

Daylight Saving Time and Seasonal Affective Disorder

- External factor influence on stock return and trading volume

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By Daniel Wallemo

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Tutor: Iñaki Rodriguez Longarela

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Abstract

This study examines the effects of the external factors Seasonal Affective Disorder and Daylight Saving Time changes on trading volume changes of two US based indexes, the S&P 500 and the NASDAQ Composite. These external effects have previously been found significant in stock returns by Kamstra et al. (2000), (2003). Both the SAD effect and the DST effect are assumed to cause the risk aversion to increase with the marginal investor and thereby affect the market equilibrium. However, they can also induce passivity with the investor, which would counteract the effect of increased risk aversion. This study does find evidence for a SAD effect, caused by increased risk aversion, in trading volume changes resulting in abnormal positive trading volume changes from the autumn to the spring equinox. However the evidence is not consistent between the two indexes. As for the DST effect the results are also inconclusive and inconsistent between the two indexes.

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Introduction

Several studies have been published within behavioural finance in recent years on the influence of external effects, such as weather, on stock returns. Saunders (1993) and Hirshleifer and Shumway (2003) have found a strong correlation between stock returns and cloud cover. Stock returns have also been related to lunar phases, Dichev and Jane (2003), and temperature variations, Cao and Wei (2005).

The subject for this study is two separate papers published by Kamstra, Kramer and Levi, henceforth KKL, that both examine the possible influence of external factors on stock returns. In their paper “Winter Blues: A SAD Stock Market Cycle” (2003) they link periods of relatively fewer hours of daylight to depression and abnormal returns on the stock market. Ten percent of the world population in general is thought to suffer from seasonal affective disorder (SAD), which is closely linked with hours of daylight. Their earlier paper “Losing Sleep at the Market: The Daylight Saving Anomaly” established a correlation between daylight saving time changes and abnormal stock returns on several markets. However, this paper has been questioned on several occasions by different researchers.¹

Behavioral finance²

Behavioral finance, as well as the closely related field behavioral economics, is primarily concerned with the lack of rationality of economic agents. The fields apply scientific research on human and social cognitive and emotional biases to better understand economic decisions and typically integrate insights from psychology with neo-classical theory. In 1979 Daniel Kahneman and Amos Tversky published one of the most important papers for the development of behavioral finance and economics: 'Prospect theory: Decision Making Under Risk'. This paper was the result of Tversky's and Kahneman's efforts to compare their cognitive models of decision making under risk and uncertainty to economic models of rational behavior.

In general, behavioural economics sits within the neoclassical framework, though the standard assumption of rational behaviour is often challenged. Market inefficiencies is one of the branches of behavioral finance. The external factors treated in my thesis belong to this branch. Observed market outcomes that are contrary to rational expectations and market efficiency are treated from a behavioral perspective. Richard Thaler, in particular has written many papers describing market anomalies from this perspective.

Critics of behavioral finance say that behavioral finance is more a collection of anomalies than a true branch of finance and that these anomalies will eventually be priced out of the market. And if the anomalies are not priced out of the market they will be explained by market microstructure arguments.

¹ Pinegar (2002), Lamb, Zuber and Gandar (2004) and Allen, Jacobsen and Marquering (2006).

² Camerer, C. F.; Loewenstein, G. & Rabin, R. (eds.) (2003) *Advances in Behavioral Economics*

Purpose

The purpose of this paper is to examine the possible influence of the external factors SAD and DST on trading volume. According to Wang (1994) trading volume is of economic interest in that it helps understanding the relation between asset returns and trading volume. This in turn can indicate how the nature of investor heterogeneity determines the behaviour of asset prices.

Theory

SAD has been documented in various parts of the world and the results are consistent.³ About ten percent of the population is believed to suffer from depressions to various extent caused by seasonal changes. However, the impact of SAD has been found to be greater in countries at more extreme latitudes. Molin et al. (1996) and Young et al. (1997) found the SAD to be correlated with hours of daylight and more pronounced in parts of the world with relatively shorter winter and fall days. SAD symptoms can occur as early as September.⁴ The seasonal depression has also been suggested to be asymmetric around the winter solstice.⁵

External effects and risk aversion

Experimental research in psychology has established a link between depression and heightened risk aversion.⁶ A change in risk aversion with a group of market participants caused by external factors would, according to theory, lead to a change in the equilibrium risk premium and abnormal market returns.⁷ Bierwag and Grove (1965) have shown that in a competitive and costless market the change in risk aversion with any one investor will influence the determination of the equilibrium price. In their model there are only two “bonds” available to investors. Every investor will choose the amounts of the two bonds in accordance with their forecasts of the future prices of the bonds. Market equilibrium is reached when the sum of all excess demands reach zero. The equilibrium price is then the weighted average of individual expectations, and these expectations are a function of individual risk aversions.

