional brain regions, as well as the central and peripheral autonomic nervous system networks that are involved in processing complex social signals(Krause et al., 2017).

to the analysts' work-life balance, cap their overall working hours, and mitigate their sleep problems, thus leading to enhanced job performance. On the other hand, the implementation of PWP might cause analysts to shift their work from weekends to weekdays (Okat and Vasudevan, 2023). Consequently, the increased workload during the weekdays exacerbates analysts' sleep deprivation, resulting in poorer job performance.

I define financial analysts that are more likely to work till late-night hours (12 a.m. to 5 a.m.) preceding the implementation of the PWP as "Night-owls", and expect that "Night-owls" are more likely to be affected by the PWP. [4] Therefore, the treatment group in my diff-in-diff design is "Night-owls" at the investment banks with PWP. Specifically, I first examine whether the difference in sleep deprivation between the treatment group and the control group (e.g., "Non-night-owls" at investment banks with PWP and all the financial analysts at investment banks without PWP) changes after the implementation of PWP. Second, I investigate whether the job performance of "Night-owls" at the investment banks with PWP changed compared to other analysts. The results of the estimates suggest that "Night-owls" at the investment bank with PWP engage in late-night work more frequently and exhibit worse job performance in the post-policy period compared to other analysts. As such, I find robust evidence that sleep deprivation is associated with poorer working performance.

In supplemental analyses, I further test the potential moderating effects of age, gender, and workload. Medical literature documents that sleep structure changes with age. In general, the sleep duration decreases across the life span but our tolerance to sleep loss augments with aging (Chaput, Dutil, and Sampasa-Kanyinga, 2018). During prolonged wakefulness led by sleep deprivation, cognitive ability seems to be better in older people than in younger ones (Smulders et al., 1997; Philip et al., 2004). Therefore, I postulate that the impact of sleep deprivation is more pronounced among younger individuals compared to older ones. Without the specific age information for financial analysts, I resort to their

[4] To rank analysts on their sleep deprivation conditions, I require an analyst to stay in the industry throughout the sample period.

median experience as a cutoff and categorize them into Junior and Senior groups. The results reveal that the declines in forecasting accuracy and market reactions are entirely attributed to the junior analyst group, which aligns with laboratory evidence (Smulders et al., 1997).

Similarly, gender gaps exist in sleep deprivation: women tend to report more sleep-related issues than men. However, in terms of associated performance decline, women often outperform men. Following sleep deprivation, women exhibit better performance than men in tasks related to vigilance, verbal memory, and visuo-construction (Binks, Waters, and Hurry, 1999). To test gender differences, I replicated my baseline analyses separately for male and female analysts. My results suggest that female analysts are less susceptible to the impact of sleep deprivation on job performance compared to their male counterparts.

The workload might also pose moderating effects on the relationship between sleep deprivation and job performance, given that analysts are less able to avoid the hazards of sleep deprivation during busy seasons (Driskill, Kirk, and Tucker, 2020), Drake et al. (2020). Analysts face heightened work pressure during earnings seasons to provide timely information to clients and compete for market attention. This increased workload can result in more severe sleep deprivation, which can further contribute to a decline in performance. Consistent with my predictions, I find that the negative relationship between analysts' sleep deprivation and job performance is more significant in the earning season compared to that in the non-earning season. This result suggests that analysts' working performance is more sensitive to sleep deprivation during earning seasons.

Finally, I conduct a supplemental test to investigate whether my results are sensitive to analysts' strategic sleep time allocation. My baseline tests are based on the assumption that reports generation during late night represents an exogenous proxy for sleep deprivation. However, the reports creation time might not be random, but be driven by analysts' strategic allocation of their efforts. According to Harford et al. (2019), analysts prioritize more important firms over less important ones. Hence, once experiencing sleep deprivation, an analyst may choose to invest less effort and issue forecasts for less important firms the following day, resulting in less accurate forecasts. To address this concern, I examine the relationship between firm characteristics and analysts' decision to work in the late-night. I find that, in most cases, firm attributes and the analyst's decision to work at the cost of sleep are statistically uncorrelated. This indicates that analysts do not intentionally sacrifice sleep time because the forecasting firm is less important.

My conclusions are robust to alternative definitions of sleep deprivation. Specifically, as I rely on (seemingly arbitrary) time interval to identify sleep deprivation, I also run a number of tests with extended time windows. Overall, my results remain significantly negative when using alternative time windows, but the coefficients decrease as I widen the time windows.

I further conduct a placebo test to show that my results are not due to the selection of reports. In the placebo test, I randomly assign report creation times and repeat my baseline specifications 1,000 times. The negative relation between sleep loss and work performance is not detected in the falsification samples, confirming my results are not a statistical artifact.

This paper contributes to both research and practice in several ways. Firstly, this study pioneers the utilization of analyst report metadata to construct a sample of their working hours, thereby helping to uncover the black box of analysts' working process and establish a highly granular indicator of analyst sleep patterns. This metric enables us to quantitatively measure the relationship between sleep deprivation and job performance from an economic perspective. Previous clinical or laboratory studies are often constrained by sample size and the conventional laboratory-based tests, such as reaction time and vigilance, hardly reflect the real-world tasks. Based on large-sample evidence, this paper contributes to interdisciplinary research by providing multidimensional evidence within a more specific professional context.

Second, this paper contributes to the literature on analysts' performance. While recent research focuses on psychological and behavioral factors explaining analyst performance, relevant research based on medical and physiological studies remains significantly limited. For instance, Lo and Wu (2018) argues that analysts are subject to seasonal affective disorder, resulting in more pessimistic and less accurate forecasts. Hirshleifer et al. (2019) uncovers that when analysts issue multiple forecasts, their accuracy decreases in time due to decision fatigue. Drawing from physiological and medical research, this paper explores a new channel that affects the forecast accuracy and informativeness of analysts' research by offering more nuanced intraday evidence. It sheds light on the impact of sleep on analysts' job performance, complementing the existing body of literature and providing a novel explanation for their performance variations.

Finally, my study may be of interest to policymakers in investment banks by showing how work-life balance programs affect analysts with different sleep conditions. When proposing or evaluating Work-Life Balance (WLB) programs, its usefulness can be biased when focusing on overarching outcomes. Since the effectiveness of the same measure varies among different employees, the final outcomes can diverge from the initial expectations of policymakers. For instance, I discovered that the PWP had a counterproductive impact on analysts who are more likely to experience chronic sleep deprivation. My study calls for more tailored WLB programs for different people.

2 Literature and Hypothesis

2.1 Chronobiology and Physiology Research on Sleep Deprivation

According to the recommendations from the Centers for Disease Control and Prevention (CDC) of the United States, adults should ideally get at least seven hours of sleep per day. [5] However, an increasing number of individuals report struggling to obtain more than six hours of sleep each night (Sheehan et al., 2019). The analyses of the American Time Use Survey show that paid work time and commuting are the two waking activities that most often replace sleep time. Several studies have found a negative association between chronic sleep loss and various physical and mental issues, including obesity, psychological anxiety,

[5] https://www.cdc.gov/sleep/about_sleep/how_much_sleep.html

and a range of metabolic disorders (e.g. McEwen, 2006; Cooper et al., 2018; Cooper et al., 2018). The neurobehavioral effects of acute sleep deprivation are even found more severe than those resulting from chronic sleep restriction (Belenky et al., 2003).

In the field of biological and behavioral studies, it has been observed that both short sleep and circadian desynchrony can lead to a decline in cognitive abilities, such as attention and working memory, during the wake period. Decreased attention makes it more challenging for individuals to maintain focus in complex environments, while impaired working memory directly affects short-term memory and information-processing capabilities. In addition to its impact on cognitive abilities, sleep deprivation also manifests in individuals' higher-level cognitive processes, including long-term memory and decision-making regarding complex tasks. In this vein, a number of experimental studies have provided evidence that sleep loss has negative effects on cognitive performance measures, such as search-and-detection tasks, simple and choice reaction time tasks, sorting, logical reasoning, and memory access (e.g. Folkard, 1975; Killgore, Balkin, and Wesensten, 2006; Goel et al., 2013).

Individuals need to call a blend of the aforementioned cognitive abilities to accomplish tasks in the real world. Consequently, sleep deprivation often yields various negative outcomes for individuals engaged in specific tasks. For instance, Swanson et al. (2011a) identifies a widespread pattern of absenteeism and work-related injuries linked to sleep deprivation. Robb and Barnes (2018) documents a significant increase in car accidents following daylight saving time changes, primarily attributed to sleep loss. Watson (2017) indicates that athletes are more susceptible to injuries and exhibit poorer performance during activities if they fail to obtain adequate sleep.

2.2 Sleep Deprivation in Financial Professionals

The investment banking industry, including sell-side equity research, is notorious for overwork and severe sleep deprivation. There are three potential factors that hinder analysts from getting sufficient sleep. First, analysts provide specialized investment advice to clients by offering research on companies, industries, and the macroeconomy. In this process, they need to dedicate a significant amount of time to gather, analyze, interpret, and ultimately distribute information (Brown et al., 2015). Second, analysts cover multiple firms in their portfolio, many of which release their earnings concentrated in a few days. Meanwhile, analysts' clients are situated in various states and even countries, making analysts should always be prepared to address their inquiries at any time (De Franco et al., 2022). Finally, the intrinsic long-working culture within investment banks can also impact analysts' sleep, as many banks have overtime practice and expect analysts to participate in morning calls before the market opens (Hope et al., 2021). Facing these challenges, sleep deprivation has become a prevalent issue among analysts.

There is anecdotal evidence of harsh working conditions and sleep deprivation in the banking and finance industry. A working conditions survey (2021) released by Goldman Sachs shows that on average, first-year analysts work over 98 hours per week and sleep 5 hours per night.[6] Analysts often go to bed after 3 a.m. due to extended working hours. Inspired by the Goldman report, Wall Street Oasis conducted a wider industry-wide survey among investment banking professionals.[7] The results indicate that sell-side equity research analysts typically get only 5 to 6 hours of sleep per night, with even fewer hours during the earnings season. In addition, new research from bed manufacturer Sealy UK has revealed that the banking and finance sector is the second most sleep-deprived sector in the UK.[8]

Although scientific research on sleep is abundant, the question of whether and how sleep loss influences financial market participants only receives limited attention. Kamstra, Kramer, and Levi (2000) is the first to propose the "daylight saving time (DST) change weekend effect" on the financial market, suggesting that sleep desynchronosis could explain the decrease in market returns following DST. Based on a similar setting, Hagendorff, Gon-

[6] https://fd-binary-external-prod.imgix.net/JHxu13NMxHm3PvR1NCk1YL3z5Pw.pdf?dl=Arbeidsomstandighedenonderzoek+Goldman+Sachs+%28pdf%29.pdf

[7] https://www.wallstreetoasis.com/files/2023%20WSO%20IB%20Working%20Conditions%20Survey%20.pdf

[8] https://urlzs.com/CmH5c

zalez, and Li (2021) and Kleppe et al. (2023) both document a significant increase in investor underreaction to firm earnings surprises following daylight-saving time changes. Regarding financial professionals, Bazley, Cuculiza, and Pisciotta (2022) shows that less experienced professional analysts become relatively less accurate compared with their more experienced counterparts following the DST. These studies highlight the importance of a regular sleep cycle in information processing in the financial market.

