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INFORMATION-BASED TRADING AND DAY-OF-THE-WEEK EFFECT

This study investigates the role of information based trading in explaining the difference in return patterns for securities across days of the week. The empirical results suggest that uninformed liquidity traders are the most active at the beginning of the week and become less active throughout the week. On the other hand, informed traders extensively use accumulative information to perform their trade at the end of the week. Overall, the results are consistent with the information-based trading hypothesis that trading activity of informed and uninformed liquidity traders are the primary cause of the differences in returns across days of the week.

JEL Classification: *G11, G14, G24.*

Keywords: *information-based trading; institutional investor; day-of-the-week effect.*

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ТРЕЙДИНГ, ЗАСНОВАНИЙ НА ІНФОРМАЦІЇ, І ЕФЕКТ ДНЯ ТИЖНЯ

В статті вивчено роль трейдингу, заснованого на інформації, в поясненні різниці прибутків від цінних паперів за днями тижня. Результати емпіричного дослідження показують, що неінформовані трейдери найбільш активні на початку тижня і стають менш активними в її кінці. З іншого боку, інформовані трейдери широко використовують накопичувальну інформацію для торгівлі в кінці тижня. В цілому, результати узгоджуються з гіпотезою трейдингу, заснованого на інформації про те, що торговельна активність інформованих і неінформованих трейдерів є основною причиною відмінностей прибутків за днями тижня.

Ключові слова: *трейдинг, заснований на інформації, інституційний інвестор, ефект дня тижня у трейдингу.*

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ТРЕЙДИНГ, ОСНОВАННЫЙ НА ИНФОРМАЦИИ, И ЭФФЕКТ ДНЯ НЕДЕЛИ

В статье изучена роль трейдинга, основанного на информации, в объяснении разницы прибылей от ценных бумаг по дням недели. Результаты эмпирического исследования показывают, что неинформированные трейдеры наиболее активны в начале недели и становятся менее активными к ее концу. С другой стороны, информированные трейдеры широко используют накопительную информацию для торговли в конце недели. В целом, результаты согласуются с гипотезой трейдинга, основанного на информации о том, что торговая активность информированных и неинформированных трейдеров является основной причиной различия прибылей по дням недели.

Ключевые слова: *трейдинг, основанный на информации, институциональный инвестор, эффект дня недели в трейдинге.*

I. Introduction. In the past 20 years, there has been a significant number of empirical researches documenting seasonal patterns in stock returns. One of the oldest and persistent is day-of-the-week effect which states that return, on average, tends to be the lowest on Monday and the highest on Friday. Cross (1973), French (1980)

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and Gibbons and Hess (1981) documented the difference in return patterns for securities across days of the week. Cross (1973) reported the relationship between price changes on Monday and Friday. French (1980) investigated daily stock return for S&P's Composite and found that the expected return on Monday was significantly negative. Gibbons and Hess (1981) and Wang, Li and Erickson (1997) reported the strong and persistent negative mean returns on Monday for stocks and below-average returns for treasury bills on Monday.

Various findings have been proposed to explain these patterns of the day-of-the week effect. These include the settlement and clearinghouse procedures, bid-ask spread biases, trading behavior of individual and institutional investors and investor's reactions to news and information release accumulated over weekend. Lakonishok and Levi (1985) argue that the differences in the returns occur as a result of time lag between trading and settlement in stock and the time of the clearing procedure. Keim and Stambaugh (1984) found the correlation between Friday and Monday returns being positive and the highest of days and the result is consistent with fairly general measurement-error explanations. Lakonishok and Maberly (1990), Abraham and Ikenburry (1994) and Sias and Starks (1995) examined the role of individual and institutional investors. While Lakonishok and Maberly (1990), Abraham and Ikenburry (1994) suggested that individual investors are active sellers of stock on Monday and therefore create buy to sell imbalance which is a primary cause of weekend effect. Sias and Starks (1995) argued that day-of-the week pattern in return and volumes are more pronounced in the securities in which institutional investors play a greater role and should be responsible in the differences in returns across days of the week.

