Day-of-the-Week Effect in High Moments

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Evidence from equity markets worldwide indicates that the Day-of-the-Week anomaly appears to fade from the first moment of the distribution of daily returns. We report highly significant pair-wise weekend effects in high moments when comparing the first and last trading days of the week. The second moment alone appears to distinguish the return distribution of the first trading day from all others. A probable explanation of the phenomena appears to be information dissemination: corporate announcements released after closing of the last trading day of the week spill-over to the opening of the first trading day, increasing its variability and carrying the closing sign.

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I. INTRODUCTION

The Day-of-the-Week (DOW or weekend) effect, defined as the return from Friday close to Monday close is an apparent anomaly that attracts much attention of academia and practitioners over two decades. This phenomenon has been extensively researched in various exchanges, across many securities and indexes, investor types and microstructure settings. The questions typically addressed relate to the return-generating process (French, 1980). If returns were generated during trade, the cessation of trade over the weekend would not lead to higher-than-average returns at the beginning of the following week. If, however, returns were generated on a calendar-day basis, value changes occurring over the weekend would accrue to the returns on the first trading day after the weekend. Studies conducted in the US, European and Asia-Pacific exchanges (Jaffe and Westerfield, 1985, Jaffe, Westerfield and Ma, 1989, Tong, 2000 and others) demonstrate that in most cases Monday's returns are significantly lower, in some cases negative, than returns of other trading days. This finding is in contradiction to both hypotheses mentioned above, granting it the term "anomaly." Yet the anomaly appears to fade (US data) starting from the

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early 1960's (Kamara, 1997), late 1970's (Schwert, 2003) or late 1980's (Connolly, 1989). One possible explanation is that its existence became public knowledge, whereas Kamara argues it is due to the increasing role of institutional investors.

This paper extends the DOW analysis to high moments and provides additional support for a conditional DOW effect, conditional on the closing sign at the last day of the week. We find that the anomaly has faded from the first moment in the Tel-Aviv stock Exchange index and extend the research to explore higher moments. We find that it is mainly the second moment that distinguishes the first and last days of the week from midweek days, and that the anomaly is stronger in conditional panels. We also find that a significantly higher number of corporate announcements affect Sunday's return, and since many of them were posted after Thursday's closing, they carry the closing sign to Sunday's opening, possibly correlating both distributions.

The interest in the DOW anomaly can be motivated by one, or more of the following: testing for profitable trading rules, examining how news disseminate in market returns, trying to relate market micro-structure features to the return generating process and/or testing statistical characteristics of return distributions in order to better price derivatives and other contingent claims. Our paper examines the effect of information dissemination on the empirically observed return distributions.

That daily returns deviate from normality is a well known fact. French and Roll (1986), Smirlock and Starks (1986), Puffer (1991) and Damodaran (1989) analyzed information flow over the weekend and, in general, find that Monday's variance is more than three times that of other days of the week. Damodaran attributes 3.4% of the Monday return differential to delay in corporate announcements after Friday close. Gibbons and Hess (1981) adjust Monday returns to market averages, to autocorrelations and hetroskedastisity, but find no substantial explanation for the observed anomaly. Jaffe, Westerfield and Ma (1989), Abraham and Ikenberry (1994), Sias and Starks (1995) and Tong (2000) demonstrate that trade-orders on Monday are conditional on the previous week or Friday's return. The statistical methodology employed in most of the studies mentioned above comprised *t*-tests of the differences between mean returns on Monday and those on any other day. Connolly (1989) employs *L*- and *M*-estimators and finds that the DOW effect declined toward the end of the 1980's, while observed market volatility and skewness increased. Aggarwal and Schatzberg (1997) also report that skewness and kurtosis significantly deviate from normality on a few days of the week. This evidence suggests that Monday's variance is indeed higher than other weekdays, yet this line of research does not address directly the question whether high moments distinguish Monday from other days of the week once the return differential has faded.

Apparently, our 10 years dataset (the MAOF index of the most liquid shares in the Tel-Aviv Stock Exchange, TASE) is particularly suitable for the DOW

analysis as there are no settlement delays (which Lakonishok and Levi, 1982 found that these can explain 17% of the anomaly), and there are no Bid-Ask spreads (which Keim, 1989 found that it accounts for 34% of the anomaly).