Another stream of literature investigates the effect of work-life balance and long working hours on analysts' job performance. Using a sample of Glassdoor reviews by financial analysts, Hope et al. (2021) document a negative relationship between work-life balance and analyst performance when analysts perceive work-life balance to be relatively low. Okat and Vasudevan (2023) is the first to examine the effectiveness of the PWP by using taxi rides from bank addresses in New York City to infer bankers' working hours. They find that investment banks that shift analysts' work from weekends to late-night hours on weekdays are associated with more earnings forecast errors.

2.3 Hypotheses

As previously suggested, sleep deprivation primarily diminishes cognitive performance by affecting attention, working memory, long-term memory, and decision-making. These fundamental cognitive functions are crucial in the work of analysts. Firstly, attention enables analysts to remain unaffected by irrelevant external factors and focus on their current tasks. Bourveau et al. (2022) shows that when analysts' attention is grabbed by extreme industry returns, their research quality decreases. Analysts need to effectively allocate their limited attention resources to optimize their equity research performance. Secondly, analysts constantly utilize their working memory to temporarily store and process information, such as verbal and acoustic information during conference call communications, visual information during roadshow presentations, and the episodic buffer to integrate information from various sources. Thirdly, during the valuation process, analysts integrate new information with existing knowledge. This process requires ongoing use of free recall and recognition to retrieve information like historical accounting figures, past conversations with firm managers, and communication with colleagues in the brokerage. Finally, analysts' expertise stems from their ability to consistently make judgments and decisions. As an advanced cognitive ability, decision-making enables analysts to determine when and how to provide recommendations.

Based on the discussion above, I hypothesize:

H1: Analysts' performance deteriorates after sleep deprivation.

Facing longstanding criticism of long working hour culture, investment banks have taken steps to address this issue. Starting in late 2013, several U.S. investment banks, such as Bank of America, Credit Suisse, and Deutsche Bank, have introduced policies known as Protected Weekends to reduce the working hours of employees and ensure their time-off. These policies aim to enforce mandatory rest periods for analysts on weekends or after consecutive workdays. In fact, the impact of the policy can vary among individuals working at the same brokerage house. Compared to analysts without sleep deprivation issues, analysts who frequently work late into the night are more likely to be influenced by a policy that aims to affect their working pattern. Analysts who consistently engage in late-night work may suffer from chronic sleep deprivation. If the implementation of PWP can decrease their workload and enable them to have more rest time during weekends, their sleep situation could potentially be improved. As a result, the enhanced well-rested state resulting from PWP may contribute to the improved job performance among these "Night-owls" analysts. However, given that the PWP only protects analysts' rest time on weekends, without a corresponding reduction in workload, analysts' sleep deprivation may intensify during the weekdays. In a similar vein, Okat and Vasudevan (2023) finds that the research quality of analysts at banks implementing the PWP declined following the implementation of this policy when compared to that of analysts at banks that did not adopt PWP. Hence, if the PWP causes analysts to lose more sleep on weekdays, they are likely to perform worse at forecasting.

Based on the discussion above, I hypothesize:

H2: Analysts with more severe sleep deprivation perform worse after the implementation of the "protected-Weekend" policies.

3 Data and Measure

3.1 PDF Metadata

PDF is short for "Portable Document Format" and was created by Adobe. According to the description on Adobe's official website, it is a versatile file format that gives people an easy, reliable way to present and exchange documents regardless of the software, hardware, or operating systems being used by anyone who views the document. In light of these benefits, the PDF format has become one of the most widely adopted file formats in modern office environments. In Investext, one of the largest databases of analyst reports, reports in PDF format account for 94% of the entire documents and this proportion is approaching 98% in recent years. These facts highlight the dominance of PDF as the primary means for analysts to convey investment ideas and provide me with comprehensive coverage of analysts' work throughout the sample period.

Metadata in PDF files refers to its intrinsically embedded information about the document. This information allows the users to track and confirm the document's creation process. The meta information incorporated in PDF files includes the creation time, creation date, modification time, modification date, time-zone, file creator, the file producer, etc. While the information of file creator and file producer could be missing in some documents, the timestamps are always available for all PDF files. Considering the dominance of the PDF format in analysts' reports, the metadata can provide valuable insight into analysts' working patterns.

3.2 PDF Creation Time and Sleep Deprivation

I first collect the analysts' reports in PDF format generated in the period from 2008 to 2021. The PDF reports in my sample consist of research reports by human analysts working in investment banks and covering US public firms. To make sure the PDF reports are targeting individual firms, only those with explicitly identified stock tickers are considered.[9] Second, I extract the metadata from the PDF reports using a Python script. Amongst all the information in the metadata, I am particularly interested in the creation time that denotes when PDF files are generated. If the modification time differs from the creation time, I replace the creation time with its modification time. 7.28% of the reports in my sample are of this type. Finally, I sum up the number of reports generated between 12 a.m. and 5 a.m., a time interval that most people should have been sleeping, as my measure of sleep deprivation. [10] More work finished late at night implies more serious sleep loss.

To the extent that the sleep pattern for the same analyst can change over time, adopting a uniform definition of sleep deprivation may not fit into the schedule of everyone. Also, even for the same analyst, sleep structure changes in the lifetime. To accommodate the differences in sleep patterns of analysts (as illustrated in figure 1), I broaden the window of the sleeping time and conduct the estimations as the robustness checks.

Figure 1 here

Once the measure is built, I conduct several validation tests to ensure that the creation time reflects analyst' working time and thus can be utilized to effectively measure their sleep deprivation.

First, I manually examine the content of the PDF reports to identify in-text timestamps. Some analysts in certain investment banks adopt a boilerplate containing timestamps, allowing me to cross-check such timestamps with the creation time in the metadata. For example,

[9] In other words, reports for industry research, fixed income research, and derivatives research are not included.

[10] I do not require the PDF report to be the corresponding report of the earnings forecast but all the reports written by a specific analyst. Working on reports of other firms also conflicts with sleep time.

starting in October of 2016, analysts at the Bank of American Merrill Lynch started to adopt a new boilerplate that explicitly discloses the creation time in the PDF reports. In a similar fashion, I randomly selected and checked 200 reports of analysts working at Bank of America, JP Morgan, Morgan Stanley, and Wells Fargo, among others. This validation test confirms that the creation time embedded in the PDF metadata reflects the time when the file is initially created, other than an arbitrary time such as when the file was uploaded to the Investext database. Appendix 1 provides examples of validated reports.

In my second validation test, I explore the variation in the creation times throughout the day. Panel A of Figure 2 provides us with visual evidence of the intraday distribution of report creation time. The overall distribution mirrors analysts' activities and, by and large, is consistent with typical human circadian rhythms. However, approximately 12% of the total reports are generated between 12 a.m. and 5 a.m., which satisfies my criteria of sleep deprivation. Not surprisingly, we also observe a clear peak in report creation in the morning. This is in line with the fact that analysts finalize their research ideas after communicating with their directors or exchanging information during brokerage morning calls. [11] Panel B of Figure 2 refines the previous graphs by decomposing the creation hours into the seven days in a week. While the distribution of creation times follows a similar pattern from Monday to Thursday, analysts start to take a break from Friday evening but gradually resume their work from Sunday evening.[12] Overall, these two graphs show that the creation times of the PDF reports are not random timestamps but genuinely capture the working patterns of financial analysts.

It is possible that there is a systematic delay in the PDF generation, such as due to the compliance procedure within the brokerage house. However, I argue that the effect of such a delay introduced by the brokerage house is only limited. Brokerage houses operate in a highly competitive and time-sensitive environment, where timely distribution of research outcomes

[11] I find supporting anecdotal evidence that an anonymous sell-side analyst shared his typical day https://www.wallstreetoasis.com/forum/equity-research/a-day-in-life-of-my-sell-side-days.

[12] In addition, I also implement other validations based on the analysts' geographical location or investment banks they are working for. See the appendix for more information.

is of great importance (Groysberg and Healy, 2013), Bradley, Clarke, and Zeng (2020). It is improbable that a brokerage house would overinvest time in compliance procedures at risk of losing commission revenues. Additionally, I employ analyst-firm fixed effects in my estimations to address any time-invariant delay that might originate outside the analysts' work. Excluding analyst-irrelevant factors and using a conservative choice of the sleep time windows (from 12 a.m. to 5 a.m.) ensures that my measure accurately captures the variation in the analysts' sleep deprivation.

Figure 2 here

A potential alternative explanation for analysts creating PDF reports late at night is that they simply have different working and sleep patterns. I argue that the late-night creation of PDF reports reflects analysts' sleep deprivation rather than individual sleep habits for two reasons. First, as mentioned earlier, a number of surveys have shown that it is common for analysts to work long hours with a lack of sleep. [13] Analysts are unlikely to catch up on sleep during the day, given their busy lifestyle and the need to participate in some work activities, such as morning calls, roadshows, and firm visits. Second, according to biological research, circadian rhythm desynchronization is another type of sleep restriction (Goel et al., 2013). Circadian disruption could impair cognitive abilities even in the absence of sleep loss.

3.3 Performance Variables

I use two measures to proxy for analysts' working performance: the earnings forecast accuracy and the forecast revision informativeness. Earnings forecast accuracy is the negative value of the proportional mean absolute forecast error (Clement, 1999; Clement and Tse, 2005). $\text{PMAFE}_{i,j,t}$ is defined as the difference between the absolute error for analyst i for firm j and the mean absolute forecast error for firm j at time t scaled by the mean absolute forecast error. Since a larger PMAFE implies worse earnings forecast accuracy, I take the negative value for better interpretability.

[13] Such as the surveys conducted by Goldman Sachs in 2021 and by Wall Street Oasis in 2021 and 2023.

While the earnings forecast accuracy reflects their relative performance to their peers, the informativeness of the forecast revisions captures the market reaction to their research quality. The revision informativeness ($\text{Abs\_CAR}_{i,j,t}$) is computed as the absolute value of the two-day cumulative excess return over the Fama-French three-factor models. I focus on the absolute value since I formulate no expectation of the market reaction to the direction of the revision (Bourveau et al., 2022). To control for the absolute value of the forecast revision, I require that an analyst issue at least two forecasts for the same quarter and the same firm. [14]

3.4 Data

From the Investext database, I collect the sell-side analysts' reports in PDF format. To obtain the quantitative outputs of analysts' research, I merge the report-related data with the IBES, CRSP, and Compustat on analysts' names and firm identifiers. Specifically, I obtain analysts' quarterly earnings forecasts from IBES, the stock price-related metrics from CRSP, and quarterly firm attributes from Compustat.

To avoid stale forecasts, I remove forecasts issued 90 days before the earnings announcements (Clement, Hales, and Xue, 2011). To get a reasonable measure of their forecast accuracy, I also exclude firms with a stock price of less than five dollars and covered by less than four analysts (Hong and Kacperczyk, 2010; Green et al., 2014). [15] To compute the cumulative abnormal returns, I remove firms with less than 50 daily return observations within 70 days. To obtain intraday patterns of analysts' working time, I require at least one PDF report to be generated by the analyst on the day and the day before the forecast announcement. Searching for PDF reports prior to earnings forecasts leaves 122,777 earnings forecasts, out of which 113,835 forecast revisions are available.

[14] This also explains the decrease in the number of observations for estimations using informative as the dependent variable.

[15] The number of analysts covering a specific firm affects the calculation of mean absolute forecast error in PMAFE, while the stock price affects the deflation of absolute forecast error and the calculation of excess stock returns.