This study examines the role of informed and uninformed liquidity trader in explaining the differences in the day-of-the week effect of stock return. Using sequential trade market microstructure model developed by Easley, Kiefer and O'Hara (1997), it differs in 3 aspects from prior studies that examine the day-of-the-week effect. First, it provides insight on how information and signal from trades varies across days which results in differences in investor's trading behaviors. Second, prior researches investigated the day of the week effect by focusing on the daily return, trading volume and proxy of institutional traders such as odd-lot trades, We provide additional insights into the analysis by using intraday transaction data. Third, while previous studies examine the role of individual and institutional investors as a cause of day-of-the-week effect, this study examines the trading patterns of informed traders and uninformed liquidity traders as the alternative explanation of the day-of-the-week effect.

The results of the analysis include the following. First, the amount of information accumulated over the weekend and bad news explain only a small proportion of the differences in days of the week. Second, information-based trading occurs extensively at the end of a week. Consequently, informed traders extensively use accumulated information to perform their trade at the end of a week, especially on Thursday. Third, information-based trading has consistently increased over time which can be attributed to the dramatically increase in the institutional investors in large market capitalization stocks.

The remainder of this study is organized in 4 sections. Section II describes the sequential trade market microstructure model. Section III containes the data descriptions and sample screening procedures. Section IV reports the empirical results and discussion of findings and Section V contains conclusions.

II. The Sequential Trade Model. Easley and O'Hara (1992) developed the theoretical sequential trade model in which trade provides the direction of new information and lack of trade provides signal of the existence of any new information. Hence, market makers and traders adjust their belief about the value of the asset according to recent arrival information. The sequential trade model enables researchers to examine various applications of the market; for example, differences in spread patterns of active and infrequently traded stocks — Easley, Kiefer, O'Hara and Paperman (1996); role of purchased order flow — Easley. Kiefer, O'Hara (1996); information role of a financial analyst — Easley, O'Hara and Paperman (1998); information role of transaction volume in option market — Easley, O'Hara and Srinivas (1998); information-based trading at dealer and auction market — Heidle and Huang (1999).

In this study, we use the sequential trade model developed by Easley, Kiefer, O'Hara (1997), thereafter EKO. The model consists of informed and liquidity traders who trade the single asset with market maker during a continuous trading day. All market participants are risk neutral and competitive. Market maker sets price in which asset will be traded and revised using Bayesian analysis. Informed and liquidity traders choose whether to trade (buy or sell) or not to trade for a given price. By assuming the independence of information between trading days, the probability of information event occurring prior to a trading day of α can be derived from the model. The probability of information event occurring prior to the trading day could convey a bad signal with the probability of δ or good signal with the probability of 1-δ. During each trading day, informed traders may observe the signal and decide to trade with the probability of μ. Informed traders decide to trade only if there is an information event. Uninformed liquidity traders, however, decide to trade regardless of information event with the probability of ε. Then, probability parameters can be estimated by maximum likelihood function. The likelihood of observing the number of buys (B), the number of sells (S) and the number of no trade (N) on a single day is specified by

$$\begin{aligned} \Pr\{B,S,N|\alpha,\delta,\mu,\varepsilon\} = {} & (1-\alpha)[[\mu+(1-\mu)S(\varepsilon)]^B \\ & [(1-\mu)S(\varepsilon)]^S[(1-\mu)(1-\varepsilon)]^N] \\ & +\alpha\delta\,[[1-\mu)S(\varepsilon)]^B[\mu+(1-\mu)S(\varepsilon)]^S \\ & [(1-\mu)(1-\varepsilon)]^N]+(1-\delta)[[S(\varepsilon)]^{B+S}(1-\varepsilon)^N] \end{aligned} \tag{1}$$

Assuming that the information event is independent between days, EOK derive the likelihood of observing trade data over *k* days as

$$\Pr\{B_k,S_k,N_k|\alpha,\delta,\mu,\varepsilon\}\ {}^{D}{}_{d=1} = \prod_{k=1}^{k} \Pr\{B_k,S_k,N_k\ |\alpha,\delta,\mu,\varepsilon\} \tag{2}$$

Given these parameters, the probability of informed trading (PI) on each trading day can be estimated by

$$PI = \frac{\alpha\mu}{\alpha\mu+2\varepsilon} \tag{3}$$

III. Data Description and Sample Screening Procedures

A. Data Description. The intraday data was obtained from New York Stock Exchange's Trade and Quote (TAQ) database. It includes time-stamped to second and price of all trades and quotes during trading day. The sample used in this study consists of 30 companies[2] listed in Dow Jones Industrial Average (DJIA) during the period from January 2003 to November, 30, 2008. All trading days during the sample period were classified into 5 groups according to the day of the week.