Our dataset is made of three return panels and one, independent, announcements dataset. The entire return dataset is denoted as the unconditional panel. The latter is broken down to two conditional panels: one conditional on positive returns on the prior trading day (Up-at t-1) and the other on such negative returns (Down-at t-1). The announcements dataset includes 1490 observations of a variety of announcements, such as deals, mergers, consolidations, profitability announcements etc.

Traditional dummy regressions for the trading-day hypothesis reveal that the anomaly has faded from the unconditional panel but not from the conditional panels. However, Levene's test for variance homogeneity shows that Sunday's variance is the only one which is significantly (pair-wise) higher than each of the other trading days of the week in all panels. This highly significant finding motivates further exploration of higher moments, which we conduct by applying the non-parametric Kolmogorov-Smirnov two-sample test. This test accounts for all distributional moments and we find that Sunday's distribution is significantly (pair-wise) different from all other days of the week in the unconditional and conditional panels possibly due to the variance significance. Yet, the effect of moments higher than the second is revealed as Thursday's return distribution turns out to be significantly different from all mid-week days but not from Sunday.

As in Bessembinder and Hertzel (1993), Tong (2000) and others, we find that the trend on Thursdays continues to Sundays. Our search for explanation revealed that 25.4% of all corporate announcements issued on Thursdays, were issued after closing time, hence their return impact rolled over to Sunday's opening. This shift, together with a small number of announcements over the weekend, turned the total number of announcements on Sunday to the highest among all other weekdays. An *F*-test reveals that Sunday announcements are significantly greater than all other weekdays, but not from Thursday, potentially explaining Sunday's highest volatility.

The rest of the paper is made of Section II with data description and summary statistics, Section III presents traditional dummy regression and ANOVA tests and Section IV analyses the DOW effect in high moments. In Section V we show that corporate announcements may explain Sunday's variability. Section VI summarizes and concludes.

II. DATA AND SUMMARY STATISTICS

The data set used in this study is the MAOF index, composed of the 25 highest value and most liquid stocks in the Tel-Aviv Stock Exchange (TASE) between 6/1988–8/1998. This value-weighted index is the underlying asset for options and

futures traded on the TASE.[1] Stocks included in the index are traded in a two-tiered system, based on a multi-sided auction followed by a continuous, computerized trade. The index is adjusted on a daily basis for splits, dividends and all other rights. A few technical attributes of the TASE microstructure make it a suitable source of data for the purpose of daily returns analysis. First, all transactions are cash-settled, an attribute that eliminates settlement effects on DOW analysis (Lakonishok and Levi, 1982, Crouhy and Galai, 1992.) Second, prices are determined in an auction-like procedure, thus no distortions arise due to bid-ask prices and "observed" vs. "tradable" prices (Gibbons and Hess, 1981, Keim, 1989.) In order to examine the weekend effect in the Israeli stock market, where Sunday is the first trading day of the week, we compare Sunday's return to that of all other days of the week, as well as cross comparisons among all other days.

We analyze three panels of the data: two conditional panels are segmented based on the sign of Thursday's rate of return, positive or negative, and one unconditional panel, being the entire dataset. Table 1 provides summary statistics for the three panels. The unconditional panel is qualitatively similar to other studies worldwide: daily rates of return diverge from normality at high moments. Sunday's average return is neither highest, as the calendar day hypothesis suggests, nor is it negative, as in many countries. Tuesday and Thursday have the highest average returns (0.181% and 0.173%, respectively) and both are significantly above the unconditional panel average (0.097%.) Sunday is unique as its standard deviation is the only one that is significantly non-normal, in the unconditional and conditional panels.

We find that the absolute value of the conditional all days mean rate of return is higher in the Up at t-1, compared to the mean for Down at t-1, 0.214 vs. −0.051. However, the difference is amplified significantly for Sunday's conditional rate of return: 0.413 compared to −0.450. The difference is also large for Thursday, but to a smaller degree. Sunday's average rate of return for the Up at t-1 is approximately twice the average (and almost 3 times the average excluding Sunday, 0.164). Sunday's average rate of return for the Down at t-1 is negative and 9 times the average for all days. We note that in both samples, Monday's return is negative and Tuesday and Wednesday are positive. The data imply that a positive (negative) return on Thursday triggers, on average, a substantial corresponding positive (negative) rate of return on Sunday. In Section V we propose an explanation for this correlation. Finally, skewness, and particularly kurtosis significantly diverge from normality for most days and overall.