3.5 Descriptive Statistics

Table 1 presents the descriptive statistics for all of the variables included in the main tests and robustness checks. I winsorize all continuous variables at the top and bottom 1% to mitigate the effects of outliers. On average, we can observe 0.215 late-night (i.e. between 12 a.m. and 5 a.m.) generated reports for a given earnings forecast. [16] With respect to the remaining analyst forecasting properties, I document similar patterns as those in prior studies. For instance, an average analyst covers 15.5 firms, has approximately 11 years of general forecast experience, and issues forecasts 58 days prior to firms' quarterly earnings announcements.

Table 1 here

4 Empirical Results

4.1 Sleep Deprivation and Forecasts Accuracy

I first examine whether analysts' accuracy decreases following sleep deprivation by estimating the following regression model:

$$\text{PMAFE}_{i,j,t} = \alpha_{i,j} + \gamma_{j,t} + \lambda_{i,t} + \omega_t + \beta \text{Sleep\_Dep}_{i,j,t} + X_{i,j,t} + \epsilon_{i,j,t} \qquad (1)$$

where the primary dependent variable $Sleep\_Dep_{i,j,t}$ is the number of PDF reports generated in the late-night hours (between 12 a.m. and 5 a.m.) before the earning forecast announcement. $X_{i,j,t}$ represents controls variables that influence analysts' forecast accuracy. These variables include analysts' general experience, firm-specific experience, the horizon of the

[16] Instead of the continuous variable, I also use the dummy variable to indicate late-night work on PDF reports. On average, 16.63% of the earnings forecasts are issued following sleep deprivation during the [12 AM, 5 AM] interval, which consists of the overall intraday distribution as in 2. See the appendix for more details.

forecast, the number of firms covered by the analysts, the forecast accuracy ranking in the previous quarter, and the decision rank of the current forecast within a day. $\alpha_{i,j}, \gamma_{j,t}, \lambda_{i,t}$ respectively denote the analyst-firm fixed effects, firm-quarter fixed effects, and Analyst-Quarter fixed effects. ω_t represents the day of week fixed effects. Depending on different model specifications, some control variables can be subsumed in fixed effects.

To test my first hypothesis, I estimate model 1 under four different specifications. In all the four specifications, I incorporate firm-quarter joint fixed effects and day-of-week fixed effects to account for the variation introduced by time-varying firm characteristics and the systematic differences amongst the seven days of the week. Therefore, the first two models estimate whether the forecast accuracy decreases, on average, as a function of the number of reports generated during late-night hours. Relative to the first two models, model three includes analyst-firm pair fixed effects to control for an analyst's average accuracy regarding a certain firm. Hence, the model examines whether the forecast accuracy deteriorates after sleep deprivation within the same analyst and firm coverage relationship. Finally, I include the analyst-quarter joint fixed effect in Column 4, which allows for further comparison of the forecast accuracy for a given analyst-quarter under different sleep loss conditions. [17]

Table 2 here

Table 2 represents the results of the model 1. Results in Column 1 and Column 2 indicate that analysts' forecast accuracy decreases as a function of the sleep deprivation of the previous night. In Column 3, I find the coefficient on the sleep deprivation term is negative (-0.015) and statistically significant at 1% level, suggesting that, on average, finishing one more PDF report during the period of 12 a.m. and 5 a.m. translates into 1.5% decrease of the forecast accuracy. This magnitude, although modest in absolute terms, appears economically meaningful in our sample as the average forecast accuracy is 1.7% of the mean forecast (see Table 1. Although its magnitude slightly decreases, the coefficient of

[17] I also include analyst-firm-quarter triple fixed effects to estimate the effect within the analyst-firm pair in a specific quarter. The coefficients are still significant at the 10% level. See the appendix for more details.

sleep deprivation in Column 4 is still significant at the 10% level, indicating that an analyst's forecast accuracy declines even for the same analyst and same quarter.

4.2 Sleep Deprivation and Forecast Revisions Informativeness

Next, I study the effect of sleep deprivation on the informativeness of forecast revisions as another measure of performance. Specifically, I estimate the following empirical model:

$$\text{Abs\_CAR}[0,1]_{i,j,t} = \alpha_{i,j} + \gamma_{j,t} + \lambda_{i,t} + \omega_t + \beta \text{Sleep\_Dep}_{i,j,t} + \phi \text{Abs\_Revision}_{i,j,t} + X_{i,j,t} + \epsilon_{i,j,t} \tag{2}$$

where AbsCAR[0,1] is the absolute value of the excess return against the Fama-French three-factor model in the two days beginning on the forecast announcement date. Beside the control variables in model 1, I also include $\text{AbsRevision}_{i,j,t}$, which denotes the distance between two consecutive forecasts by the same analysts for the same quarter, scaled by the stock price at the end of the previous quarter (Green et al., 2014; Bradley, Gokkaya, and Liu, 2017).

Table 3 here

Across the four columns, I find consistent evidence that β is negative, indicating that the market reaction to analysts' forecast revisions decrease once an analyst experiences sleep deprivation. Column 1 shows that one more PDF generation during the late-night hours is associated with a 7.1 basis points reduction in the absolute stock price reaction. Moreover, the coefficients for sleep deprivation become larger in magnitude when incorporating an additional set of fixed effects. From column 1 to column 4, the reduction in market reaction following sleep loss enlarges by 4.8 basis points, suggesting the effect becomes stronger if I keep the analyst, firm, and quarter unchanged. Economically, the effect of sleep loss on the market reaction is comparable to that documented in the existing studies such as Hirshleifer et al. (2019) and Bourveau et al. (2022). This evidence leads me to conclude that the earnings forecast revisions issued under sleep deprivation conditions are viewed by investors as less informative.

4.3 A shock to analysts sleep deprivation

The empirical analyses above discuss the relation between sleep deprivation and working experience in general conditions, which is subject to potential endogeneity problems. Next, I explore the implications of shocks to analysts' sleep conditions that are specific to certain investment banks. This allows me to test analysts' performance change after exogenously induced actions without solely relying on the sleep deprivation measure. Specifically, I investigate the implementation of the PWP in early 2014 and evaluate its effectiveness of analysts with different pre-policy sleep patterns. [18]

To capture the variation in the analysts' late-night work habits, I categorize them as "Night-Owls" and "Non-night-owls". "Night-owls" are defined as analysts who rank the top 10% based on their sleep deprivation between 2008 and 2013.[19] Figure 3 reports the distribution of the "Night-Owls" in the major investment banks that produced over 10,000 PDF reports before the PWP within the sample periods. The circles' area denotes the proportion of the analysts fitting my "Night-owls" definition. This figure reveals that the "Night-owls" are not limited to specific brokerage houses; instead, they exist across brokerage houses of various sizes, measured by either headcount or PDF production. Therefore, based on the size of the brokerage houses, the deployment of the PWP cannot be predicted *ex-ante*.

Figure 3 here

While the PWP aims to directly guarantee rest time on the weekend, it may indirectly

[18] See Appendix for more details.

[19] Our results hold if I use other cut-offs to identify "Night-Owl". For example, the top 10% sleep deprivation in the pre-policy window remains robust when I decrease its value to 20% or increase its value to 95% except if I go too high, resulting in too few observations for the Night-Owl group. Refer to table A6 for more details about the results of the univariate tests on the differences between "Night-Owls" and "Non-night-owls".

affect sleep time if analysts shift their work to late night on weekdays. To assess whether the "Night-owls" and the "Non-night-owls" are affected differently by the policy. I conduct the following two-step estimations:

$$\begin{aligned}\text{Sleep\_Dep}_{i,k,t} = {} & \alpha_{i,j,k} + \gamma_{j,t} + \omega_t + \beta_1 \text{Night\_Owl}_i \times \text{Policy\_Bank}_k \times \text{Post\_Policy}_t \\ & + \beta_2 \text{Policy\_Bank}_k \times \text{Post\_Policy}_t + \beta_3 \text{Night\_Owl}_i \times \text{Post\_Policy}_t \\ & + \beta_4 \text{Post\_Policy}_t + X_{i,j,k,t} + \epsilon_{i,j,k,t}\end{aligned} \tag{3a}$$

$$\begin{aligned}\text{PMAFE}_{i,j,k,t} = {} & \alpha_{i,j,k} + \gamma_{j,t} + \omega_t + \beta_1 \text{Night\_Owl}_i \times \text{Policy\_Bank}_k \times \text{Post\_Policy}_t \\ & + \beta_2 \text{Policy\_Bank}_k \times \text{Post\_Policy}_t + \beta_3 \text{Night\_Owl}_i \times \text{Post\_Policy}_t \\ & + \beta_4 \text{Post\_Policy}_t + X_{i,j,k,t} + \epsilon_{i,j,k,t}\end{aligned} \tag{3b}$$

where Night-owl is an indicator for analysts with the top-decile sleep deprivation before the policy is taken into action. Policy bank and Post Policy are two dummy variables that respectively indicate whether a bank is a policy bank and the time period after the implementation of the policy.

To correctly identify the effect of the policy, I include multiple fixed effects to capture unobservable firms, analysts, or brokerage house attributes. First, I control the brokerage-analyst-firm fixed effects to subsume analysts' average performance regarding a certain firm and analysts' working mode when he/she works at a specific brokerage house. Second, I include the firm-quarter fixed effects to control for the time-varying firm characteristics. Last, I include the day-of-week fixed effects to eliminate the impact by variation among the seven days in the week. Therefore, if there are any changes in analysts' sleep deprivation levels and working performance, it should be driven by their reallocation of sleep time after the implementation for the same analysts working in the same brokerage house.

Table 4 here

The results are reported in table 4. Panel A table 4 shows the effect of policy on analysts' sleep deprivation where the dependent variable is the number of reports completed during the [12 AM, 5 AM] time interval. The interaction term between Night Owl and Post Policy is negative and significant, suggesting that sleep conditions for the night owls in non-policy banks are improving. However, the triple interaction term is positive and significant across all the specifications, indicating that the "night owls" in the policy banks are more sleep-deprived after the implementation of the policy. According to the results in Column 4, the night owls in the policy banks generate 0.4 more reports on average, in the late-night hours in the post-event period. Given that the mean value of *Sleep_Dep* is 0.214, these results appear economically meaningful.

Panel B table 4 displays the results for the effect of the policy on analysts' forecast accuracy. In all the specifications, the triple interaction term Night $\text{Owl}_i \times$ Policy $\text{Bank}_k \times$ Post Policy_t remains negative and significant at 1% level. These results suggest that the night owls in the policy banks are performing worse after the policy is introduced. Complementing the finding in Okat and Vasudevan (2023), my results imply that not all the affected analysts, but those who are *ex-ante* more likely to experience sleep deprivation problems, exhibit lower forecast quality post policy.

4.4 Robustness Tests

An assumption of the previous tests is that completing the reports between 12 a.m. and 5 a.m. implies sleep deprivation. I argue the choice of the late-night hours in this paper is arbitrary but reasonable because people are affected by the circadian rhythms, and the five hours after midnight cover the sleeping time for most analysts. To lend more credibility to the previous findings, I widen the time interval and reestimate the model 1 and model 2.

Table 5 here

Panel A table 5 presents the results for sleep deprivation in alternative night-night hours.

Consistent with the baseline results (Column 4), the coefficients in Columns 1-3 are always negative and significant. Across the four columns, the magnitude of the coefficients for sleep deprivation increases as I shorten the night window, suggesting that the five hours between 12 a.m. and 5 a.m. captures the sleeping time for the majority of the analysts. Panel B Table 5 presents the results for similar robustness checks on the informativeness of forecast revisions. Compared with Column 1, the coefficient for sleep deprivation in Column 4 is more than two times larger, indicating that market reaction to forecasts by sleep-deprived analysts is robust with respect to the extended late-night hours.