KKL suggested that the SAD effect influence stock returns through heightened risk aversion with a group of investors. What would then be the implications of heightened risk aversion for trading volume? Campell et al. (1993) have studied the relationship between aggregate stock market trading volume and the serial correlation of daily stock returns. Their model consists of risk-averse “market makers” that accommodate buying or selling pressure from “liquidity” or “non-informational” traders and suggests that increased risk aversion in itself increases trading volume as return decreases. Campell et al. suggests that low returns accompanied by high trading volumes are more likely due to increases in risk aversion with the marginal trader

³ SAD has been documented in, for example, Canada by Williams and Schmidt (2003), in Italy by Faedda (2003) and in India by the Mayo Clinic (2002).

⁴ Dilsalver (1990).

⁵ Palinkas et al. (1996) and Palinkas and Houseal (2000).

⁶ The effect of anxiety and depression on sensation seeking and general willingness to take risk has been documented by Zuckerman (1984), Marvel and Hartman (1986), Carton et al. (1992, 1995) and Eisenberg et al. (1998).

⁷ See also Hicks (1963) for further evidence of the impact of the marginal trader on market equilibrium.

than new information. Wang (1994) examines the correlation between trading volume and absolute stock returns, which he finds to be positively correlated. In his model, trading is always accompanied by price changes as investors are risk averse. The price discount, demanded by uninformed investors, increase with increasing information asymmetry. The model also implies that the correlation between trading volume and absolute stock returns increase with information asymmetry. It could be argued that an increased risk aversion due to external factors would have the same effect.

External effects and passivity

However, the effect of a depression on the human psyche can lead to additional manifestations, besides increased risk aversion. According to the World Health Organisation's depression diagnostic system, ICD-10, symptoms of depression are, for example, loss of self confidence and self esteem as well as lower capacity for concentration, together with decision anxiety and passivity.⁸ Pessimism and passivity related to depression have been documented on several occasions.⁹

Hypothesis

My hypothesis is that increased risk aversion with the marginal investor leads to positive growth in trading volume, while passivity with the investor collective will lead to negative growth in trading volume. This of these mechanisms that is the most influential will hopefully be indicated by the calculations below.

KKL are not as explicit about the mechanisms behind the external factor influence of daylight saving time changes. However, the reasoning around the effects is quite similar although they are not directly linked to risk aversion. The argument is that sleep desynchronosis following a DST change can result in anxiety.¹⁰ As for the SAD effect, the DST effect would then have an effect on market equilibrium through heightened risk aversion with the marginal investor. KKL found a negative abnormal return on the first weekday following daylight saving time changes relative to other first weekdays following a weekend.

Trading volume and absolute returns

The correlation between trading volume and absolute stock returns found by Wang is an important factor when examining whether the SAD effect and the DST effect found by KKL in stock returns are also present in trading volume. It could be the case that external effects found in volume are just the outcome of the correlation between volume and return. Trading volume has been found to be correlated with absolute price changes in many studies. Most of them were carried out a couple of decades ago.¹¹ Karpoff (1987) states in a survey over past research on the correlation between trading volume and absolute stock returns, that some of

⁸ The Swedish Council on Technology Assessment in Health Care (2005)

⁹ See Lisspers and Almén (2005), Denollet (2000)

¹⁰ Coren (1996)

¹¹ With the obvious exception of Wang (1994). See also Crouch (1970), Morgan (1976), Epps and Epps (1976), Harris (1983) and Karpoff (1986).

the findings show weak correlation. He argues that the weak correlation could be the result of misspecification. Perhaps the relation between volume and return is rather asymmetric than linear, as assumed in the studies he examines. He also states that tests using data on volume and the absolute value of price changes will yield positive correlations and heteroskedastic error terms.

I have not found any studies on the relation between volume trade changes and absolute return. The evidence of correlation between trading volumes and absolute return is however so strong that it seems reasonable to control for the variable in my regressions.

Monday effect

Although there is evidence of a positive contemporaneous correlation between daily stock returns and trading volume, there is also evidence for the opposite. The weekend effect or the day-of-the-week effect in stock returns has been examined by several researchers. Chang, Pinegar and Ravichandran (1993) find that sample size and/or error term adjustments to US data render the day-of-the-week effect insignificant. However, they find robust evidence for the effect in European countries, Canada and Hong Kong. One important feature of the Chang, Pinegar and Ravichandran study is that returns are lower on Mondays if not significantly so in the US. Similar findings for the US by Connolly (1989),(1991) suggest that the day-of-the-week effect or weekend effect disappeared in the US around 1975.

Lakonishok and Maberly (1990) on the other hand find that trading volume at NYSE is lower on Mondays than during the rest of the week, using data from 1962 to 1986. This finding could contradict the positive correlation between trading volume and absolute return, bearing in mind the possible weekend effect of stock returns. This market anomaly will be an important factor in interpreting the tests of a possible DST effect on trading volume as daylight saving time changes occur on weekends.

Data

KKL study the SAD effect in twelve different daily stock indexes, out of which four are US indexes. The data series used by KKL range from more than 70 years for the S&P 500 index to 20 years for New Zealand's main stock index. The DST study by KKL contains 7 indexes, including the same US indexes as in the SAD study.