[1] For the period 1988–1991 we use another official index that had somewhat broader base (up to 100 of the most actively traded stocks), but similar principle of calculations. We further note that only one stock was traded in Israel and US in our sample period, and the time difference allowed some 15 minutes of simultaneous trade each day. Hence, if a US Monday effect existed for the stock, it would have affected Tuesday's return, but the data lends no support for such effect.

Table 1: Day-of-the-Week Summary Statistics
1988–1998 Daily Rates of Return (%)

		Sunday	Monday	Tuesday	Wednesday	Thursday	All days
Unconditional Panel	Average	0.053	−0.039	0.181*	0.117	0.173*	0.097*
	St. Deviation	2.113*	1.587	1.675	1.473	1.462	1.675
	Skewness	−0.344	−1.169*	−0.277*	0.140	−0.379*	−0.433*
	Kurtosis	3.376*	7.456*	4.898*	1.949*	1.042*	4.477*
	n	451	474	469	468	474	2,336
Conditional Up at t-1 Panel	Average	0.413*	−0.019	0.152	0.166	0.366*	0.214*
	St. Deviation	2.000*	1.626	1.453	1.440	1.357	1.599
	Skewness	−0.328*	−1.541*	−0.221	0.146	−0.443*	−0.491*
	Kurtosis	6.527*	10.915*	1.095*	0.965*	1.596*	6.308*
	n	263	272	246	273	260	1,314
Conditional Down at t-1 Panel	Average	−0.450*	−0.067	0.226	0.049	−0.064	−0.051
	St. Deviation	2.168*	1.538	1.886	1.519	1.554	1.758
	Skewness	−0.300	−0.589*	−0.325*	0.149	−0.233	−0.338*
	Kurtosis	0.718*	1.838*	5.903*	3.137*	0.659*	2.891*
	n	188	202	222	195	213	1,020

* Asterisks indicate 5% significance.

Our announcements dataset includes 1490 announcements by listed firms to the exchange. Data availability constrained our analysis to the period June 1st, 2004–December 31st, 2004. Announcements are made online through the MAYA reporting system, where announcements are classified by type (financial reports, deals, equity and debt offering, profit distribution, legal procedures, announcements concerning the firm management etc.) This internet-based system currently makes the information immediately available to all traders and to the public. Throughout our return data period there was a short delay between the firm's reporting to the exchange, and the release of the announcement from the exchange to the public.[2]

III. TRADITIONAL TESTS

In this section, we briefly demonstrate that applying a traditional statistical test in order to analyze the day-of-the-week effect exemplifies that like recent other studies, the effect appears to be fading away (Schwert, 2003.) The regression model for the trading day hypothesis is

$$R_t = \alpha + \beta_2 D_{2,t} + \beta_3 D_{3,t} + \beta_4 D_{4,t} + \beta_5 D_{5,t} + \delta_t, \tag{1}$$

where α estimates the average return on Sunday and β_i estimates the average difference between the i-th trading day's return ($i = 2,3,4,5$) and the return on Sunday. $D_{i,t}$ is the dummy for the i-th trading day on date t.[3] The null hypothesis for this model is H_0: $\beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$, i.e. equality of average daily rates of return.

In the unconditional panel of Table 2 Sunday exhibits no unique statistical attributes when compared with other days; its mean return is neither negative nor three times the average. The regression has a non-significant p value of the F test (0.226) and Sunday's t value is not significant as well (0.676), hence the null hypothesis cannot be rejected.[4]

The regressions for the conditional panels are significant ($F = 0.012$ and $F = 0.003$) with Sunday being significantly above, and Monday significantly below the average returns in the Up-at t-1 conditional panel. Sunday is significantly negative and all other days significantly above it for the Down at t-1 conditional panel. These findings comply with findings of similar conditional day-of-the-week tests worldwide (e.g., Tong, (2000)).[5]

[2] Since the reporting system and requirements did not change between our return data period and the announcements data period, at least with any apparent respect to intra-week or intra-day distribution of announcements, we do not see an inherent reason to assume any bias in the fact that the periods do not overlap.