Separating sleep deficiency from overtime is a by-product of widening the time windows. Staying in their office and working on a report until 9 p.m. is more in line with the definition of overtime but not sleep deprivation. The estimations using the extended time windows determine the effect of not only sleep deprivation but also overtime, on job performance. Therefore, the results in the robustness tests also suggest that the adverse effect of sleep deprivation is stronger than that of overtime.

4.5 Placebo Tests

To further ensure that I am capturing the effect of sleep deprivation on analysts' performance, I conduct simulation-based placebo tests. First, I randomly assign a creation time amongst the 24 hours in a day for each PDF report. In this way, a late-night generated (e.g. 3 AM) report might be manually moved to the afternoon (e.g. 3 PM) and vice versa. Next, I re-estimate model 1 and model 2 to recover the coefficient of sleep deprivation. This procedure is repeated for 1,000 times and the results are displayed in figure 4.

Panel A figure 4 plots the density of the coefficients concerning forecast accuracy. The vertical line represents the estimation based on actual data, which corresponds to the 99.1 percentile of the simulated coefficients. Panel B plots the similar simulated coefficient distribution with respect to forecast revision informativeness. The vertical line represents the estimation based on actual PDF generation time, which is located far to the left. Overall, the placebo tests demonstrate that the decline in forecast accuracy and forecast revisions informativeness is unique to the analysts' true sleep patterns.

Figure 4 here

5 Additional Analyses

5.1 Moderation Role of Age

Sleep deprivation is unlikely to affect the working performance of all analysts equally. First, the cognitive and behavioral effects of sleep deprivation vary with age. Sleep studies suggest that after sleep loss, cognitive performance tends to be better maintained in older individuals compared to younger ones. This phenomenon could be attributed to increased tolerance to sleep deprivation with age. In addition, the ability to learn from past experiences can reduce the cognitive demands of certain tasks and improve performance (Mikhail, Walther, and Willis, 1997). Consequently, when analysts experience sleep deprivation, those who are older or more experienced may be able to rely on their expertise to accomplish tasks more easily.

Without the precise data on analysts' ages, I repeat my baseline analyses for analysts at different seniority levels. Specifically, I divide each analyst's general forecasting experience into two phases: junior phase and senior phase. Using the idiosyncratic median experience as the cutoff is valid for two reasons. First, age and experience are highly correlated, making the general experience a reasonable proxy for age. Second, by controlling for the analysts-firm fixed effects, I am actually examining the change in performance over time after the same amount of sleep loss for the same individual analyst.

Table 6 reports the results in the two subsamples. Similar to the baseline estimations, the results in Column 1 and Column 3 (younger analysts) show a negative and significant association between sleep deprivation and job performance. In contrast, this association diminishes as the analysts age and gain more experience. These results support the finding in the existing literature that the effect of sleep deprivation on working performance is more prominent when analysts are younger or less experienced.

Table 6 here

5.2 Moderation Role of Gender

Besides age differences, there is gender dissimilarity in sleep loss. Some evidence suggests that due to differences in brain structure and hormonal levels, women tend to report more sleep-related problems than men. However, women seem to cope better with fatigue after sleep loss than men. It's important to note that sleep patterns are influenced by a complex interplay of genetic, behavioral, environmental, and social factors. Disparities in performance for analysts of different genders could potentially be attributed to their distinct social and familial roles. For instance, Wang et al. (2022) finds that female analysts, who are more likely to be distracted by household chores during the COVID pandemic, tend to issue less accurate earnings forecasts.

Based on their names, I use forebears.io, an online genealogical database, to determine the gender of the analysts. Subsequently, I replicate my estimations separately for male and female analysts.

I expect that female analysts are less affected by sleep deprivation. Consistent with my prediction, the negative association between sleep loss and working performance is not detected amongst female analysts. On the one hand, these results support the conclusion of Kumar 2010, which suggests that self-selected female analysts exhibit better performance. On the other, one should interpret the disparities with caution given that female analysts constitute only around 10% of the total analyst population.

Table 7 here

5.3 Moderation Role of Workloads

When analysts are not busy, they may voluntarily choose to work late at night and their decreased performance due to sleep deprivation can easily recover after rest. However, analysts are more likely to be exposed to forced sleep deprivation due to a heavier workload during earnings season. When earnings season arrives, firms in the same industry often announce their earnings simultaneously to compete for limited market attention. This leads to a large amount of new information being released in a short period of time (Hirshleifer and Teoh, 2003; Truong, 2023). Meanwhile, analysts are responsible for diverse research activities aimed at shaping investment strategies and informing decisions for their buy-side clients. During earnings season, analysts have stronger incentives to cater to their clients to fulfill the increased demand for information interpreting (Chiu et al., 2021). In practice, analysts are observed busy attending conference calls, constantly answering phone calls from every client, and striving to provide the latest reports in the shortest possible time. As a result, analysts inevitably sacrifice sleep time, leading to poorer performance than usual. Therefore, I hypothesize that when analysts encounter a heavier workload, the influence of sleep deprivation on their performance becomes more pronounced.

Figure 5 here

Figure 5 illustrates the annual distribution of late-night generated reports and the distribution of earnings announcements by US public firms within a calendar year. The figure clearly highlights a substantial synchronicity between report production and firm announcements. Notably, analysts tend to generate more reports late at night during the four earnings seasons in a year.

Table 8 here

To investigate the moderation role of workload, I repeat my baseline estimations for the earnings forecasts in normal times and earnings season. A date is categorized into the earnings season if the earnings announcements on that day exceed the median value. Table 8 reports the results for the two performance measures with different workloads. Similar to the baseline results, the correlations between sleep deprivation and forecast quality remain negative. In particular, both the economic and statistical significance are greater in Column 2 (Column 4) than in Column 1 (Column 3), suggesting earnings forecasts issued during the earnings seasons are more sensitive to sleep deprivation. Put differently, the results suggest that analysts are more vulnerable to sleep deprivation in an environment with an increased workload.

5.4 Strategic Sleep Time Allocation

Although incorporating confounding factors and various fixed effects helps to distinguish the real effect of sleep deprivation on research quality, a remaining possibility is that analysts strategically allocate their time and energy. More precisely, if an analyst considers the forecasting firm as less important, he or she may spend the time of the preceding night on other tasks such as writing reports. If so, the underperformance after sleep deprivation is attributed to the deliberate prioritization of some firms over others.[20]

To test whether analysts adopt a sleep time allocation rule depending on the importance of the forecasting firm, I regress the sleep deprivation variable over the characteristics of the forecasting firm as follows:

$$\begin{aligned} \text{Sleep\_Dep}_{i,j,t} = \lambda_{i,t} + \beta_1 \text{Size}_{j,t} + \beta_2 \text{ROA}_{j,t} + \beta_3 \text{Trading Volume}_{j,t} \\ + \beta_4 \text{BTM}_{j,t} + \beta_5 \text{Following}_{j,t} + \epsilon_{i,j,t} \end{aligned} \tag{4}$$

where Sleep_Dep denotes the number of reports generated in late-night hours. The inde-

[20] In the literature, there is always a debate on the self-selection problem in the context of behavioral-driven labor productivity. For example, Hirshleifer et al. (2019) suggests that analysts subject to decision fatigue thus performance decreases over the course of a day. However, Jiao (2023) argues that analysts also strategically manage their decision fatigue since they tend to issue forecasts for more important firms earlier in the day.

pendent variables include firm size, return on assets (ROA), trading volume, book-to-market ratio, and the number of analysts following the firm. $\lambda_{i,t}$ represents the analyst-quarter fixed effects that allow me to conduct the analysis across firms in the analyst's portfolio for a given quarter.

Table 9 here

Table 9 reports the results of the estimations. In columns 1-3, it is observed that the firm attributes are by large not significant determinants of analysts' sleep deprivation, which does not support the strategic time allocation explanation. The coefficients in column 4 indicate that analysts are more prone to work late at night if the forecasting firm exhibits higher ROA, trading volume, analysts following, and a smaller book-to-market ratio. Given that firm with these characteristics are generally considered more important to analysts, these associations suggest that working on important firms at the expense of sleep do more harm than good.[21] Therefore, the decreased performance is unlikely to be the result of analysts' strategic time allocation amongst different firms in their portfolios.

6 Conclusion

In this paper, I construct a unique dataset that tracks analysts' work routines, particularly their working time, by extracting the metadata in their PDF reports. Using the creation time of these reports, I capture individual analysts' sleep patterns and examine whether and how sleep deprivation affects their working performance. I find that when analysts work on reports up to the late-night hours, their forecast quality, measured by both Forecast accuracy and informativeness of forecast revisions experience a significant decline. To the best of my knowledge, this paper is the first to assess analysts' sleep condition on a daily basis and

[21] Harford et al. (2019) suggests that analysts distribute more effort to more important firms and thus make more accurate forecasts. As such, analysts who strategically allocate their time are less likely to work in the late night for larger forecasting firms or firms with larger trading volumes.

provide large-sample empirical evidence regarding the sleep-performance relation outside of the lab environment.

Furthermore, I assess the effectiveness of the PWP in the investment banks. The PWP is designed to free analysts from weekend work but indirectly leads to more work during weekday nights. By categorizing analysts as "Night owls" based on their ax-ante sleep deprivation levels, I find that that the implementation of this policy has had a detrimental impact on "Night owls". They are more inclined to complete reports in the late-night hours, resulting in a significant decrease in their research quality. This finding extends the existing literature evaluating the long working hours culture within the financial industry by showing how differences in pre-policy working conditions can lead to dissimilar outcomes for the same policy.

In conclusion, sleep deprivation can significantly impact cognitive functions, including working memory, attentional networks, and other crucial neurocognitive processes. understanding the intricate relationship between sleep and performance is crucial for developing strategies to mitigate the adverse effects of sleep deprivation and maintain cognitive functioning.

On the individual level, addressing sleep loss, promoting sleep quality, and optimizing working schedules can all play a positive role in achieving personal work-life balance. For organizations, implementing more targeted policies tailored to different groups of people and regularly monitoring the effectiveness of the policy can help shape corporate culture, safeguard employees' well-being, and eventually improve overall firm productivity.

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Tables

Table 1: This table presents descriptive statistics for the variables used in the main tests. Variable definitions and the descriptive statistics for other variables are in Appendix 1.