My study is much more limited. I have only been able to gather trading volume data for two indexes for which the time span is long enough to be able to produce significant results of some sort; the S&P 500 (1970-2006) and the NASDAQ Composite (1984-2006), which both are included in the two studies by KKL.¹² To be able to compare my findings with those of KKL, I have replicated their studies using the more limited data series.

In the boxes below the time series I have used are summarized.

¹² The trading volume data is taken from Yahoo Finance (finance.yahoo.com). The data on stock returns are taken from Datastream. Datastream does not offer trading volume history for any indexes.

Table 1. Summary Statistics for the Limited NASDAQ Composite and S&P 500 Time Series

Return						
	Mean	Standard deviation	Minimum	Maximum	Skewness	Kurtosis
NASDAQ Composite	0.049	1.4	-11.3	14.2	-0.02	8.7
S&P 500	0.033	1	-20.5	9.1	-0.94	24.0

Volume						
	Mean	Standard deviation	Minimum	Maximum	Skewness	Kurtosis
NASDAQ Composite	1.72	19.6	-76.0	283.0	2.96	27.94
S&P 500	1.99	21.0	-75.5	220.2	2.19	15.91

NASDAQ Composite 1984/10/16-2006/06/09, S&P 500 1970/01/07-2006/06/09

The DST study is based on the same time series as the previous SAD study. However, in the examination of a possible DST effect on trading volume and stock returns, the series are limited to the first day following the weekend, usually a Monday. (Henceforth, Monday is used to depict the first day following the weekend and Tuesday similarly is used to depict the second day following the weekend.) In the New York, where both exchanges are situated, daylight saving time changes have occurred every year since 1970, with the exception of 1974. The majority of the changes have occurred in late April and late October.

Table 4. Summary Statistics for the NASDAQ Composite and S&P 500 Monday Time Series

Return						
	Mean	Standard deviation	Minimum	Maximum	Skewness	Kurtosis
NASDAQ Composite	-0.061	1.5	-11.4	7.9	-1.01	8.3
S&P 500	-0.022	1.2	-20.4	5.4	-3.32	55.0

Volume						
	Mean	Standard deviation	Minimum	Maximum	Skewness	Kurtosis
NASDAQ Composite	-4.74	27.8	-76,1	222,7	4,1	23,6
S&P 500	-3.88	27.8	-75,5	218,6	3,6	20,1

NASDAQ Composite 1984/10/16-2006/06/09, S&P 500 1970/01/07-2006/06/09

Method

KKL. expect the SAD effect to manifest itself in lower returns in the fall from the autumn equinox (21 September) to winter solstice (21 December) as the days grow shorter, only to turn into above average returns from the winter solstice to the spring equinox (March 20). Based on their expectations they construct a regression where return is dependent on, what the call, a SAD variable.

The SAD regression variable

The SAD variable gives the length of the night relative to the yearly average length of night of twelve hours, but only during the so called SAD period, 21 September to 20 March. Otherwise it equals 0.¹³

$$SAD_t = H_t - 12 \text{ (from 21 September to 20 March)}$$

Where H_t is:

$$H_t = 7.72 \cdot \arccos \left[-\tan \left(\frac{2\pi\delta}{360} \right) \tan(\lambda_t) \right] \text{ (in the southern hemisphere)}$$

$$H_t = 24 - 7.72 \cdot \arccos \left[-\tan \left(\frac{2\pi\delta}{360} \right) \tan(\lambda_t) \right] \text{ (in the northern hemisphere)}$$

Where λ_t is:

$$\lambda_t = 0.4102 \cdot \sin \left[\left(\frac{2\pi}{365} \right) (julian_t - 80.25) \right]$$

$Julian_t$ equals 1 for January 1, 2 for January 2, and so on.

Other regression variables

KKL also introduces lagged returns (to correct for residual autocorrelation), a tax-loss selling effect dummy, a Monday dummy and a SAD variable.¹⁴ a fall dummy to distinguish the fall effect from the spring effect. In addition, KKL control for other external factors and introduce dummies for cloud cover, temperature and precipitation.

I have not been able gather data for daily cloud cover over New York why my regression is limited to the following:¹⁵

$$r_t = \mu + \rho_1 r_{t-1} + \rho_2 r_{t-2} + \mu_{SAD} D_t^{SAD} + \mu_{Fall} D_t^{Fall} + \mu_{Monday} D_t^{Monday} + \mu_{Tax} D_t^{Tax} + \mu_{Temperature} D_t^{Temperature} + \mu_{Precipitation} D_t^{Precipitation} + \varepsilon_t$$

Where the dependent variable r_t is the daily return and ρ_1 and ρ_2 are the lagged daily returns.

¹³ For the use of the AR(1) specification for stock returns, as well as the monday and tax dummy, KKL refer to Akgiray (1989), Nai-Fu Chen et al. and Brown et al. (1984).