[3] $D_{i,t} = 0$ if t is a trading day other than i, and $D_{i,t} = 1$ if t is the i-th trading day.

[4] In all regressions results we provide the p-value of the F statistic (denoted Sig. F).

[5] Results of the calendar day hypothesis for the unconditional panel imply that Tuesday and Thursday are significantly higher than 1/3 of Sunday's return, turning the regression significant ($F = 0.019$.) Since these findings are inconsistent with the null hypothesis of the calendar day, we conclude that there is greater support for the trading day hypothesis.

Table 2: Dummy Regressions for the Trading Day Hypothesis

		Sun.	Mon.	Tue.	Wed.	Thu.	Mult. R	Sig. F	n
Unconditional Panel	Coefficient	0.053	−0.093	0.127	0.064	0.120	0.049	0.226	2331
	t Statistic	0.676	−0.841	1.153	0.578	1.086			
Conditional Up at t-1	Coefficient	0.413	−0.432	−0.261	−0.247	−0.047	0.099	**0.012***	1309
	t Statistic	**4.206***	**−3.137***	−1.848	−1.797	−0.338			
Conditional Down at t-1	Coefficient	−0.450	0.384	0.676	0.499	0.386	0.125	**0.003***	1015
	t Statistic	**−3.532***	**2.166***	**3.902***	**2.795***	**2.207***			

* Asterisk represents 5% significance.

Table 3: ANOVA
Levene Test of Homogeneity of Group Variances*

Levene Statistic	df1	df2	Sig.
15.362	4	2337	0.000

* Does not depend on the assumption of normality.

Finally, we conducted a one-way ANOVA among all days of the week to test for homogeneity of variances. Based on a Levene test for variance homogeneity among days of the week, Table 3 shows that the null hypothesis of equal variances across days of the week should be rejected (p-value 0.000.)

We summarize this section by concluding that the dummy regression tests in the unconditional panel imply that the day-of-the-week effect has faded over time; we emphasize *faded* since prior research on the TASE index proved that DOW significantly prevailed at least until mid-1987.[6] While the conditional panels reveal significantly different Sunday returns, they also reveal significant differences of other days of the week, which may or may not be related to Sunday's return. For example, Sunday is a continuation of a higher conditional Thursday return (for Up-at t-1) whereas Monday exhibits a significant reversal vs. Sunday's return.

IV. DOW IN HIGH MOMENTS

We start by a pair-wise comparison of daily return variances across all days of the week and all three panels in Table 4.

The results are self explanatory – Sunday is significantly different from each one of the other days of the week, and is the only one that differs from other days of the week. The results are similar for the unconditional and conditional panels, substantiating the role of the second moment in distinguishing Sunday's return *distribution* from the other days of the week. Many of the early and recent contributors to the DOW anomaly also recognized the high variance on Monday, but not as the principal research object.

In order to explore the possibility that the joint effects of the first, second and possibly higher moments differentiate Sunday's distribution from the other days of the week we account for all moments by exploring the *entire distribution* of daily returns using the non-parametric Kolmogorov-Smirnov (K-S) Two Sample Test. The K-S test enables comparison of the entire distribution, without relying on the normality assumption of the underlying variable (see Sokal and Rohlf, 1981). This test, which tests the trading day hypothesis, yields the results presented in Table 5.

[6] Galai and Kedar-Levy (1996) and Unger and Lauterbach (1991).