	Observations	Mean	SD	Min	Median	Max
Abs_CAR	113835	3.535	4.201	0.033	2.058	23.125
Abs_Revision	113835	0.005	0.011	0.000	0.002	0.082
PMAFE	122777	0.017	0.622	-2.279	0.051	1.000
Sleep_Dep	122777	0.215	0.534	0.000	0.000	3.000
Gen_Exp	122777	45.666	23.301	2.000	46.000	93.000
Firm_Exp	122777	21.943	18.437	1.000	17.000	77.000
Horizon	122777	57.628	28.993	1.000	69.000	89.000
Broker_Size	122777	47.274	32.887	2.000	38.000	115.000
Past_Accy	122777	3.990	4.533	0.000	3.000	20.000
Port_Size	122777	15.550	8.190	1.000	15.000	45.000
Decision_Rank	122777	0.945	0.428	0.693	0.693	2.708
Night_Owl	122777	0.083	0.275	0.000	0.000	1.000
Post_Policy	122777	0.738	0.440	0.000	1.000	1.000
Policy_Bank	122777	0.286	0.452	0.000	0.000	1.000

Table 2: This table presents regression results for forecast accuracy. The dependent variable, Accuracy, is the negative value of PMAFE, where PMAFE is the proportional mean absolute forecast error. Sleep_Dep is the number of reports generated during the period of 12 a.m. and 5 a.m. (not included). Other variables are defined in Appendix 1. Absolute values of t-statistics are reported in the parentheses with heteroskedastic-consistent standard errors double clustered by analyst and quarter. $*$, $**$, and $***$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Accuracy			
Sleep_Dep	-0.014***	-0.012***	-0.015***	-0.013*
	(2.88)	(2.69)	(3.27)	(1.92)
Gen_Exp		0.000	-0.011	
		(0.95)	(0.70)	
Firm_Exp		0.000*	0.007*	0.004
		(1.94)	(1.66)	(0.71)
Horizon		-0.004***	-0.004***	-0.004***
		(19.30)	(19.56)	(18.21)
Broker_Size		-0.000	0.000	
		(1.00)	(0.19)	
Past_Accy		-0.007***	0.003***	0.003***
		(10.19)	(4.08)	(3.07)
Port_Size		-0.001	0.001	
		(1.60)	(0.68)	
Decision_Rank		-0.026***	-0.028***	-0.024***
		(3.78)	(4.16)	(3.10)
Day-of-Week FE	Yes	Yes	Yes	Yes
Firm-Quarter FE	Yes	Yes	Yes	Yes
Analyst-Firm FE	No	No	Yes	Yes
Analyst-Quarter FE	No	No	No	Yes
N	124197	124197	124197	107973
R^2	0.241	0.258	0.408	0.569

Table 3: This table presents regression results for forecast revision informativeness. The dependent variable, Informativeness, is the absolute value of CAR, where CAR is calculated as the two-day excess return against the Fama-French three-factor model. Sleep_Dep is the number of reports generated during the period of 12 a.m. and 5 a.m. (not included). Other variables are defined in Appendix 1. Absolute values of t-statistics are reported in the parentheses with heteroskedastic-consistent standard errors double clustered by analyst and quarter. $*$, $**$, and $***$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Informativeness			
Sleep_Dep	-0.071**	-0.088***	-0.094***	-0.119***
	(2.07)	(2.64)	(2.62)	(2.74)
Abs_Revision	25.289***	16.025***	18.146***	21.933***
	(8.54)	(5.79)	(5.85)	(5.59)
Gen_Exp		0.001	0.144**	
		(1.40)	(2.46)	
Firm_Exp		-0.000	-0.012	-0.023
		(0.38)	(0.82)	(1.15)
Horizon		0.014***	0.014***	0.014***
		(6.84)	(7.71)	(7.08)
Broker_Size		0.003***	-0.002	0.022
		(5.28)	(1.10)	(1.24)
Past_Accy		-0.005*	-0.000	0.001
		(1.88)	(0.08)	(0.22)
Port_Size		0.004	0.010***	
		(1.51)	(2.76)	
Decision_Rank		-0.075	-0.094	-0.056
		(0.92)	(1.22)	(0.63)
Day-of-Week FE	Yes	Yes	Yes	Yes
Firm-Quarter FE	Yes	Yes	Yes	Yes
Analyst-Firm FE	No	No	Yes	Yes
Analyst-Quarter FE	No	No	No	Yes
N	115228	115228	115228	99221
R^2	0.658	0.664	0.724	0.772

Table 4: This table reports the change in analysts' sleep deprivation and forecast accuracy after the "protected-weekend" policy. Informativeness is the absolute value of the two-day excess return against the Fama-French three-factor model. Sleep_Dep is the number of reports generated during the period of 12 a.m. and 5 a.m. (not included) in the previous night. Other variables are defined in Appendix 1. Absolute values of t-statistics are reported in the parentheses with heteroskedastic-consistent standard errors double clustered by analyst and quarter. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Post PWP Sleep Deprivation				
	(1)	(2)	(3)	(4)
	Sleep_Dep			
Post_Policy	-0.007	-0.004	-0.028	-0.026
	(0.51)	(0.26)	(1.46)	(1.33)
Night_Owl × Post_Policy	-0.081*	-0.084*	-0.092***	-0.094***
	(1.81)	(1.81)	(2.71)	(2.72)
Policy_Bank × Post_Policy	-0.012	-0.010	0.003	-0.004
	(0.51)	(0.41)	(0.16)	(0.20)
Night_Owl × Policy_Bank × Post_Policy	0.297***	0.308***	0.389***	0.400***
	(3.84)	(3.74)	(4.05)	(4.21)
Controls	No	Yes	Yes	Yes
Analyst-Brokerage-Firm FE	Yes	Yes	Yes	Yes
Firm-Quarter FE	No	No	Yes	Yes
Day-of-Year FE	No	No	No	Yes
N	122777	122777	122777	122777
R^2	0.319	0.324	0.528	0.538

Panel B: Post PWP Performance				
	(1)	(2)	(3)	(4)
	Accuracy			
Post_Policy	0.002	0.008	0.080	0.079
	(0.21)	(0.66)	(1.58)	(1.56)
Night_Owl × Post_Policy	-0.040	-0.041	-0.021	-0.021
	(1.27)	(1.30)	(0.67)	(0.66)
Policy_Bank × Post_Policy	0.040**	0.040**	0.032	0.031
	(2.12)	(2.15)	(1.47)	(1.46)
Night Owl × Policy_Bank × Post_Policy	-0.119***	-0.130***	-0.132***	-0.132***
	(4.63)	(4.06)	(3.35)	(3.30)
Controls	No	Yes	Yes	Yes
Analyst-Brokerage-Firm FE	Yes	Yes	Yes	Yes
Firm-Quarter FE	No	No	Yes	Yes
Day-of-Year FE	No	No	No	Yes
N	122777	122777	122777	122777
R^2	0.192	0.209	0.422	0.422

Table 5: This table presents regression results for forecast accuracy and informativeness under different sleep deprivation definitions. The dependent variable in panel A is the earnings forecast accuracy. Accuracy is the negative value of the PMAFE, where PMAFE is the proportional mean absolute forecast error. The dependent variable in panel B is the forecast revision informativeness. Informativeness is AbsCAR, where AbsCAR is calculated as the absolute value of the two-day excess return against the Fama-French three-factor model. Sleep_Dep is the number of reports generated during the period of 12 a.m. and 5 a.m. (not included). Other variables are defined in Appendix 1. Absolute values of t-statistics are reported in the parentheses with heteroskedastic-consistent standard errors double clustered by analyst and quarter. $*$, $**$, and $***$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Forecast Accuracy				
	(1) [-9PM,8AM]	(2) [-10PM,7AM]	(3) [-11PM,6AM]	(4) [12AM,5AM]
Sleep_Dep	-0.010***	-0.011***	-0.012***	-0.015***
	(3.67)	(3.97)	(3.22)	(3.27)
Gen_Exp	-0.012	-0.012	-0.012	-0.011
	(0.73)	(0.74)	(0.75)	(0.70)
Firm_Exp	0.007*	0.007	0.007	0.007*
	(1.66)	(1.65)	(1.65)	(1.66)
Horizon	-0.004***	-0.004***	-0.004***	-0.004***
	(19.51)	(19.53)	(19.56)	(19.56)
Broker_Size	0.000	0.000	0.000	0.000
	(0.03)	(0.10)	(0.15)	(0.19)
Past_Accy	0.003***	0.003***	0.003***	0.003***
	(4.09)	(4.06)	(4.08)	(4.08)
Port_Size	0.001	0.001	0.001	0.001
	(0.71)	(0.70)	(0.69)	(0.68)
Decision_Rank	-0.026***	-0.027***	-0.028***	-0.028***
	(3.82)	(4.01)	(4.16)	(4.16)
Analyst-Firm FE	Yes	Yes	Yes	Yes
Firm-Quarter FE	Yes	Yes	Yes	Yes
Day-of-Week FE	Yes	Yes	Yes	Yes
N	124197	124197	124197	124197
R^2	0.408	0.408	0.408	0.408

Panel B: Forecast Revision Informativeness				
	(1) [-9PM,8AM]	(2) [-10PM,7AM]	(3) [-11PM,6AM]	(4) [12AM,5AM]
Sleep_Dep	-0.059***	-0.073***	-0.084***	-0.094***
	(3.02)	(3.06)	(2.51)	(2.62)
Abs_Revision	18.140***	18.107***	18.129***	18.146***
	(5.87)	(5.85)	(5.86)	(5.85)
Gen_Exp	0.141**	0.141**	0.139**	0.144**
	(2.44)	(2.44)	(2.41)	(2.46)
Firm_Exp	-0.012	-0.013	-0.013	-0.012
	(0.81)	(0.83)	(0.83)	(0.82)
Horizon	0.014***	0.014***	0.014***	0.014***
	(7.72)	(7.71)	(7.71)	(7.71)
Broker_Size	-0.002	-0.002	-0.002	-0.002
	(1.31)	(1.22)	(1.13)	(1.10)
Past_Accy	-0.000	-0.000	-0.000	-0.000
	(0.06)	(0.09)	(0.08)	(0.08)
Port_Size	0.010***	0.010***	0.010***	0.010***
	(2.81)	(2.78)	(2.77)	(2.76)
Decision_Rank	-0.085	-0.089	-0.093	-0.094
	(1.13)	(1.16)	(1.22)	(1.22)
Analyst-Firm FE	Yes	Yes	Yes	Yes
Firm-Quarter FE	Yes	Yes	Yes	Yes
Day-of-Week FE	Yes	Yes	Yes	Yes
N	115228	115228	115228	115228
R^2	0.724	0.724	0.724	0.724

Table 6: This table presents regression results for forecast accuracy and informativeness for analysts with different seniority. The dependent variables are as follows: Accuracy is the negative value of the PMAFE, where PMAFE is the proportional mean absolute forecast error; informativeness is the absolute value of the two-day excess return against the Fama-French three-factor model. Sleep_Dep is the number of reports generated during the period of 12 a.m. and 5 a.m. (not included) in the previous night. Other variables are defined in Appendix 1. Absolute values of t-statistics are reported in the parentheses with heteroskedastic-consistent standard errors double clustered by analyst and quarter. $*$, $**$, and $***$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Accuracy		Informativeness	
	Junior	Senior	Junior	Senior
Sleep_Dep	-0.012*	-0.010	-0.127***	-0.072
	(1.82)	(1.41)	(3.12)	(1.25)
Abs_Revision			13.819***	24.277***
			(3.42)	(4.25)
Gen_Exp	-0.016	0.013	-0.051	0.146**
	(0.22)	(0.64)	(0.14)	(2.06)
Firm_Exp	-0.024	0.008*	-0.205***	0.005
	(0.93)	(1.84)	(5.05)	(0.22)
Horizon	-0.005***	-0.004***	0.013***	0.015***
	(18.84)	(14.49)	(7.67)	(6.03)
Broker_Size	-0.001	0.000	-0.000	-0.004
	(1.64)	(0.28)	(0.06)	(1.51)
Past_Accy	0.007***	0.008***	0.001	0.001
	(5.38)	(5.84)	(0.16)	(0.16)
Port_Size	0.000	0.003*	0.016***	0.017**
	(0.26)	(1.67)	(2.70)	(2.30)
Decision_Rank	-0.031**	-0.031***	-0.259***	0.006
	(2.45)	(3.44)	(4.40)	(0.04)
Analyst-Firm FE	Yes	Yes	Yes	Yes
Firm-Quarter FE	Yes	Yes	Yes	Yes
Day-of-Week FE	Yes	Yes	Yes	Yes
Observations	49996	57927	45549	54514
R^2	0.490	0.479	0.740	0.731