¹⁴ The tax dummy equals 1 when period t is in the last trading day or first five trading days of the tax year.

¹⁵ The climate data was taken from the US National Climatic Data Center (www.ncdc.noaa.gov/oa/mpp/freedata). The cloud cover dummy was not significant for neither the S&P 500 nor the NASDAQ Composite in the study by KKL.

The trading volume is regressed in the same manner, with the addition of the absolute daily stock returns, which is included to control for the possible correlation between trading volume changes and absolute stock returns.¹⁶

$$v_t = \mu + \rho_1 v_{t-1} + \rho_2 v_{t-2} + \mu_{SAD} D_t^{SAD} + \mu_{Fall} D_t^{Fall} + \mu_{Monday} D_t^{Monday} + \mu_{Tax} D_t^{Tax} + \\ + \mu_{Temperature} D_t^{Temperature} + \mu_{Precipitation} D_t^{Precipitation} + \mu_{ABSreturn} D_t^{ABSreturn} + \varepsilon_t$$

The dependent variable v_t is the daily change in trading volume and p_1 and p_2 are the lagged daily changes. I use two-sided tests as the impact of the SAD-effect is dual and for the uncertainty of the impact of a possible correlation between volume changes and absolute returns. Daily changes in trading volume, as opposed to the actual volume itself, are used because trading volume on the S&P 500 index as well as the NASDAQ Composite index have increased steadily over time.

Test of equal means

In line with KKL, I use t-tests to see if the mean of returns and change in trading volumes on the first day following a daylight saving time change significantly differs from other first days following a weekend. Where appropriate the independent samples t-test applies the central limit theorem. If the number of observations is too limited equal variances is assumed. Levene's test for equality of variances is used as an indication to whether this assumption is valid.

The use of two-sided tests when testing the mean volumes is also motivated by the possible presence of the Weekend effect, in addition to the previous mentioned duality of the SAD-effect. Theory suggests that the abnormal returns associated with Mondays in the SAD regressions should be accompanied by positive abnormal volumes. However, previous empirical evidence¹⁷ show negative abnormal volumes on Mondays, i.e. the day-of-the-week effect described earlier. The SAD regressions presented earlier also show significant negative correlation between Monday abnormal returns and Monday volume changes.

In addition to the test performed by KKL, my study contains corresponding tests of the equality of means of returns and volume changes of Tuesdays. This is done in order to examine whether the DST effect has a lasting impact on return and volume changes. The DST study by KKL has been questioned and said to be showing nothing more than the well-known October effect, why I also examine this possibility for trading volume changes.¹⁸

Results

My replication of KKL's SAD return regressions also shows significant SAD effects for the two indexes. However, the fall dummy is much less significant for the NASDAQ series and not at all significant for the S&P series. My results does at least point in the same direction as

¹⁶ I have not been able to find previous examples of the AR(1) specification for volume change regression, but it is included because of the possible strong correlation between returns and trading volume changes.

¹⁷ Lakonishok and Maberly (1990)

¹⁸ Lamb, Zuber and Gandar (2004)

the expectations by KKL, that is the correlation between return and the fall dummy is negative for both indexes.¹⁹

Table 2. Return Regression Results for Both Indexes and the Original KKL Study
(Heteroskedasticity-robust t-tests)²⁰

		u	p1	p2	SAD	Fall	Monday	Tax	Temp	Precip
S&P	Wallemo	0.000 (0.84)	0.069*** (2.77)	-0.033 (-1.32)	0.030** (2.246)	-0.012 (-0.90)	-0.030** (-2.50)	-0.006 (-0.12)	-0.001 (-0.23)	0.006 (0.60)
	KKL	-0.049 (-0.45)	0.063*** (3.54)	-0.042*** (-2.40)	0.038*** (2.43)	-0.058** (-2.20)	-0.209*** (-9.50)	0.065 (1.14)	0.003** (1.80)	-0.002 (-0.59)
NASDAQ	Wallemo	0.002** (2.04)	0.054* (1.94)	-0.038 (-1.35)	0.041** (2.339)	-0.032 (-1.57)	-0.041*** (-2.87)	0.008 (0.78)	-0.021 (-1.255)	0.015 (1.144)
	KKL	-0.017 (-0.11)	0.145*** (4.93)		0.071*** (2.96)	-0.134*** (-3.30)	-0.256*** (-7.50)	0.067 (0.72)	0.003* (1.35)	-0.003 (-0.61)

* Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

Notably, several of the variables have a much stronger influence on the dependent variable in the regressions by KKL, than in my regressions. This is true for both the Fall dummy, the Monday dummy and the Tax dummy. It is interesting to note that the influence of the Monday dummy is about the same as the SAD variable in my regressions while the Monday dummy is much more influential in the regressions by KKL. This is an indication that the Monday effect has become weaker in recent decades, which is in line with findings by Connelly (1989), (1991).

Temperature and precipitation do not have a significant impact on returns in my regressions. This is also true for the tax dummy.