B. Sample Screening Procedures. In the study, we use only best bid or offer (BBO) eligible quotes. We also exclude all trades and quotes occurring before 9:30 a.m. and after 4:00 p.m. and the opening transaction price since it is typically conducted in the different market mechanisms. We discard trades and quotes initiated from other exchanges except for NYSE and AMEX.

The estimation procedure requires the classification of the number of buys, sells and no trades for each stock. We therefore make several adjustments to the sample data. First, large order sometimes has multiple participants on one side of the trade which in fact should be treated as one trade. Second, quotes may be recorded earlier than trades even when trades precede the quotes. To solve these problems, we follow the standard approach employed by researchers[3]. Hasbrouck (1988) suggests matching trade with the last quote of more than 5 second and combining all trades occurring within 5 seconds. Not surprisingly, it significantly reduces the misclassification trades by approximately 17% of the total sample.

To classify the direction of the trades, we employ the methodology developed by Lee and Ready (1991) which classifies directions based on trade initiation. Trades above (below) midpoint of spread on the last quote are buyer (seller) initiated and classified as buy (sell). Trades at the midpoint of spread on the last quote are classified by matching them up to the previous trade prices. Trades executed at the higher (lower) prices than previous trade are classified as buy (sell). If trade price is the same as that of the previous trade, then it is compared to next previous trade on the same trading day until trade direction is classified. To identify the number of no trade in each day, the choice of 30-second interval would be appropriate since our sample consists of the most actively trade stocks and 30-second should be able to capture information in trade process[4].

IV. Empirical Results.

A. Parameter Estimates. The graphical representation of all the estimated parameters is presented in Figure 1. The plotted parameters of arrival rate of informed traders (μ), the arrival rate of uninformed liquidity traders (ε) and fractions of trade made by informed trading (PI) clearly show the dissimilar patterns across days of the week with the highest on Thursday. On the other hand, the plotted parameters estimated of new information event (α) new information with a low signal (δ) are consistent across days of the week.

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[2] 4 companies were added and deleted from the sample as a result of March 17, 1997's changes in DJIA listing; Citigroup (TRV) replaced Westinghouse Electric Corp. (WX), Hewlett-Packard Co. (HWP) replaced Texaco Inc (TX), Johnson & Johnson replaced Bethlehem Steel Corp. (BS) and Wal-Mart Stores Inc. (WMT) replaced Woolworth Corp. (WOW).

[3] For Example, see Easley, O'Hara, and Paperman (1998) and Heidle and Huang (1999).

[4] For discussion on sensitivity of time filter choices, see Easley, Kiefer, and O'Hara (1997).

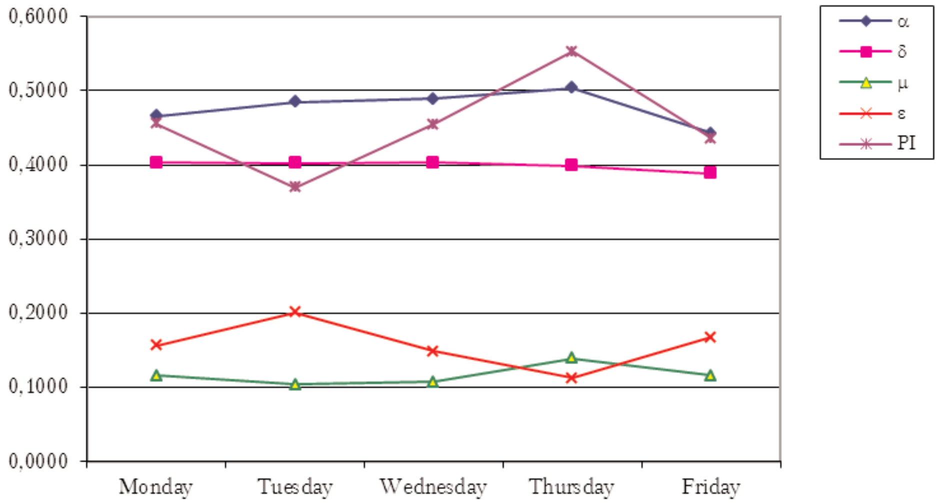

Figure 1. **Parameter estimates by day of the week**

The graph shows the plotted mean average for each estimated parameter from January 2003 to November 2008; probability of information event occurs prior to the trading day (α), probability of a new information with a bad signal (δ), the arrival rate of informed trader (μ), the arrival rate of uninformed liquidity traders (ε) and probability of information based trading (PI) by day-of-the-week.