Table 7: This table presents regression results for forecast accuracy and informativeness for analysts with different gender. The dependent variables are as follows: Accuracy is the negative value of the PMAFE, where PMAFE is the proportional mean absolute forecast error; informativeness is the absolute value of the two-day excess return against the Fama-French three-factor model. Sleep_Dep is the number of reports generated during the period of 12 a.m. and 5 a.m. (not included) in the previous night. Other variables are defined in Appendix 1. Absolute values of t-statistics are reported in the parentheses with heteroskedastic-consistent standard errors double clustered by analyst and quarter. $*$, $**$, and $***$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Accuracy		Informativeness	
	Male	Female	Male	Female
Sleep_Dep	-0.017***	-0.001	-0.097**	-0.093
	(3.08)	(0.05)	(2.59)	(0.61)
Abs_Revision			15.494***	40.541***
			(5.20)	(4.07)
Gen_Exp	-0.019	-0.035	0.103*	0.509***
	(0.90)	(1.10)	(1.74)	(2.68)
Firm_Exp	0.006	0.021	-0.006	-0.070
	(1.53)	(1.08)	(0.33)	(1.61)
Horizon	-0.004***	-0.005***	0.014***	0.015***
	(18.64)	(7.98)	(7.70)	(4.59)
Broker_Size	-0.000	0.004	-0.001	-0.011
	(0.63)	(1.19)	(0.35)	(1.00)
Past_Accy	0.004***	0.009***	0.000	-0.030***
	(3.91)	(2.81)	(0.15)	(3.30)
Port_Size	0.001	-0.004	0.006	0.047**
	(1.17)	(0.78)	(1.54)	(2.22)
Decision_Rank	-0.024***	-0.056**	-0.087	-0.200
	(3.37)	(2.26)	(1.01)	(1.15)
Analyst-Firm FE	Yes	Yes	Yes	Yes
Firm-Quarter FE	Yes	Yes	Yes	Yes
Day-of-Week FE	Yes	Yes	Yes	Yes
Observations	106950	8282	99167	7721
R^2	0.424	0.504	0.730	0.679

Table 8: This table presents regression results for forecast accuracy and informativeness under different workloads. The dependent variables are as follows: Accuracy is the negative value of the PMAFE, where PMAFE is the proportional mean absolute forecast error; informativeness is the absolute value of the two-day excess return against the Fama-French three-factor model. Sleep_Dep is the number of reports generated during the period of 12 a.m. and 5 a.m. (not included) in the previous night. Other variables are defined in Appendix 1. The absolute value of t-statistics is reported in the parenthesis with heteroskedastic-consistent standard errors double clustered by analyst and quarter. $*$, $**$, and $***$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Accuracy		Informativeness	
	Low Workload	High Workload	Low Workload	High Workload
Sleep_Dep	-0.006	-0.023***	-0.084*	-0.126***
	(0.92)	(3.07)	(1.82)	(2.78)
Abs_Revision			21.901***	15.435***
			(4.88)	(3.72)
Gen Exp	0.010	-0.027	0.118	0.246**
	(0.60)	(1.07)	(1.28)	(2.45)
Firm_Exp	0.006	0.007	-0.014	-0.031
	(1.32)	(0.96)	(0.77)	(1.04)
Horizon	-0.004***	-0.004***	0.013***	0.016***
	(19.67)	(12.88)	(7.17)	(7.29)
Broker_Size	0.001	-0.000	-0.002	-0.002
	(1.05)	(0.52)	(0.74)	(0.92)
Past_Accy	0.003***	0.003**	-0.004	-0.000
	(3.59)	(2.05)	(1.07)	(0.04)
Port_Size	0.000	0.001	0.007	0.004
	(0.09)	(0.88)	(1.28)	(0.91)
Decision_Rank	-0.042***	-0.014	-0.137**	-0.031
	(4.91)	(1.36)	(2.14)	(0.29)
Analyst-Firm FE	Yes	Yes	Yes	Yes
Firm-Quarter FE	Yes	Yes	Yes	Yes
Day-of-Week FE	Yes	Yes	Yes	Yes
Observations	56414	60144	52194	55856
R^2	0.421	0.452	0.716	0.736

Table 9: This table presents regression results for the determinates of sleep deprivation. The dependent variable is the sleep deprivation. For example, SD4[12AM,5AM] is the number of reports generated during the period of 12 a.m. and the 5 a.m. (not included) in the previous night. The independent variables are firm size, ROA, analysts following, trading volume, and book-to-market ratio. Definitions of The valuables are provided in Appendix 1. The absolute value of t-statistics are reported in the parentheses with heteroskedastic-consistent standard errors double clustered by analyst and quarter. $*$, $**$, and $***$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Sleep_Dep			
	[-9PM,8AM]	[-10PM,7AM]	[-11PM,6AM]	[12AM,5AM]
Size	0.007**	0.003	0.002	0.001
	(2.08)	(1.28)	(1.18)	(0.72)
ROA	0.046	0.052	0.061	0.081*
	(0.47)	(0.64)	(0.96)	(1.67)
Trading_Volume	-0.001	-0.000	0.000	0.001*
	(0.50)	(0.42)	(0.16)	(1.97)
Following	0.001	0.001**	0.001**	0.001**
	(1.30)	(2.28)	(2.54)	(2.34)
BTM	-0.037***	-0.037***	-0.017**	-0.021***
	(2.73)	(3.95)	(2.42)	(3.61)
Analyst-Quarter FE	Yes	Yes	Yes	Yes
Day-of-Week FE	Yes	Yes	Yes	Yes
N	142417	142417	142417	142417
R^2	0.462	0.458	0.469	0.488

Figures

Figure 1: This figure demonstrates the construction of the sleep deprivation variable. The X-axis is the points of time in 24 consecutive hours, where 12 a.m. denotes midnight. The red line segments represent the time intervals used to define sleep deprivation. The red brackets represent the time interval for the definition of sleep deprivation; the black brackets represent the time interval of the earnings forecast by the same analyst.

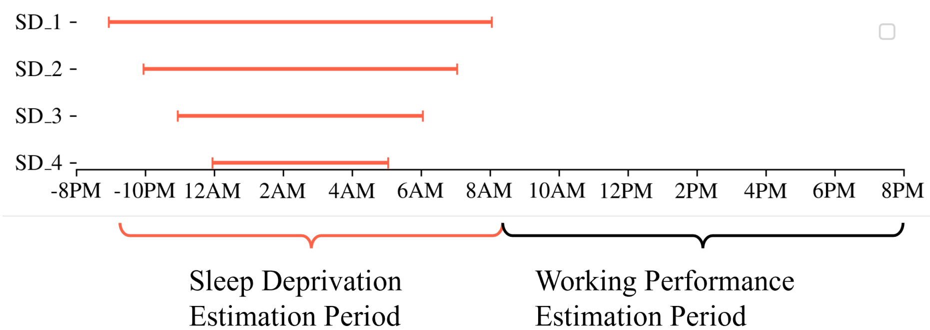
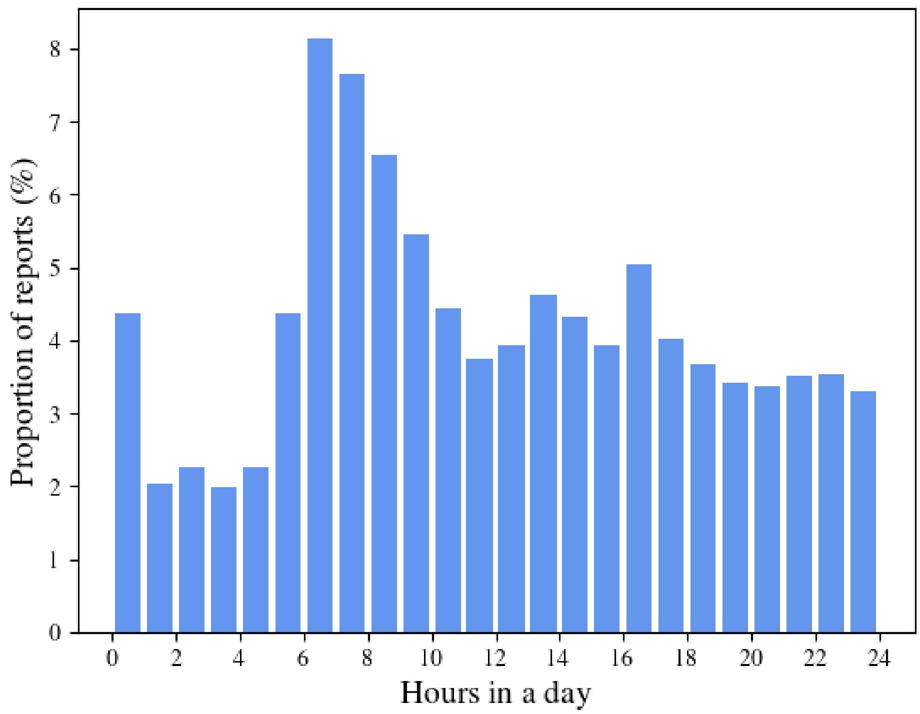


Figure 2: This figure plots the intraday distribution of the PDF report creation time. The X-axis is the 24 hours in a day and the Y-axis is the proportion of reports created during the hour.

(a) Intraday PDF Generation Distribution



(b) Intraday PDF Generation Distribution By Days in the Week

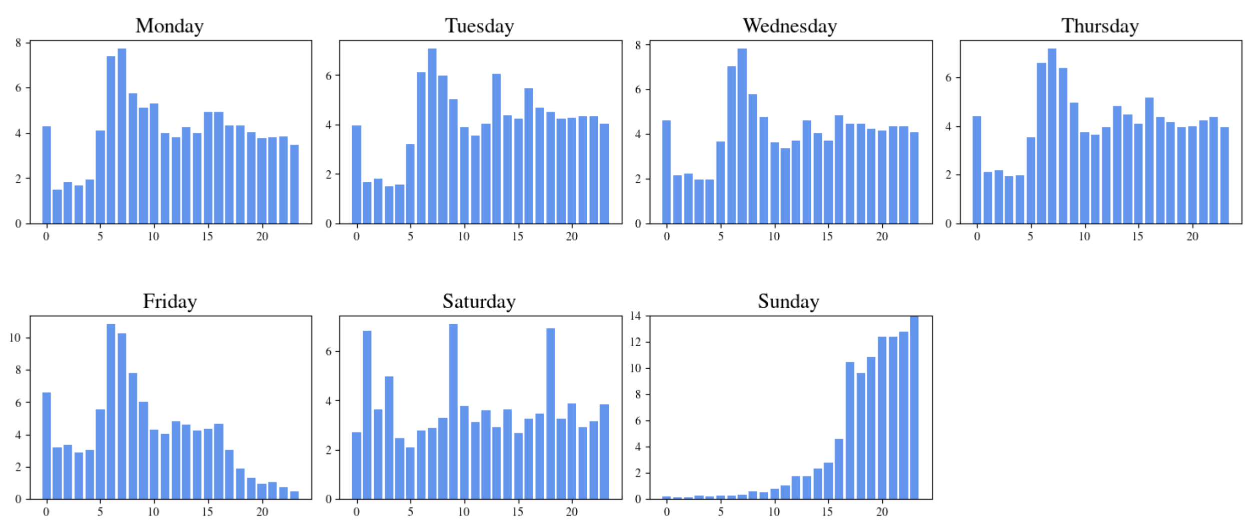


Figure 3: This figure displays the distribution of the "Night-owls" in the investment banks that generated more than 10,000 reports from 2008 to 2013. The x-axis is the number of analysts in the investment banks; the y-axis is the total number of reports (in thousands) by analysts working in the investment banks. The area of the circle represents the proportion of "Night-owls" in the investment banks, where "Night-owls" are defined as the analysts ranked in the top decile of sleep deprivation (from 12 a.m. to 5 a.m.) from 2008 to 2013. Circles in red represent the banks with PWP.