Table 4: Levene's Test for Equality of Variances

		P-Values			
Entire Sample		Mon.	Tue.	Wed.	Thu.
	Sun	**0.000**	**0.000**	**0.000**	**0.000**
	Mon	x	0.295	0.906	0.977
	Tue.		x	0.313	0246
	Wed.			x	0.871
Up at t-1		Mon.	Tue.	Wed.	Thu.
	Sun.	**0.003**	**0.001**	**0.001**	**0.000**
	Mon.	x	0.887	0.937	0.371
	Tue.		x	0.801	0.405
	Wed.			x	0.255
Down at t-1		Mon.	Tue.	Wed.	Thu.
	Sun.	**0.000**	**0.002**	**0.000**	**0.000**
	Mon.	x	0.159	0.889	0.493
	Tue.		x	0.196	0.384
	Wed.			x	0.583

P-Value < 5% indicates significant dissimilarity of return variance

Table 5: Kolmogorov-Smirnov Two Sample Test

		P-Values			
Unconditional Panel		Mon.	Tue.	Wed.	Thu.
	Sun.	**0.003**	**0.014**	**0.012**	**0.009**
	Mon.	x	0.093	0.365	**0.040**
	Tue.		x	0.756	0.989
	Wed.			x	0.473
Conditional		Mon.	Tue.	Wed.	Thu.
Up at t-1 Panel	Sun.	**0.001**	**0.021**	**0.031**	0.253
	Mon.	x	0.414	0.473	**0.003**
	Tue.		x	0.862	**0.044**
	Wed.			x	**0.042**
Conditional		Mon.	Tue.	Wed.	Thu.
Down at t-1 Panel	Sun.	**0.003**	**0.000**	**0.001**	**0.011**
	Mon.	x	0.116	0.889	0.678
	Tue.		x	0.324	0.106
	Wed.			x	0.702

P-Values < 5% indicates significant difference of entire distribution

A few conclusions stem from Table 5. First, based on the unconditional panel we conclude that Sunday's distribution of rates of return is significantly different from each of the weekdays when the comparison is made pair wise (i.e., Sun vs. Mon., Sun. vs. Tue. etc.) Second, on the same panel we find that Thursday's return distribution is significantly different from Sunday's and Monday's but not from the other weekdays. Third, Sunday is different from all weekdays in the conditional Down-at t-1 panel and from all weekdays except for Thursday in the conditional Up-at t-1 panel. Fourth, Thursday's distribution is significantly different from the Monday, Tuesday and Wednesday return distributions in the Up-at t-1 panel. The asymmetric distinction of Thursday in the two conditional panels is probably because Thursday's average return is second to Sunday's high return in the conditional Up-at t-1 panel with the lowest standard deviation, but is close to the weekly average in the conditional Down–at t-1 panel (see Table 1.)

We note here that based on the calendar analysis of corporate announcements we present in Section V, Monday has the lowest number of announcements while Sunday, Tuesday and Thursday are highest. Comparing Monday's distribution to all other days of the week reveals that it is different from Sunday and Thursday at 5% confidence level, and from Tuesday by 10% confidence level. There is a possibility that Monday does not differ significantly from Wednesday since both have the lowest number of announcements.

These findings demonstrate, first, that the impact of third, fourth and potentially higher moments on the distribution of daily returns reveal differences between days of the week that were not present in the first and second moments. Recall that the trading day regressions (Table 2) indicated no significance of any day in the unconditional panel, yet the K-S test reveals Sunday's, and in the Up-at-t-1 panel also Thursday's distinction, probably due to the effect of the second moment (Table 4). Additionally, while Sunday and Monday were significant in the conditional Up-at t-1 panel regressions for bearing the highest and lowest mean return (Table 2), the K-S test illustrates that Sunday's and Thursday's distributions are significantly different from the other days of the week, but not between themselves. The finding that Thursday's distribution is different from all other days but from Sunday's in the conditional Up-at t-1 panel was not found in parametric tests of the first and second moments, thus it might reflect the net effect of all moments grouped together, though it might as well be due to data-mining.

In an Appendix to the paper, we conduct a Multiple Comparison Procedure (MCP), being a statistical procedure aimed to test whether paired comparisons (e.g., Sun–Mon., Sun.–Tue. etc.) are strong enough to conclude that Sunday is different from all other weekdays, combined. The procedure demonstrates that Sunday's entire distribution is different from all other days of the week, combined, for both the unconditional and the conditional Down-at t-1 panels. For the Up-at t-1 panel however, Sunday and Thursday can be considered as a group of similar distributions since, as Table 5 indicates, they are not significantly different from each other. We also applied the MCP procedure to the

Levene's Test statistics (not shown) and find that Sunday's variance is significantly different from the variance of all other days combined (at 5%) for all three panels.

