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By the light of day: The effect of the switch to winter time on stock markets ☆

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ABSTRACT

We studied the effect of the shift from Daylight Saving Time (summer time) to Standard Time (winter time) on stock markets around the globe. Using a detailed cross-country data set of daily returns, we documented that (a) market returns on the day following the time shift were significantly lower than those on the corresponding day of the week unaffected by the change; (b) the economic magnitude of the effect was substantial, on average 5–6 times greater than the unconditional mean of market returns; and (c) the outcome was more prominent in local, relatively small markets. Furthermore, we attempted to identify the mechanism underlying the gloomy market returns accompanying the switch to winter time. Our results suggest that the mechanism underlying the effect may be based on the temporary loss of investor internal clock harmony.

1. Introduction

> "Be governed by your internal compass, not by some clock on the wall."— Stephen R. Covey, A. Roger Merrill, Rebecca R. Merrill, *First Things First*, 1996"

For thousands of years, there have been widespread beliefs in human cultures worldwide that elements of nature, including moon cycles, temperature, and rainfall, affect humans. Following this age-old fascination, a considerable body of research exists on the impact of natural phenomena on our daily behavior.

In the field of behavioral finance, the question of whether investor sentiments affect stock market has attracted substantial interest in the literature.[1] Saunders (1993), wrote the seminal paper on this subject, demonstrating statistically significant

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[1] For more in-depth discussions on the empirical determinants and implications of the importance of the influence of behavioral factors considering financial decisions, see e.g. Mugerman, Ofir and Wiener (2016).

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weather effects on stock returns. Subsequent studies have supported the notion that weather, disasters, lunar phases, cloudiness, temperature, wind, etc. affect stock returns (see, for example, Hirshleifer, 2001; Hirshleifer, and Shumway, 2003; Cao and Wei, 2005; Yuan, Zheng, and Zhu, 2006; Kaplanski, and Levy, 2010; Dehaan, Madsen, and Piotroski, 2017; You, Guo, and Peng, 2017; Xu, and Zhou, 2018; Glogger et al., 2019; Erdemlioglu, and Joliet, 2019; Gao et al., in press).

A special place among natural phenomena effects is reserved for sunlight, which has played a pivotal role in shaping belief systems. For centuries, the sun has been a preeminent factor in religious ceremonies and sundry activities alike. Light has served a symbol of "the good", hope, optimism and happiness. Thus, one of the aims of instituting Daylight Saving Time (DST)[2] was to make sure that people's active hours coincide with the sunlight hours. Despite the significant implications for human mood, efficiency, and general feelings of comfort, there has been scarce research on the possible effects of time changes on financial market behavior. Kamstra et al. (2000), were the first to find that Monday market returns following the DST switch were much more negative than on regular Mondays in the United States, Canada, and the United Kingdom, but not in Germany. Using data from securities indices in these countries, the authors suggest that the decline in returns following the time switch may be the result of *desynchronosis*. Though the time change involved in moving to and from DST is "only" an hour, it may have significant physiological effects on humans adjusting to the new clock setting. Seminal studies (e.g. Monk and Folkard, 1976; Monk and Alpin, 1980) documented the effects on the human body of sleep deficiency and desynchronization of the circadian system. Similarly, behavioral and physiological changes that have been observed following daylight time changes include disruption in waking time (Monk and Alpin, 1980), and a significant increase in the number of traffic accidents in the week following the time shift (Hicks et al., 1983). On the other hand, Morassaei and Smith (2010) found no evidence supporting the notion that the loss (or the gain) of one hour of sleep results in a decrease or increase in work injury claims. More generally, Folkard et al. (1976) found that even a slight shift in one's sleep schedule can result in substantial performance changes, particularly regarding tasks with a high cognitive load. This suggests that even a one-hour time shift may have significant physiological and psychological effects. Remarkably, the literature shows that the conclusion is relevant not only when the clock moves forward and people, apparently, have an hour less of sleep, but also when the clock moves back and people can, prima facie, sleep longer.

In line with research that demonstrates how changes in sleeping patterns affect an individual's level of anxiety, judgment, problem solving ability, and reaction time, the authors assert that these changes might also lead to greater anxiety and lower risk-taking stock market activity. Their findings, however, have been called into question by several more recent studies. Pinegar (2002) shows that under several rigorous robustness tests, the effect faded. Similarly, Berument et al. (2010) concluded that evidence gathered from the major U.S. stock markets for the period between 1967 and 2007, does not support the existence of a DST effect on stock returns. In their respective studies, Lamb et al. (2004) and Worthington (2003) also reject the existence of a perceptible DST effect.

The above-mentioned studies concentrate primarily on a particular U.S. market (or several large markets). Despite the size and prominence of these markets, this narrow approach raised concerns regarding accidental spurious correlations. We contribute to the literature by presenting an extensive *cross-country* analysis. Taking into account that trading in the so-called global markets operating in countries such as the United States, Germany, and the United Kingdom may be highly dispersed, we concentrate on what we presume to be local markets. This allowed us to better study actual behavioral phenomena tied to the local behavioral changes precipitated by the time shift.