Table 1 presents the parameters estimated with maximum likelihood function (Equation 1) by days of the week. The parameter estimation consists of the probability of information event that occurs prior to the trading day (α), probability of a new information with a bad signal (δ), the arrival rate of informed traders (μ), the arrival rate of uninformed liquidity traders (ε) and probability of information-based trading (PI). The statistical analysis is performed to examine whether the individual estimated parameters are different by days of a week. To ensure the precision of the analysis, nonparametric Kruskal-Wallis test on differences of parameters among days of the week and the Mann-Whitney test for paired comparison of parameters by days of the week were conducted.

Panel A: reports nonparametric tests. Kruskal-Wallis test is used to compare the differences on parameters probability of information event occurs prior to the trading day (α), probability of a new information with a bad signal (δ), the arrival rate of informed trader (μ), the arrival rate of uninformed liquidity traders (ε) and probability of information-based trading (PI) for each paired day. Panel B: reports nonparametric tests Mann-Whitney test is used to compare the parameters the probability of information event occuring prior to a trading day (α), probability of a new information with a bad signal (δ), the arrival rate of informed trader (μ), the arrival rate of uninformed liquidity traders (ε) and the probability of information-based trade (PI) among day-of-the-week.

Table 1. **Nonparametric Tests**

Panel A: Kruskal-Wallis Test on Parameters		
Parameters	**Test Statistics**	
α	1.1812	
δ	1.747	
μ	6.7626	
ε	11.0251*	
PI	12.8891*	
Critical Value at α (0.05) = 9.488 *Level of confidence at α = 0.05		

Panel B: Mann-Whitney Tests of Differences on Parameters					
	α	δ	μ	ε	**PI**
Monday - Tuesday	-0.417	-0.0736	-0.7666	-0.877	-0.5213
Monday - Wednesday	-0.5642	-0.0981	-0.3128	-0.4416	-0.9506
Monday - Thursday	-0.184	-0.4968	-1.8644*	-0.7237	-1.9319**
Monday - Friday	-0.6623	-1.3615	-0.4968	-1.0058	-1.1836
Tuesday - Wednesday	-0.2453	-0.3312	-0.9567	-2.0055*	-1.5577
Tuesday - Thursday	-0.1962	-0.3802	-1.6130*	-2.3674*	-2.5513***
Tuesday - Friday	-0.9445	-0.8954	-1.1162	-0.0061	-0.7053
Wednesday - Thursday	-0.1104	-0.4845	-1.9196*	-0.5706	-1.8644*
Wednesday - Friday	-0.6746	-0.9935	-0.6624	-2.6006***	-1.9441*
Thursday - Friday	-0.8218	-0.3312	-1.9871*	-3.0178*	-3.0664***
Critical Value α (0.05) = 1.96 *Level of confidence at α = 0.10 **Level of confidence at α = 0.05 ***Level of confidence at α = 0.01					

The first group of parameters relate to the observed new information event and its signal that occur only prior to a trading day. Mean estimates for probability of new information event occurring at the beginning of each trading day (α) are approximately one-half which are similar among each day of the week. The statistical results suggest that the estimated parameter of probability of new information event is not significantly different among days of a week. The statistics of Kruskal-Wallis test is very small (1.1182) and fails to reject the null hypothesis of equal mean of α estimates among days of the week. The probabilities of new information with a bad news (δ) are approximately 40% for each day of the week with Monday slightly higher as it's decreasing throughout the week. Consequently, this is no compelling evidence to conclude that a difference in the probability of a bad news exists across days of a week. More importantly, it should be noted that estimated probability of bad news has no difference between Monday and Friday. Kruskal-Wallis test confirms this conclusion with the insignificant test statistic at 1.747 and fails to reject the null hypothesis. The result is consistent with Damodaran (1989) and Kamara (1997) that news and its signal accumulated over the weekend explains only very small proportion of differences in returns between Monday and Friday.