V. A POSSIBLE EXPLANATION

Striving to explain Sunday's significantly highest volatility, we hypothesize that since stock prices change in response to the arrival of new information to the market, the number of corporate announcements to the exchange should also be highest on Sunday. We therefore analyzed the distribution of corporate announcements to the exchange across days of the week and across hours of the trading day, see Table 6.

Raw data shows that the number of corporate announcements to the exchange on Sunday was 275 over the sample period, which is second to the lowest announcements day (Monday, with 263), while the largest number of announcements were released on Thursday, 323. This finding appears to be against our hypothesis since Sunday's return variability is highest while Thursday's return variability was lowest among days of the week. Yet, analyzing the number of announcements across hour of the day reveals that a substantial proportion of total daily announcements is reported to the exchange after the official closing time, 16:45. The lowest number of post-trade announcements was 34, on Sunday, while the largest was 89, on Thursday. Since post-trade announcements affect share prices at the opening of the next trading day, one must calculate the relevant number of announcements on day t as the sum of daily announcements before the end of the trading session, plus post-trade announcements of day t-1. Sunday must also account for announcements that were released over the weekend, which in our sample was relatively small (27, 1.8%). When accounting for these spillover effects, the number of relevant announcements on Sunday becomes highest among all weekdays, 357 vs. an average of 298.2, which is 19.7% above the average. Monday has the lowest number of relevant announcements, 242, or 18.8% below the average. The spill-over of post-closing announcements from the last trading day of the week to the opening of the first trading day of the week has been reported by Damodaran (1989), as discussed in the introduction.

The spill-over effect from Thursday to Sunday not only increases Sunday's volatility, but also serves to explain why would Thursday's closing be so strongly correlated with Sunday's return as reported above in both conditional panels. If negative (positive) closing returns on Thursday result from a proportionally large number of negative (positive) announcements, their spill-over to Sunday conveys the sign of Thursday's closing. Our data shows that 89, about 27.6% of Thursday's announcements spill-over to Sunday, affecting its return

Table 6: Inrta-week and Intra-day Distribution of Corporate Announcements

	Sunday		Monday		Tuesday		Wednesday		Thursday		Fri.–Sat.
Hour	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*
pre 9:45	52	18.5%	26	9.9%	34	10.6%	30	10.6%	35	10.8%	1
10:45	69	25.1%	38	14.4%	52	16.3%	49	17.4%	51	15.8%	3
11:45	29	10.5%	17	6.5%	48	15.0%	21	7.4%	27	8.4%	2
12:45	31	11.3%	22	8.4%	28	8.8%	26	9.2%	20	6.2%	3
13:45	25	9.1%	30	11.4%	24	7.5%	24	8.5%	28	8.7%	2
14:45	15	5.5%	25	9.5%	27	8.4%	21	7.4%	29	9.0%	3
15:45	13	4.7%	32	12.2%	32	10.0%	29	10.3%	17	5.3%	3
16:45	8	2.9%	18	6.8%	17	5.3%	20	7.1%	27	8.4%	3
16:45 up	34	12.4%	55	20.9%	58	18.1%	62	22.0%	89	27.6%	7
Total Raw Ann.	275	100%	263	100%	320	100%	282	100%	323	100%	27
Announcements that affect day $t+1$	34		55		58		62		89		27
Daily Relevant Announcements	357		242		317		278		296		Average = 298

Table 7: F-Test for Daily Announcements

	Mon.	Tue.	Wed.	Thu.
Sun.	**0.002**	**0.045**	**0.048**	*0.085*
Mon.	x	0.205	0.195	0.118
Tue.		x	0.976	0.752
Wed.			x	0.775

with the same sign. Together with the 27 weekend announcements, these 116 announcements make 32.5% of Sunday's 357 announcements.

We have further compared the distribution of relevant daily announcements throughout the day (between 9:45 AM and 16:45 PM), considering the t-1 spill-over announcements at the opening of day t announcements. An F-test across all possible pairs of trading days reveals that Sunday is (pair-wise) significantly different from Monday, Tuesday, and Wednesday at 5% confidence level while it differs from Thursday at 10% confidence level. These results are summarized in Table 7.