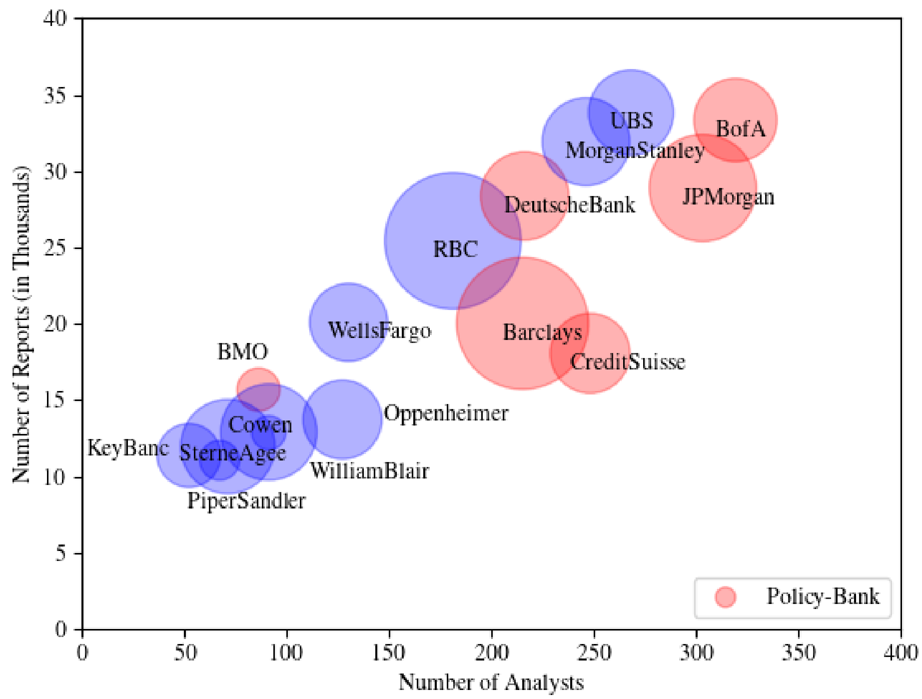


Figure 4: This figure plots the distribution of the estimate of the simulation-based falsification tests. During each repetition, I randomly assign a creation time to a selected PDF report from the 24 hours in a day. I then calculate the number of reports finished between 12 a.m. and 5 a.m. as the measure of sleep deprivation. Next, I reestimate the baseline test as in Column 3 of table 2 and table 3 for 1,000 times. Panel A displays the distribution of the coefficients representing the effect of sleep deprivation on forecast accuracy. Panel B displays the distribution of the coefficients representing the effect of sleep deprivation on forecast revision informativeness. The vertical line represents the effect of sleep deprivation in the true data.

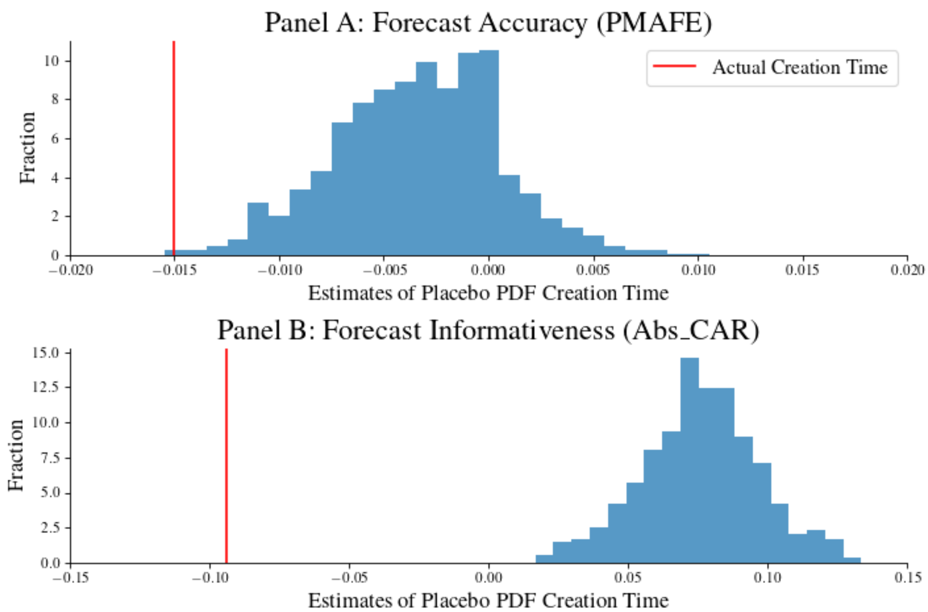
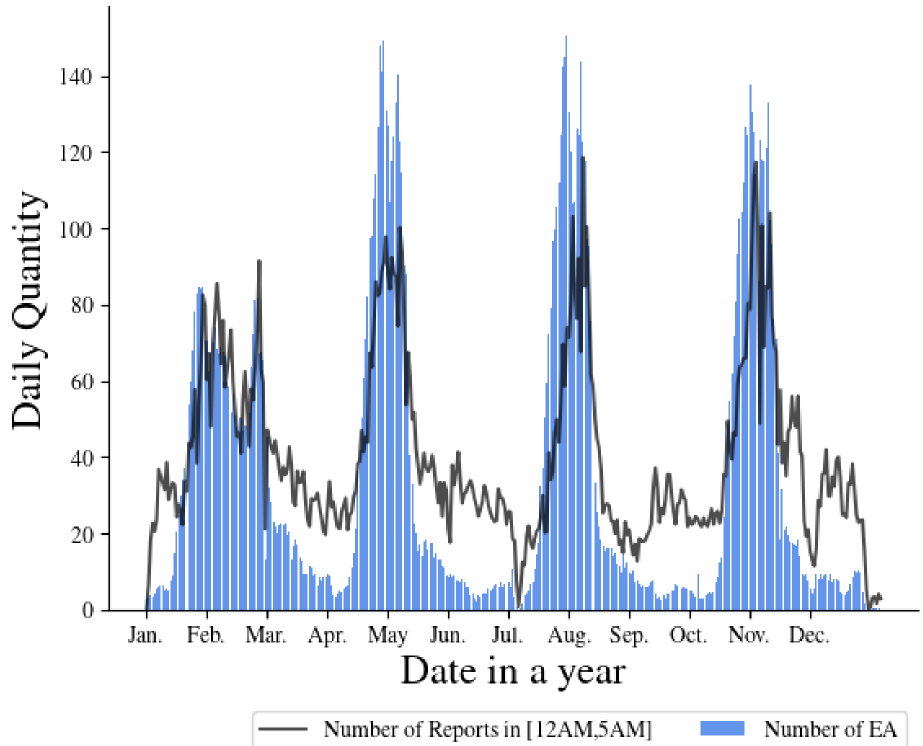


Figure 5: This figure displays the density distribution of the firms' earnings announcement and the number of reports generated in late-night hours from 2008 to 2021. The bar chart represents the daily count of the number of firms' earnings announcements throughout the year; the line chart represents the resolution of the number of reports generated between 12 a.m. and 5 AM.



Appendix

Variable Definition

Variables in the body tests	
Accuracy	I first calculate the proportional mean absolute forecast error (PMAFE) as the difference between the absolute forecast error of an analyst and the average absolute forecast error across all analysts covering the firm, scaled by the average absolute forecast error. Since negative (positive) values of PMAFE indicate above (below) average performance, Accuracy is defined as PMAFE $\times$ (-1).
Informativeness	I first calculate the CAR as the Fama-French three-factor adjusted excess return over the two-day period beginning on the forecast announcement date. Then Informativeness is defined as the the absolute value of CAR, multiplied by 100.
Sleep_Dep	Number of reports generated in the late-night hours before the forecast announcement date. Where the late-night hours are defined as the time between 12 a.m. and 5 a.m. (not included).
Abs_Revision	The absolute difference between the current earnings forecast and the preceding forecast by the analyst for the same quarter, scaled by the stock price at the end of the previous quarter. The final values are multiplied by 100 for better presentation.
Gen_Exp	Number of quarters since the analyst first issued a forecast for any IBES firm.
Firm_Exp	Number of quarters since the analyst first issued a forecast for the corresponding firm.
Horizon	The natural logarithm of the number of days between a forecast and fiscal quarter-end.
Broker_Size	Number of analysts a broker employed in a given quarter.
Past_Accy	The decile rank of analyst i on average absolute forecast error for all analysts covering firm j in the previous quarter.
Port_Size	Number of firms covered by the analyst.
Decision_Rank	The logarithm of one plus the number of earnings forecast the analysts has issued in a day.
Night Owl	An indicator that equals one if the analyst's sleep deprivation is in the top decile from 2008 to 2013 before the implementation of the "protected weekend" policy.
Policy Bank	An indicator that equals one if the analyst works in an investment bank that implements the "protected weekend" policy.
Post Policy	An indicator that equals one if the forecast is issued after the implementation of the "protected weekend" policy. For non-policy banks, this value equals one after the 1st January of 2014.

Variables in additional tests and appendix	
Size	The natural logarithm of the market value of the equity at the end of the previous fiscal quarter.
ROA	The ratio of the quarterly income before extraordinary items to the book value of assets at the end of the previous fiscal quarter.
Trading Volume	The trading volume (in million shared) for firm j in the quarter t.
Following	Number of analysts following firm j in the quarter t.
BTM	The ratio of the book value of assets to the market value of assets at the end of the previous fiscal quarter.
Dummy SD4	A dummy variable that equals one if at least one report is generated in the late-night hours before the forecast announcement date. Where the late-night hours are defined as the time between 12 a.m. and 5 a.m..
Lag1_Sleep_Dep	One-day lagged value of the *Sleep_Dep*.
Lag2_Sleep_Dep	Two-days lagged value of the *Sleep_Dep*.
File Pages	Average number of pages in the PDF reports.

Table A2: This table reports the descriptive statistics for variables used in the additional tests section and in the appendix.

	Observations	Mean	SD	Min	Median	Max
Sleep_Dep [-9PM,8AM]	122777	0.675	0.947	0.000	0.000	5.000
Sleep_Dep [-10PM,7AM]	122777	0.518	0.804	0.000	0.000	4.000
Sleep_Dep [-11PM,6AM]	122777	0.330	0.641	0.000	0.000	3.000
Size	122777	8.845	1.541	5.365	8.788	12.509
ROA	122716	0.007	0.033	-0.164	0.009	0.086
Trading_Volume	122777	2.123	3.320	0.038	0.979	20.426
Following	122777	15.414	7.119	5.000	15.000	35.000
MTB	122736	0.627	0.294	0.090	0.614	1.422
Lag1_Sleep_Dep	122777	0.093	0.340	0.000	0.000	2.000
Lag2_Sleep_Dep	122777	0.037	0.190	0.000	0.000	1.000
#Pages_1	49980	9.674	5.699	1.000	8.000	38.667
#Pages_2	40717	10.043	5.891	1.000	9.000	40.000
#Pages_3	27355	10.630	6.258	1.000	9.000	42.000
#Pages_4	18914	11.208	6.540	1.000	10.000	45.000

Pdf Metadata

PDF's popularity among financial analysts can be attributed to several key factors. First, PDF format is known for its ability to preserve the integrity and readability of documents, ensuring that the content, formatting, and layout remain consistent across different devices and platforms. In the financial market, maintaining the accuracy of data, charts, tables, and graphs is crucial. This feature is particularly valuable when sharing complex financial information.