In the current research we concentrate specifically on the time shift from DST to standard time, which allows us to investigate an alternative factor that might explain the negative effect of resetting the clock on investor sentiment: the sudden one-hour reduction of daylight during waking hours as a result of the return to standard time. This time shift is the first manifestation of impending winter (winter is just around the corner). According to experimental psychological research, the lack of daylight can lead to depression among those experiencing seasonal affective disorder (SAD) (e.g. Molin et al., 1996; Young et al., 1997)—or to the milder "winter blues." Kamstra et al. (2003) find that this phenomenon is linked in turn to heightened risk aversion in fall and winter and is reflected in stock market returns. We hypothesize that time shift from DST to standard time, which leads to the shortening of "active" daylight hours, can precipitate short-term negative returns. We identify two possible mechanisms driving this effect: interruption in the circadian rhythm as a result of the time shift or sullenness *triggered* by the sudden shorter hours of daylight, signaling that "Winter is coming".

Using daily stock market data spanning several decades from dozens of countries at different latitudes and on both sides of the equator, we find that the discontinuation of DST has a statistically significant negative impact on stock market returns and that this time shift effect holds after controlling for local and global trends, the day of the week, and the season. The economic magnitude of this effect is five to six times greater than the unconditional mean of daily returns. In about 80% of the countries comprising our sample, stock markets exhibited bearish outcomes stemming from less enthusiastic investor behavior over the day following the return to standard time. When we restricted our sample solely to "small" markets[3] where behavioral biases are held to have a greater impact, the results are even more striking.

Furthermore, we took a preliminary step toward determining the causal mechanism underlying the stock market "dips" following the return to standard time. We found that the effect is short-lived, waning rapidly within a few days. This leads us to believe is caused by a perceived lack of balance among investors immediately after the switch, which is regained within a

[2] The DST regime consists of setting the clocks forward 1h from standard time during the late spring and summer months, and back again in the fall.

[3] Markets where the total market cap is bellow USD 2 trillion, as of 12/2007. This specification excludes Germany, Great Britain, France, and Canada.

few days. An alternative explanation is akin to the "SAD effect" documented by Kamstra et al. (2003) in their study tracking returns over the entire diminished daylight autumn and winter seasons. In our case, which focuses on the impact of a single day of the year, sadness is triggered by the sudden loss of an hour of afternoon/evening daylight. The time shift signals the imminence of winter.

Unlike Kamstra et al. (2003) we found no evidence of any correlation between the latitude at which a stock exchange is located and either the existence or magnitude of the "standard time" effect on that market.[4] We also added the spring time shift to DST as an additional explanatory, and documented a statistically significant negative "DST effect" on the markets following this shift as well.

While the two explanations are by no means mutually exclusive, these findings seem to undermine the strength of the "impending winter blues" hypothesis, and support the desynchronization of investors' "internal clock" as the more likely explanation for the effect. After applying a set of robustness tests, the results remain qualitatively the same.

In Section 2 we describe the sample and data. In Section 3 we present our empirical strategy. We report and discuss our results in Sections 4–6 and conclude in Section 7.

2. Data

We used the daily returns of the flagship stock market indexes of 45 countries (see Appendix A) for the years 2000 to 2017.[5] These included European and non-European countries, developed and emerging markets, from both the northern and southern hemispheres. The one thing these countries have in common is that they all implement DST for the summer months or have done so at some point in the past (for details, see Appendix B). The source of all our market data is the Bloomberg Market Data system. Daily returns (R_t) for each index were calculated according to the formula $R_t = \ln(P_t/P_{t-1})$, where P_t is the price of the index on day t and P_{t-1} is the price of the index on day t-1. In all of our analyses we used trimmed returns at 2% (1% on each side).

Fig. 1 depicts the distribution of daily returns for the entire sample. Unsurprisingly, daily returns spike around zero, and the overall distribution has a typical "fat tails" shape—positive kurtosis (leptokurtic). It means that the probability of extreme high or extreme low returns is significantly higher than of the respective (same mean and standard deviation) normal distribution (blue line). Fig. 2 portrays several additional data features, demonstrating the association between local returns at time t (R_t) and S&P 500 returns at time t (US_t, Fig. 2A) and between R_t and S&P 500 returns at time t-1 (US_{t-1}, Fig. 2B). As these plots demonstrate, global trends account for some variation in local returns. Fig. 2C portrays the correlation between local returns in time t and time $t-1$. Unsurprisingly, the autocorrelation coefficient for local markets is very close to zero.

Table 1 provides a summary of the descriptive statistics for our sample. The average unconditional daily return is 0.036%. This return is slightly higher than the S&P 500 return, which, in turn, averaged 0.020%. Table 2 shows that conditional on first trading day after DST ends, the average daily return drops from 0.037% to −0.199% (in annual terms almost a 82% drop). The t statistic of the conditional mean differences is fairly high 3.549.