A Chi-test for the equality of the number of relevant announcements across days of the week rejects the null (uniform distribution) at $p = 0.000$. Based on the above we conclude that information dissemination appears to be a key explanatory variable of Sunday's high return variability and its high correlation with previous Thursday closing. Our analysis does not exclude the possibility that other factors might be relevant as well.

VI. SUMMARY AND CONCLUSIONS

As researchers reveal financial market anomalies, rational investors who trade in efficient markets are bound to eliminate them. Hence, an increasing number of anomalies turn apparent, rather than real (Schwert, 2003). In this paper, we start by conducting the traditional dummy regression on the entire, unconditional panel (TASE, 1988–1998,) and two conditional panels (Up and Down return on the previous day.) We show that the day-of-the-week (DOW) anomaly, which existed in the past at the first moment, has indeed faded in our sample period. However, conducting the Levene test for variances homogeneity among week-days, we find that Sunday is the only day that significantly differs from all other days of the week. We then employ the non-parametric Kolmogorov-Smirnov two sample test and find that moments higher than the variance are relevant when comparing daily return distributions pair wise (Sun.–Mon., Sun.–Tue. etc.) Yet, there is a possibility that information flow over the weekend, micro-structure, or other factors make the first trading day of the week different from weekdays.

We sought to reveal the source for the high volatility on Sundays and the high correlation between Thursday's closing sign and Sunday's return by comparing the distributions of corporate announcements to the exchange across days of the week. We found that a significantly higher number of corporate announcements affect Sunday's return distribution (357 vs. average of 298), and 25% of them were posted between Thursday's closing and Sunday's opening. The distribution of intra-week relevant announcements, i.e., those including the spillover from day t-1 after closing until closing on day t, is significantly non-uniform. Moreover, the intra-day distribution of corporate announcements on Sunday is significantly different from all other days of the week, but not from Thursday. Monday has the lowest number of relevant announcements, but we cannot relate this finding to its lowest rate of return.

We further examined whether Sunday's entire distribution differs from *all other days combined*, rather than on a pair-wise basis. Hence, we apply a multiple comparison procedure, which adjusts the combined significance level and find mixed results. Sunday's distribution is different from all midweek, but not from Thursday's distribution in the unconditional panel and in the conditional Down-at t−1 panel, but not in the conditional Up-at t-1 panel. Sunday and Thursday differ from all midweek days combined at the Up-at t-1 panel.

Our results may have important implications for volatility estimation using daily rates of return (e.g., options and other derivatives.) Additionally, one may conclude that the second and higher distributional moments cannot be ignored when estimating return volatility based on daily data.

VII. APPENDIX: MULTIPLE COMPARISON PROCEDURES (MCP)

Our findings of the significant distinction of Sunday's variance from other days of the week (Table 4) and the significant distinction of Sunday's *distribution* of daily returns from all but Thursday's distributions are based on pair-wise comparisons. Paired comparisons (not to be confused with matched-pair tests) generate a statistic, t-statistic for the mean, Levene-statistic for the variance or K-S z-score for the entire distribution that can tell whether one group significantly differs from its pair with respect to the analyzed statistic. However, the actual economic question is whether the properties of the returns distribution on the day after the weekend are different from *all other days of the week*, not only from each day on a pair-wise comparison.

In this section we test whether the distribution of Sunday's returns differs from that of all other days of the week, combined. In order to do so we calculate a general significance level for the entire series of paired comparisons between Sunday and each other day of the week (Sun–Mon, Sun–Tue, Sun–Wed and Sun–Thu). Merely adding a number of pair-wise comparisons to determine the general level of significance of multiple comparisons is statistically invalid.