Security is of paramount importance in the financial industry, where sensitive information such as investment strategies, market insights, and proprietary data is frequently shared. PDF documents offer a range of security features that financial analysts can leverage to protect their reports. These include encryption, digital signatures, and metadata records. Encryption helps restrict access to authorized clients, preventing unauthorized distribution or modification. Digital signatures provide a means of verifying the authenticity and integrity of the document, ensuring that it has not been tampered since its creation.

Table A3: Examples of PDF Metadata. This table displays the metadata in five randomly selected reports. Column 1 reports the id of the reports. Column 2 and Column 3 report the initial creation date and time of the reports. Column 4 reports the timezone of the device used to generate the PDF report. Column 5 and Column 6 report the last modification date and time of the reports. Column 7 reports the person or the organization of the PDF report. Column 8 reports the software or application used to create the PDF document. Column 9 reports the software or application used to convert the document into PDF format.

Report ID	Creation Date	Creation Time	Timezone	Modification Date	Modification Time	Author	Creator	Producer
US082267601	20080428	095536	-7	20080428	130448	cdenny	PScript5.dll Version 5.2	Acrobat Distiller 7.0.5 (Windows)
US113012056	20110727	080215	-4	20110727	080215	N/A	N/A	iText 2.1.7 by 1T3XT
US140000019	20140227	104451	-5	20140227	104455	Bryan Goldberg	Acrobat PDFMaker 10.1 for Word	Adobe LiveCycle PDF Generator ES3
US193021388	20190801	094431	-4	20190801	094431	Software Solutions Group	Microsoft® Word 2016	Microsoft® Word 2016
US203002049	20200803	210540	-4	20200803	210545	N/A	pdfg	modified using iTextSharp 5.4.4 2000-2013 1T3XT BVBA (AGPL-version)

Figure A1: This table displays the timestamps within the text of PDF reports for selected investment banks. These timestamps often record the information about when the document is produced or distributed and the timezone. The names of the investment banks are reported at the top of each figure.

(a) Bank of American

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Refer to important disclosures on page 8 to 10. Analyst Certification on page 6. Price Objective Basis/Risk on page 6. 11677936

Timestamp: 25 October 2016 06:04PM EDT

(b) Morgan Stanley

Morgan Stanley | RESEARCH UPDATE

August 4, 2020 01:05 AM GMT

Five9 Inc | North America

MORGAN STANLEY & CO. LLC
Meta A Marshall

(c) Royal Bank of Canada

Disseminated: Dec 2, 2021 03:44EST; Produced: Dec 2, 2021 03:44EST
For Required Conflicts Disclosures, see page 8

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(d) JP Morgan

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Completed 09 May 2023 07:09 AM BST

Disseminated 09 May 2023 07:11 AM BST

(e) Walls Fargo

Please see page 8 for rating definitions, important disclosures and required analyst certifications. All estimates/forecasts are as of 08/01/19 unless otherwise stated. 08/01/19 09:44:30 ET

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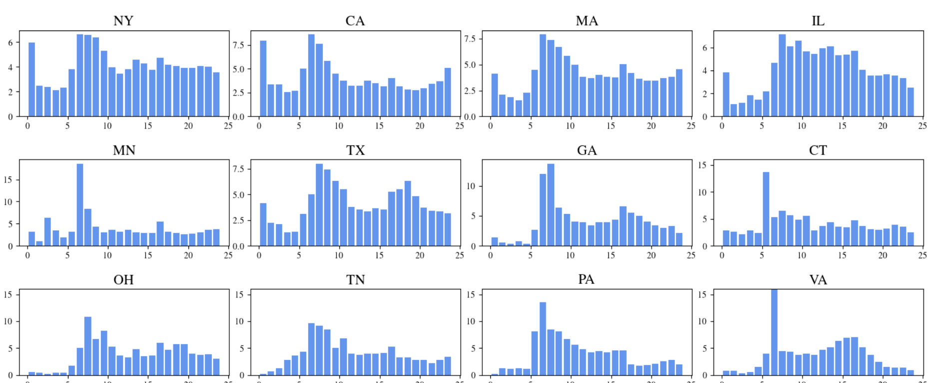
Together we'll go far

Figure A2: This figure plots the intraday distribution of the PDF report creation time for analysts located in 12 US states, including New York (NY), Califonia (CA), Massachusetts (MA), Illinois (IL), Minnesota (MN), Texas (TX), Georgia (GA), Connecticut (CT), Ohio (OH), Tennessee (TN), Pennsylvania (PA), and Virginia (VA). The X-axis is the 24 hours in a day and the Y-axis is the proportion of reports created during the hour. The subfigures are arranged in descending order of the number of analysts residing in the state, where the location is identified from the phone number in the PDF reports.



Additional Robusness Checks

Table A4: This table reports the results for additional tests. The dependent variable, Informativeness, is the absolute value of CAR, where CAR is calculated as the two-day excess return against the Fama-French three-factor model. The independent variable is the average number of pages for the PDF reports generated during the corresponding late-night hours intervals. Other variables are defined in the Appendix. Absolute values of t-statistics are reported in the parentheses with heteroskedastic-consistent standard errors double clustered by analyst and quarter. $*$, $**$, and $***$ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)
	Informativeness			
	[-9PM,8AM]	[-10PM,7AM]	[-11PM,6AM]	[12AM,5AM]
File Pages	-0.029***	-0.026***	-0.022***	-0.023*
	(5.94)	(5.09)	(4.50)	(3.80)
AbsRevision	36.951***	37.596***	37.451***	38.308***
	(9.98)	(8.67)	(7.36)	(6.31)
Gen_Exp	0.028	0.026	0.036	0.010
	(1.40)	(1.39)	(1.12)	(0.26)
Firm_Exp	-0.034*	-0.030	-0.041	-0.015
	(1.68)	(1.61)	(1.22)	(0.40)
Horizon	0.012***	0.012***	0.012***	0.012***
	(7.66)	(7.80)	(7.31)	(6.54)
Broker_Size	-0.006	-0.008	-0.007	-0.007
	(0.99)	(1.20)	(0.99)	(0.74)
Past_Accy	-0.029***	-0.031***	-0.021**	-0.025**
	(3.73)	(3.62)	(2.23)	(2.33)
Port_Size	0.002	0.004	0.003	0.003
	(0.39)	(0.53)	(0.33)	(0.26)
Decision_Rank	-0.003	0.032	0.013	0.104
	(0.03)	(0.36)	(0.12)	(0.78)
Analyst-Brokerage-Firm FE	Yes	Yes	Yes	Yes
Brokerage FE	Yes	Yes	Yes	Yes
Year-Week FE	Yes	Yes	Yes	Yes
Day-of-Year FE	Yes	Yes	Yes	Yes
N	52666	41782	26693	17953
R^2	0.424	0.430	0.441	0.446

Table A5: This table presents results for additional robustness tests. The dependent variables are the negative value of the PMAFE and AbsCAR, where PMAFE is the proportional mean absolute forecast error and AbsCAR is the absolute value of the two-day excess return against the Fama-French three-factor model. Sleep_Dep is the number of reports generated during the period of 12AM and the 5AM (not included) in the previous night. Dummy SD4 is a dummy variable that equals one if SD4 is positive. Lag1 SD4 and Lag2_Sleep_Dep are the one-day and two-days lagged variables of *Sleep_Dep*. Other variables are defined in the Appendix 1. Absolute value of t-statistics are reported in the parenthesess with heteroskedastic-consistent standard errors double clustered by analyst and quarter. ∗, ∗∗, and ∗ ∗ ∗ indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Dummy Variable		Including Lags		Alternative FE	
	PMAFE	AbsCAR	PMAFE	AbsCAR	PMAFE	AbsCAR
Sleep_Dep			-0.015***	-0.093***	-0.018**	-0.092*
			(3.34)	(2.61)	(1.97)	(1.74)
Dummy_Sleep_Dep	-0.016***	-0.167***				
	(2.77)	(3.76)				
Lag1_Sleep_Dep			-0.004	-0.053		
			(0.61)	(1.64)		
Lag2_Sleep_Dep			0.016	-0.109*		
			(1.16)	(1.69)		
Abs_Revision		18.149***		18.147***		26.169***
		(5.85)		(5.85)		(6.28)
Gen_Exp	-0.011	0.144**	-0.011	0.144**		
	(0.71)	(2.46)	(0.70)	(2.47)		
Firm_Exp	0.007*	-0.013	0.007*	-0.012		
	(1.66)	(0.82)	(1.66)	(0.81)		
Horizon	-0.004***	0.014***	-0.004***	0.014***	-0.005***	0.014***
	(19.55)	(7.71)	(19.63)	(7.75)	(39.05)	(18.40)
Broker_Size	0.000	-0.002	0.000	-0.002	-0.005	0.028*
	(0.15)	(1.07)	(0.18)	(1.02)	(1.13)	(1.69)
Past Accy	0.003***	-0.000	0.003***	-0.000		
	(4.09)	(0.05)	(4.08)	(0.07)		
Port_Size	0.001	0.010***	0.001	0.010***		
	(0.68)	(2.77)	(0.68)	(2.81)		
Decision_Rank	-0.029***	-0.098	-0.028***	-0.096	-0.045***	-0.166***
	(4.31)	(1.25)	(4.13)	(1.24)	(4.61)	(3.08)
Analyst-Firm-Qtr FE	No	No	No	No	Yes	Yes
Analyst-Firm FE	Yes	Yes	Yes	Yes	No	No
Firm-Quarter FE	Yes	Yes	Yes	Yes	No	No
Day-of-Week FE	Yes	Yes	Yes	Yes	Yes	Yes
N	124197	115228	124197	115228	39434	36907
R^2	0.408	0.724	0.408	0.724	0.534	0.597

Protected Weekend Policy

Table A6: Univariate Statistics for "Night-owls" vs "Non-night-owls" before the PWP

	Night-owls N = 3362	Non-night-owls N = 37830	P-value
Abs_CAR	3.931	3.373	0.000
PMAFE	0.029	-0.008	0.001
Sleep_Dep	0.344	0.201	0.000
Gen_Exp	33.733	36.259	0.000
Firm_Exp	14.878	17.609	0.000
Horizon	60.118	58.946	0.022
Broker_Size	41.965	45.345	0.000
Portfolio Size	12.476	13.958	0.000
Firm_Size	8.233	8.361	0.000
Trading_Volume	2.331	2.088	0.000
ROA	0.010	0.011	0.039
Following	15.235	14.295	0.000
MTB	0.620	0.677	0.000

Table A7: Protected Weekend Policy in Investment Banks. This table lists the implementation of the "protected weekend" policies in investment banks. I verify and complement the policies documented by Okat and Vasudevan (2023).

Investment Bank	Policy Date	Protected Time
Goldman Sachs	20131108	Friday 9:00 PM to Sunday 9:00 AM
JP Morgan	20140101	One weekend a month
Bank of American	20140110	Four weekend days off per month
Credit Suisse	20140108	Four weekend days off per month
Bank of Montreal	20140123	From Friday 14:00 PM
Citibank	20140207	Friday 10:00 PM to Sunday 10:00 AM
Barclays	20140228	Mandatory off after 12 consecutive days of work
Deutsche Bank	20140409	Some weekend days off