Volume change regression

The same regression is performed on the daily change in trading volume except for the introduction of a new variable that is supposed to control for the correlation between trading volume and absolute return, i.e. volume changes are also regressed on absolute return.

Table 3. Volume Change Regression Results for Both Indexes
(Heteroskedasticity-robust t-tests)

	u	p1	p2	SAD	Fall	Monday	Tax	Temp	Precip	ABS return
S&P	-0.006 (0.51)	-0.347*** (-17.68)	-0.250*** (-16.28)	0.020 (1.445)	0.017*** (2.85)	-0.215*** (-20.74)	0.077*** (6.30)	-0.005 (-0.57)	0.006 (0.623)	0.243*** (15.75)
	0.020*** (3.14)	-0.357*** (-9.86)	-0.236*** (-9.09)	0.041*** (2.585)	0.013* (1.67)	-0.243*** (-17.26)	0.051*** (3.85)	-0.006 (-1.45)	0.004 (0.76)	0.154*** (10.59)

* Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

The correlation between SAD and volume is also positive, but insignificant for the S&P index. The influence of the SAD variable is about as strong in the volume regressions as in my return regressions. The Fall dummy is significant for both indexes indicating that the

¹⁹ One interesting detail between my regression and that of KKL is the reversed correlation between return and temperature and precipitation.

²⁰ Heteroscedasticity-robust standard errors from the statistics programme Stata 9 were used.

volume changes are more pronounced during the fall. Compared to my return regressions the influence of the Monday is much stronger. In addition there seems to be increased trading in the beginning of the tax year as indicated by the positive and significant Tax dummy.

Trading volume changes are strongly correlated with returns in both the S&P and the NASDAQ time series. Changes in return is accompanied by increased trading.

Both regressions on trading volume change are quite robust to the exclusion of the absolute return variable. The SAD variable and the fall dummy become somewhat less significant for the NASDAQ index. The fall dummy becomes somewhat more significant and the SAD variable somewhat less significant.

Test of equal means

The study by KKL showed significant differences in mean returns. As I perform the same tests on shorter return series I fail to find as significant results. The hypothesis of equal means is rejected just short of the 10%-level for both the S&P and the NASDAQ index.

Table 5. Equality of Monday Return Mean Test Results for Both Indexes and the Original KKL Study

			N	Mean	Difference	Joint t-test
S&P	Wallemo	Monday	1830	-0.01		-1.931*
		DST	71	-0.28	-0.27	
	KKL	Monday	1558	-0.04		-2.582***
		DST	60	-0.28	-0.24	
NASDAQ	Wallemo	Monday	1086	-0.04		-1.693*
		DST	44	-0.64	-0.60	
	KKL	Monday	1259	-0.01		-3.997***
		DST	48	-0.45	-0.44	

Variable DST is the first day to follow on a DST weekend. The Monday variable is all other first days following the weekend.

* Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

The difference in mean returns is greater for the NASDAQ index than for the S&P index in both my and KKL's study.

Table 6. Equality of Tuesday Return Mean Test Results for Both Indexes

			N	Mean	Difference	Joint t-test
S&P	Tuesday		1830	0.04		-0.114
	DST scnd		71	0.02	-0.02	
NASDAQ	Tuesday		1086	0.01		-0.485
	DST scnd		44	-0.10	-0.11	

Variable DST scnd is the second day to follow on a DST weekend. The Tuesday variable is all other second days following the weekend.

* Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

When testing the equality of mean returns of Tuesdays the significance is lost all together. The differences in mean returns are also lower for both indexes. The tests do not support the

notion of a lasting DST effect, although both DST return series exhibit lower means than the Monday return series.

Monday effect

Table 7. Equality of Monday Volume Change Mean Test Results for Both Indexes

		N	Mean	Difference	Joint t-test
S&P	Monday	1830	-3.84		-0.624
	DST	71	-4.91	-1.07	
NASDAQ	Monday	1086	-4.50		-3.226***
	DST	44	-10.80	-6.30	

Variable DST is the first day to follow on a DST weekend. The Monday variable is all other first days following the weekend.

* Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

The test for equality of means between trading volume changes on Mondays and DST Mondays is rejected for the NASDAQ index but not for the S&P index. The mean trading volume change on DST Mondays is lower than for other Mondays for both indexes, and notably negative.

The difference in significance between the S&P index and the NASDAQ index mean trading volume changes is not reflected in the tests for equality of mean returns, where the hypothesis of equal means was rejected for both indexes. I therefore test for correlation between DST volume changes and absolute returns.

Table 8. Regression Results for Both Indexes
(Trading volume change regressed on absolute return)

	u	ABSreturn
S&P	-0.073	0.283
	(-4.022***)	(2.449**)
NASDAQ	-0.126	0.234
	(-6.043***)	(1.560)

* Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

Regressions of volume on absolute return indicate a positive correlation between DST volume changes and absolute return for both indexes. However the correlation is only significant for the S&P index. The influence of the absolute returns on volume changes are about the same for the both indexes.