The second group of parameters is the arrival rate of informed (μ) and uninformed liquidity (ε) traders. The results suggest only small differences in the arrival rate of informed traders (μ), who observe information and actually trade across days of the week, being 0.1157 for Monday, 0.1037 for Tuesday, 0.1074 for Wednesday, 0.1387 for Thursday and 0.1158 for Friday. The Kruskal-Wallis results support this conclusion with insignificant test statistics of 6.675. For the arrival rate of uninformed liquidity traders, however, shows the highly different patterns across days of a week. The statistical analysis shows strong evidence supporting the proposition that uninformed liquidity traders carry out their trade differently across days of a week, with significantly high test statistics of 11.0251.

The estimates of fraction of trade made by informed trading (PI) are calculated based on equation 3. The result shows that informed trading occurring with highest on Thursday (0.529) and lowest on Tuesday (0.369). The parameters estimates for the rest of the days are quite similar, being 0.453 for Monday, 0.455 for Wednesday and 0.436 for Friday. Interestingly, the PI is not systematically different for Monday when compared with that of Friday. The result also implies that informed traders are most likely to accumulate available information throughout the week and conduct their trades on Thursday.

The paired comparisons of parameter estimates by day of the week using Mann-Whitney test are shown in Panel B. The results strongly confirm the statistically test using Kruskal-Wallis test. None of the paired comparisons of the parameters estimated for new information event (α) and new information with a low signal (δ) is significant. The arrival rates for both informed trader and uninformed trader are insignificant between Monday and Friday. This finding parallels with Badrinath, Broussard and Chakravarty (1999) in that large trader and small trader trade at about the same rate on Monday and Friday. As a matter of fact, the results also suggest the significant differences of the arrival rate of informed trader (μ) between Thursday and Friday and of the arrival rate of uninformed liquidity traders (ε) between in 4 pairs of comparison, being Tuesday and Wednesday, Tuesday and Friday, Wednesday and Friday, and Thursday and Friday. The most important result consists of the probability of information based trading (PI) which clearly suggests the differences in most of the pair comparisons which means that informed traders carry out their trade differently between days of the week.

B. Subperiod Analysis. Table 2 reports the parameter estimates for 2 subperiods for the sample during the period from January 2003 to November 2008.

This table presents subperiod means for the parameters the probability of information events (α), the probability of bad signals (δ), the arrival rate of informed trading (μ), the arrival rate of uninformed trading (ε), and the probability of information based trade (PI) by the day of the week during the period from January 2003 to November 2008.

The parameter estimates show similar patterns in 2 subperiods. The parameters estimated of new information event (α), new information with a low signal (δ) and arrival rate of informed traders (μ) are slightly decreased from 0.4939, 0.4005, 0.1777 during the first subperiod to 0.4610, 0.3976, 0.1432 during the second subperiod for each parameter, respectively. However, the probability of information based trading (PI) dramatically increases in most days of the week, but slightly decreases on Friday. During the first subperiod, the information based trading is approximately 0.419 but increases to 0.488 in the second subperiod.

To illustrate the consistently increasing in the information-based trading activity, the plot and the results of parameter estimates for probability of information-based trading (PI) from 2003 to 2008 is shown in Figure 2 and Table 3. The mean for information-based trading has increased from 0.3889 in 2003 to 0.4966 in 2008.

Interestingly, there are convincing evidences for the dramaticall increase in information-based trading on Tuesday, Wednesday and Thursday for in the period under study. Moreover, the information-based trading on Thursday has consistently increased during the period of study.

Table 2. **Subperiod of Parameter Estimates by Day-of-the-Week**

2003-05	α	β	μ	ε	**PI**
Monday	0.4675	0.4008	0.1046	0.1470	0.4428
Tuesday	0.5194	0.3999	0.0896	0.2325	0.2975
Wednesday	0.5051	0.4018	0.0972	0.1837	0.3695
Thursday	0.5172	0.4000	0.1122	0.1216	0.5096
Friday	0.4603	0.4000	0.1350	0.1708	0.4774
Average	0.4939	0.4005	0.1077	0.1711	0.4194
2006-08	α	β	μ	ε	**PI**
Monday	0.4651	0.4049	0.1267	0.1651	0.4678
Tuesday	0.4507	0.4038	0.1178	0.1688	0.4417
Wednesday	0.4735	0.4047	0.1176	0.1133	0.5404
Thursday	0.4909	0.3970	0.1329	0.1038	0.5962
Friday	0.4249	0.3776	0.0966	0.1648	0.3935
Average	0.4610	0.3976	0.1183	0.1432	0.4879
2003-08	α	β	μ	ε	**PI**
Monday	0.4663	0.4029	0.1157	0.1560	0.4553
Tuesday	0.4851	0.4019	0.1037	0.2006	0.3696
Wednesday	0.4893	0.4032	0.1074	0.1485	0.4550
Thursday	0.5040	0.3985	0.1387	0.1127	0.5529
Friday	0.4426	0.3888	0.1158	0.1678	0.4355
Average	0.4775	0.3990	0.1130	0.1571	0.4536

Table 3 presents year-by-year mean of parameter estimates for the probability of information-based trade (PI) by day of the week.