In order to test the significance level for this type of multiple comparisons, we apply the Hochberg (1988) procedure, which is based on Simes (1986) and

Table A: Multiple Comparisons Procedure

Panel		H(4) $\alpha^* = 5\%$	H(3) $\alpha^*/2 = 2.5\%$	H(2) $\alpha^*/3 = 1.67\%$	H(1) $\alpha^*/4 = 1.25\%$
Unconditional	Ranked P-Values	1.40%	1.20%	0.90%	0.30%
	Paired Day	Tue.	Wed.	Thu.	Mon.
		◆	———	———	——— ▶
Conclusion: Sunday's distribution is significantly different (5%) from all days of the week, combined.					
Conditional Up at t-1	Ranked P-Values	25.30%	3.10%	2.10%	0.10%
	Paired Day	Thu.	Wed.	Tue.	Mon.
					◆——▶
Conclusion: Sunday's distribution is significantly different (10%) from all Monday's distribution only.					
Conditional Down at t-1	Ranked P-Values	1.10%	0.30%	0.10%	0.00%
	Paired Day	Thu.	Mon.	Wed.	Tue.
		◆	———	———	——— ▶
Conclusion: Sunday's distribution is significantly (5%) different from all days of the week, combined.					

The arrow indicates that the current comparison and all lower comparisons (on its right hand side), are significant at the H(i) significance level.

Hommel (1988), from the field of biometrics. This family of statistical tools is capable of addressing the degree of similarity between compared statistics and sub-groups within these statistics. Discrepancies in significance level that stem from the repeated implementation of paired comparisons are neutralized by this multiple comparison procedure. We chose the Hochberg procedure as it does not impose external assumptions on the underlying distributions, which is not the case for alternative multiple comparison methods, such as the Tukey-B or Student-Newman-Keuls procedures.[7]

In the first stage, P-values that were derived from the K-S test of the paired comparisons of Sunday to each individual day are ranked from highest to lowest.[8] We denote the number of paired comparisons by m, where in our case $m = 4$, (Sun–Mon, Sun–Tue, Sun–Wed and Sun–Thu), and the highest P-value is marked P(m). In the second stage we examine the m paired hypotheses, H(m), sequentially. The test starts with P(m), the highest P-value, which is compared with significance level, α. If P(m) $\leq \alpha$, then H(m) *and all the hypotheses lower then* H(m), which will be marked H(i), ($i = m$-1, m-2, ... ,1) are rejected. If P(m) $> \alpha$, than H(m) cannot be rejected, and the second highest P-value, marked P(m-1), is compared, but this time to the next significance level, $\alpha/2$. If P($m-1$) $\leq \alpha/2$ holds, H(m-1) is rejected and all the H(i) (i = m-2, ... ,1) hypotheses are rejected as well. If not, P(m-1) cannot be rejected and P(m-2) is compared with $\alpha/3$, and so on.

Table A reports the Hochberg (1988) MCP results, where P-values of the K-S paired comparisons reported in Table 6 between Sunday and all weekdays are ranked from high (H(4), on the left) to low (H(1) on the right). Consider for example the unconditional panel; if a P-value for H(4) is less than the associated critical value $\alpha^* = 5\%$, than the null hypotheses of equality between the paired samples Sunday vs. Tuesday, and all lower paired comparisons are rejected. Such a conclusion is illustrated by the arrow that stretches from H(4) to H(1).

Notice that the MCP concludes that Sunday's entire distribution is different from all other days of the week, combined, for both the unconditional and the conditional Down-at t−1 panels. For the Up-at t-1 panel however, Sunday and Thursday can be considered as a group of similar distributions since, as Table 5 indicates they are not significantly different from each other.

Application of the MCP to Levene's Test for equality of variances (not shown) straightforwardly concludes that Sunday's variance is significantly different from the variance of all other days combined (at 5%) for all three panels. Moreover, the MCP shows that variances of all weekdays other than Sunday are not significantly different among themselves, indicating that volatility is

[7] The Tukey-B procedure arranges the means from smallest to largest and then calculates a range value for each comparison based on the distance between two means in the ranking. The means for that test must be calculated based on the Tukey-HSD procedure or the Student-Newman-Keuls Procedure (SNK), which assumes normality.

[8] It should be pointed out that it is not important what statistic was estimated for a pair of distributions. In order to carry out the procedure, P-values from each paired comparison are required.

significantly higher only on the first day of trading in the week. These results are consistent with results from international markets using traditional tests, where the variances for the first day of the week were found to be significantly higher than other days.[9]

VIII. REFERENCES

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[9] We also applied the MCP to explore similarity of means by the t-Test for two independent samples. Significant difference between Sunday's mean to the mean of all other days has been revealed only for the conditional Down-at t-1 panel. There were no significant differences, even at 10% significance level, in the other panels.

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