Table 9. Equality of Tuesday Volume Change Mean Test Results for Both Indexes

		N	Mean	Difference	Joint t-test
S&P	Tuesday	1830	13.4		
	DST scnd	71	12.66	-0.74	-0.354
NASDAQ	Tuesday	1086	13.73		
	DST scnd	44	16.02	2.29	0.971

Variable DST send is the second day to follow on a DST weekend. The Tuesday variable is all other second days following the weekend.
* Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

The test of equality of Tuesday volume changes is not rejected for either index. The NASDAQ index mean DST volume change does exhibit higher growth than ordinary Tuesdays, however not significantly so.

Spring vs. Fall DST effect

KKL, in their study, found fall DST changes to be more pronounced and also more significantly different from ordinary weekends compared to spring DST changes.

Table 10. Equality of Monday Volume Change Mean Test Results for the NASDAQ Index
(Spring vs. Fall)

		N	Mean	Difference	Joint t-test
Spring	Monday	1086	-4.50		-1.977*
	DST	22	-10.31	-5.81	
Fall	Monday	1086	-4.50		-2.917***
	DST	22	-11.28	-6.78	

Variable DST is the first day to follow on a DST weekend. The Monday variable is all other first days following the weekend.
* Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

The significant difference in volume change means in the NASDAQ index is present in both the spring and the fall DST means. The hypothesis of equal means is rejected at a lower significance level for the fall DST mean. As for the S&P spring and fall DST means, none of them are significantly different from the mean of ordinary Mondays.

Table 11. Equality of Monday Volume Change Mean Test Results for the S&P Index
(Spring vs. Fall)

		N	Mean	Difference	Joint t-test
Spring	Monday	1830	-3.84		-0.495
	DST	36	-4.88	-1.04	
Fall	Monday	1830	-3.84		-0.425
	DST	35	-4.94	-1.10	

Variable DST is the first day to follow on a DST weekend. The Monday variable is all other first days following the weekend.
* Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

October effect

The study by KKL has been questioned by Lamb, Zuber and Gambar (2004) on the basis that the DST fall effect, that in large drives the KKL findings, is really an October effect. The October effect is present in the trading volume change time series for both indexes.

**Table 12. Equality of Monday Volume Change Mean Test Results
for Both Indexes
(The October effect)**

		N	Mean	Difference	Joint t-test
S&P	Monday	1701	-3.05		-5.640***
	October	160	-12.45	-8.40	
NASDAQ	Monday	1010	-3.74		-5.902***
	October	96	-13.80	-10.06	

Variable October is the first day to follow on a weekend in October. The Monday variable is all other first days following the weekend.
* Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

The mean of October Mondays is much lower than that of other Mondays. When comparing DST October Mondays with other October Mondays the hypothesis of equal means is rejected for the S&P index. Even more interestingly is the fact that for both indexes the negative growth is lower on DST Mondays. The number of observations of this test is however few for both indexes.

**Table 13. Equality of Monday Volume Change Mean Test Results
for Both Indexes
(The DST effect in October)**

		N	Mean	Difference	Joint t-test
S&P	October	130	-14.22		3.007***
	DST	34	-4.90	9.32	
NASDAQ	October	76	-14.59		1.196
	DST	22	-11.28	3.31	

Variable DST is the first day to follow on a DST weekend in October. The October variable is all other first days following the weekend in October. * Significant at the 10-percent level, ** significant at the 5-percent level, *** significant at the 1-percent level.

Analysis

The impact of the SAD and DST external factors on volume changes of the S&P and NASDAQ Composite indexes is difficult to interpret in a uniform way. If there are a SAD and a DST effect, they do not appear to affect investor aggregates in the same way.

Seasonal affective disorder

KKL. find positive abnormal returns during the SAD period, which stretches from the autumn equinox, over the winter solstice to the spring equinox. They also find that the returns are lower during the fall, as indicated by the Fall dummy. This is in line with their expectations.

While I also find a significant SAD effect in my more limited return regressions, the same regressions fail to return significantly lower returns for the fall period. As for the study by KKL, I find a significant Monday effect in my return time series.

The SAD effect is also present in the volume change regression on the NASDAQ index series. The correlation is positive, indicating that the SAD effect is working through increased risk aversion, which in turn leads to increased trading. This result indicates that passivity caused by SAD depression has a weaker impact on the investor aggregate than the increased risk aversion.

However, this result is not supported by the S&P volume change regression. Although the SAD variable has a positive correlation with volume change, the correlation is not significant. This is surprising as the corresponding return regression showed a significant SAD correlation, the same as for the NASDAQ index. If there does exist a SAD effect the most likely reason for the disparity between the two indexes is that investors at the NYSE are less affected in general than those investors acting at the NASDAQ. However, bearing in mind that both exchanges are situated in New York and are likely to attract largely the same individuals makes this a vulnerable explanation. At the same time it is difficult to overlook that the NASDAQ index does show a significant SAD effect.