Table 3. **Year-by-Year Parameter Estimates of Information Based Trade by Day of the Week**

	2003	**2004**	**2005**	**2006**	**2007**	**2008**
Monday	0.47375	0.36080	0.50305	0.43408	0.38080	0.56013
Tuesday	0.20822	0.40591	0.36748	0.45671	0.44987	0.42326
Wednesday	0.27973	0.40947	0.46867	0.48866	0.59743	0.52681
Thursday	0.46893	0.50049	0.55823	0.58630	0.59213	0.61161
Friday	0.51430	0.43863	0.47444	0.42161	0.39701	0.36132
Average	0.38898	0.42306	0.47437	0.47747	0.48345	0.49663

Since institution investors are typically better informed than individual ones and their marginal cost of trading is substantially smaller than of individual investors, as suggested by Kamara (1997) and Kawaller (1991), the findings parallel to the behavior of trading cost evidenced in Chordia, Roll and Subrahmanyam (2000) in that Tuesday's spread is the highest among the day of the week which results from the highly active trade of uninformed liquidity traders. Moreover, the spread decreases through the middle of the week as informed trader become more active. This relationship is consistent with the information cost model evidence in Copeland and Galai (1983), Glosten and Milgrom (1985) that market makers optimize their position by setting spread to maximize revenue from uninformed liquidity traders to offset the losses from informed traders.

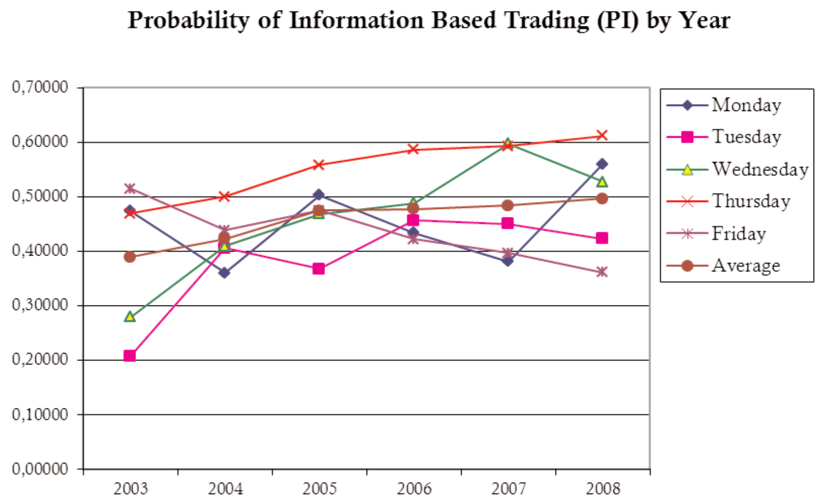

Figure 2. **Parameter estimates of information-based trading (PI) by year**

The graph shows the plotted mean average for probability of information-based trading (PI) by year during the period from January 2003 to November 2008.

V. Summary and Conclusion

This paper provides additional insights into the day-of-the-week effect. Using the sample of the 30 stocks listed at Dow Jones Industrial Average (DJIA) during the period from January 2003 to November 30, 2008, we found the evidences of significantly high information based trading activities occur at the middle of the week with the highest on Thursday. In addition, the results indicate that the amount of information accumulated over the weekend and investor's reaction to bad news are relatively insignificant in explaining differences in returns between days of the week. On the other hand, trading patterns of uninformed liquidity trader and informed traders provide more the convincing evidence in explaining the decreasing magnitude of the day-of-the-week effect. While uninformed liquidity traders are the most active at the beginning of the week, informed traders extensively use the accumulative information to perform their trade in the middle of a week, especially on Thursday. More importantly, information-based trading has consistently increased over time which can attribute to the dramatical increase in the institutional investors in large market capitalization stocks.

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