Another intriguing feature of the volume change regressions are the significant Fall dummies present in both the NASDAQ and the S&P volume change regressions. The fall dummies indicate that the SAD effect is stronger as the day grows shorter, that is, as the depression symptoms can be expected to increase. The effect is not as strong as the day grows shorter, reducing the SAD symptoms. The difference is biggest and most significant in the S&P volume change regression, which could indicate that the increasing number of daylight hours does not cause trading to increase as expected and so rendering the SAD variable insignificant.

The significant fall dummies also question the relevance of passivity caused by SAD. Passivity induced by depression could be expected to increase as the day grows shorter and increase as the day grows longer. This means that passivity would counteract the change in risk aversion in the fall and support increased trading in the spring. However, this is not supported by the Fall dummies.

There seems to be a strong Monday effect present in the volume change series, as in the return series. Trading on Mondays is significantly lower than on other days of the week, both on the NASDAQ as well as the NYSE. This is in line with the findings by Lakonishok and Maberly (1990) in their study of trading patterns at the NYSE.

The correlation between absolute returns and volume changes is strong and important, as expected.

It seems as if although returns are not abnormal during the first trading days of the year, there is a substantially higher activity at the exchanges during this period as indicated by the Tax dummy.

Daylight saving time

None of the tests supports the idea of a DST effect on trading volume changes that would increase trading volumes as the marginal investor becomes more risk averse. Instead the Weekend effect is found to be stronger on DST Mondays. The question is however, if the DST effect is more likely to manifest itself as passivity with the investor. Bearing in mind the significantly lower trading change volumes manifested in the volume change regressions, i.e.

a Monday effect, the question is whether the DST effect is somehow strengthening the Monday effect. If this is the case the most likely explanation would be depression induced passivity.

It is important to note that the working paper by Allen, Jacobsen and Marquering (2006) rejects the findings by KKL. They have replicated the study by KKL but on a much larger number of indexes spread over the globe.

When testing for the equality of equal means for volume changes the hypothesis is rejected for the NASDAQ index, but not for the S&P index. (The fact that the S&P index again fail to prove significantly affected by the external factor is difficult to speculate on.) It is interesting to note that the opposite occurs when I regress Monday volume changes on absolute returns. Now the correlation is significant with the S&P index, but not with the NASDAQ index. If there is no DST effect the difference in correlation with absolute returns could perhaps explain why S&P DST Mondays are no different from other Mondays.

A possible DST effect does not seem to be lasting; not with the mean returns nor the mean volume changes. Both indexes show higher trading volumes on Tuesdays, which is to expected given the presence of a Monday effect.

The results prove to be consistent as I test the means for the spring and fall DST changes separately. Again the NASDAQ series rejects the notion of equal volume change means while the S&P series does not.

Lamb, Zuber and Gambar has questioned the study by KKL, arguing that the results merely is a manifestation of an October effect. This October effect is also present in the volume change series. Mondays in October show less trading activity than other Mondays. However, when testing for the equality of volume change means of DST Mondays in October and other Mondays in October a possible DST effect seems to work against the October effect. Trading volume changes are not as strong on DST October Mondays as on other October Mondays.

Not only does it appear as if a possible DST effect is strengthening the Monday effect, while weakening the October effect, there are also differences in significance between the two indexes. Equality of means is not rejected for the S&P index when it comes to the Monday effect, but is rejected for the October effect. The opposite is true for the NASDAQ index.

According to Lakonishok and Maberly (1990), who studied trading volumes at the NYSE, part of the volume Monday effect can be explained by less trading activity by institutions and more trading activity by individuals, who also tend to increase the number of sell relative to buy transactions. Perhaps there is a difference between the indexes in this respect. A possible DST effect could be more likely to induce passivity with individual investors than institutional investors. And perhaps the patterns found at the NYSE by Lakonishok and Maberly are even more pronounced at the NASDAQ. However, this is merely speculations on my part.

Conclusions

My data does not return any compelling evidence for a SAD effect on trading volume, however the effect is not completely rejected either. The most interesting observation is the

difference in results between the return series and the volume change series. I fail to reject the notion of an equally strong SAD effect around the winter solstice for the return series. The same result applies for the NASDAQ volume change series, but not for the S&P volume change series. The regressions indicate that both indexes hold a significant correlation between returns and trading volume change and the correlation is strongest and most significant with the S&P index.

Apparently the SAD effect, if it has an effect on trading volume change through heightened risk aversion with the marginal investor, results in a different impact on the New York Stock Exchange (S&P 500) than on the NASDAQ, at least during spring when the days grow longer. I find it however unlikely that the investor aggregate at the NYSE and the NASDAQ would differ in sensitivity to the number of hours of daylight.

The same disparity between the indexes is present in the study of the DST effect. The mechanism behind a possible DST effect is not apparent. It is not likely however, that the DST effect cause increased trading volume changes through heightened risk aversion, as for the SAD effect, because DST Mondays show lower trading volumes than other Mondays.

The most interesting notion following my thesis is the differences between the NASDAQ and the S&P index that are present in the studies of both the SAD and the DST effect. If these effects are an illusion, as would be argued by critics of behavioural finance, perhaps the reason for these disparities can be found in respective market microstructure. Wang (1994) argued the importance of volume studies for the understanding of asset pricing and perhaps my results indicate differences in investor heterogeneity between the two exchanges.

Appendix: Robustness tests

Return regressions

$$r_t = \mu + \rho_1 r_{t-1} + \rho_2 r_{t-2} + \mu_{SAD} D_t^{SAD} + \mu_{Fall} D_t^{Fall} + \mu_{Monday} D_t^{Monday} + \mu_{Tax} D_t^{Tax} + \mu_{Temperature} D_t^{Temperature} + \mu_{Precipitation} D_t^{Precipitation} + \varepsilon_t$$

S&P

Model fit

Ramsey RESET test using powers of the fitted values of R

Ho: model has no omitted variables

$$F(3, 9185) = 36.57$$

$$\text{Prob} > F = 0.0000$$

The hypothesis is rejected indicating a misspecification of the regression. This is true for all the regressions but is also ignored on the basis that this study is a replication of the KKL study.

Multicollinearity

Variable	VIF	1/VIF
-----+-----		
SAD	1.66	0.601848
Fall	1.42	0.705751
Tax	1.16	0.858471
Temp	1.13	0.885221
Rlag1	1.01	0.994519
Rlag2	1.01	0.994697
Precip	1.00	0.999549
Monday	1.00	0.999658
-----+-----		
Mean VIF	1.17	

Autocorrelation

Durbin-Watson d-statistic(9, 9197) = 2.001198

Heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of R

$$\text{chi2}(1) = 310.74$$

$$\text{Prob} > \text{chi2} = 0.0000$$

There is heteroskedasticity present in all regressions, why I use heteroskedasticity-robust standard errors offered by the statistics programme Stata 9.

NASDAQ

Model fit

Ramsey RESET test using powers of the fitted values of R

Ho: model has no omitted variables

$$F(3, 5450) = 5.03$$

$$\text{Prob} > F = 0.0018$$

Multicollinearity

Variable	VIF	1/VIF
-----+-----		
SAD	1.71	0.586240
Fall	1.57	0.636518
Temp	1.47	0.679222
Tax	1.17	0.854112
Rlag2	1.01	0.992720
Rlag1	1.01	0.994306
Precip	1.00	0.997848
Monday	1.00	0.999298
-----+-----		
Mean VIF	1.24	

Autocorrelation

Durbin-Watson d-statistic(9, 5462) = 2.000966

Heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of R

$$\text{chi2}(1) = 9.93$$

$$\text{Prob} > \text{chi2} = 0.0016$$

Volume change regressions

$$v_t = \mu + \rho_1 v_{t-1} + \rho_2 v_{t-2} + \mu_{SAD} D_t^{SAD} + \mu_{Fall} D_t^{Fall} + \mu_{Monday} D_t^{Monday} + \mu_{Tax} D_t^{Tax} + \mu_{Temperature} D_t^{Temperature} + \mu_{Precipitation} D_t^{Precipitation} + \mu_{ABSreturn} D_t^{ABSreturn} + \varepsilon_t$$

S&P

Model fit

Ramsey RESET test using powers of the fitted values of V

Ho: model has no omitted variables
 $F(3, 9184) = 134.45$
 $\text{Prob} > F = 0.0000$

Multicollinearity

Variable	VIF	1/VIF
-----+-----		
SAD	1.66	0.602008
Fall	1.42	0.702305
Tax	1.19	0.843082
Temp	1.13	0.885018
Vlag1	1.10	0.905889
Vlag2	1.09	0.917263
Monday	1.03	0.970842
ABSR	1.01	0.993846
Precip	1.00	0.999732
-----+-----		
Mean VIF	1.18	

Autocorrelation

Durbin-Watson d-statistic(10, 9197) = 2.027937

Heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of V

$\text{chi2}(1) = 1326.01$
 $\text{Prob} > \text{chi2} = 0.0000$

NASDAQ

Model fit

Ramsey RESET test using powers of the fitted values of V

Ho: model has no omitted variables

$F(3, 5449) = 234.62$
 $\text{Prob} > F = 0.0000$

Multicollinearity

Variable	VIF	1/VIF
-----+-----		
SAD	1.70	0.587079
Fall	1.57	0.635262
Temp	1.47	0.679498
Tax	1.19	0.840642
Vlag1	1.11	0.897078
Vlag2	1.09	0.915547
Monday	1.04	0.963001

ABSR	1.00	0.995686
Precip	1.00	0.999662
-----+-----		
Mean VIF	1.24	

Autocorrelation

Durbin-Watson d-statistic(10, 5462) = 1.983511

Heteroskedasticity

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of V

chi2(1) = 927.85

Prob > chi2 = 0.0000

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