3. Methodology

We used an ordinary least squares regression model in an attempt to measure the affect of the shift to standard time on the value of the share price indexes. The use of multiple countries provided us with differentiation in the dates on which this shift took place, as the shift occurs on different days as well as different months of the year in different jurisdictions. For instance, countries situated south of the equator shift to standard time in February, March, or April, while countries to the north of the equator make this shift in September, October, or November. In our view, the multiple transition dates allowed us to better isolate the time shift anomaly, as we were better able to attribute any excess return on those days specifically to the time shift, rather than to other "seasonalities", for which excess returns occur at a fixed time on the calendar (a certain day of the week, month of the year, season, etc.).

We employed the following set of regressions, through which we examined the effect of a dummy variable representing the day of the time shift (the first trading day following the time shift) in the country on the daily return of the share price index at the local stock exchange:$R_{i,t} = \alpha_0 + \beta_1 * DST_{i,t} + \varepsilon_{it}$:

$$R_{i,t} = \alpha_0 + \beta_1 * DST_{i,t} + \beta_2 * US_t + \beta_3 * US_{t-1} + \varepsilon_{it} \tag{1}$$

$$R_{i,t} = \alpha_0 + \beta_1 * DST_{i,t} + \beta_2 * US_t + \beta_3 * US_{t-1} + \gamma_1 * Dmonday_{i,t} + \gamma_2 * Dfall_{i,t} + \varepsilon_{it} \tag{2}$$

$$R_{i,t} = \alpha_0 + \beta_1 * DST_{i,t} + \beta_2 * US_t + \beta_3 * US_{t-1} + \gamma_1 * Dmonday_{i,t} + \gamma_2 * Dfall_{i,t} + \delta_i * Dcountry_i + \theta_t * Dyear_t + \varepsilon_{it} \tag{3}$$

where $R_{i,t}$ is the daily return of the share price index in country i on day t; $DST_{i,t}$ is an indicator variable that receives a value of 1 for dates (the first trading day following the time shift) on which country i shifted from DST to standard time, and 0

[4] Higher latitude (absolute value) markets are thought to show a more pronounced winter blues effect.

[5] We were unable to obtain data for the entire period for six countries. The inclusion of these countries, therefore, started later: New Zealand (2001), Croatia (2002), Montenegro (2003), Slovenia (2003), Cyprus (2004), and Serbia (2004).

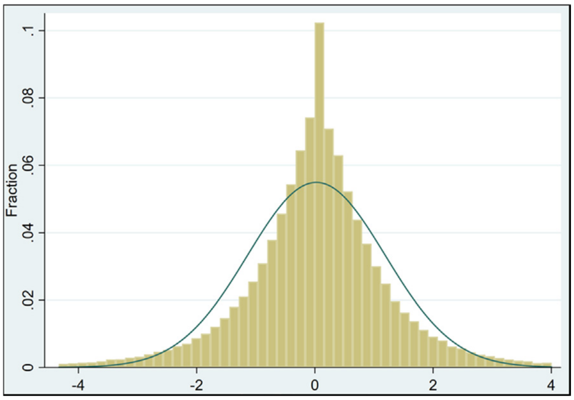


Fig. 1. The distribution of daily returns. We depict the distribution of the daily return in the years 2000–2017, trimmed at the 2% (1% on each side). Trimming is performed in the overall sample (45 markets). The daily returns (R_t) for each index were calculated according to the formula $R_t = \ln(P_t/P_{t-1})$, where Pt is the price of the index on day t, and where P_{t-1} is the price of the index on day t-1. The corresponding (same mean and standard deviation) normal distribution is shown as a solid line.

otherwise; US_t is the daily return of the S&P 500 index on day *t*; US_{t-1} is the daily return of the S&P 500 index on day *t-1*; $Dmonday_{i,t}$ is a dummy variable that receives a value of 1 for observations on the first trading day of the week in country *i* (typically Monday), otherwise 0; $Dfall_{i,t}$ is a dummy variable that receives a value of 1 for observations during autumn (in the northern hemisphere: observations during the months of September, October, and November; in the southern hemisphere: observations during the months of March, April, and May), otherwise 0; $Dcountry_i$ is a dummy variable for country *i* (country fixed effects); and, finally, $Dyear_t$ is a dummy variable for year *t* (time fixed effects).[6] We cluster standard errors at the country level. In the robustness tests that follow we examine clustering on other dimensions, including double-clustering at the country and time levels. In addition, we control for autocorrelation in stock returns, and add a lagged *t-1* return (for each market) as a control. The results, available from the authors upon request, are qualitatively and quantitatively similar to our main results.

Our primary interest was the estimator β_1, which represents the effect of the shift from DST to standard time on the daily return. In Model Regression1, we tried to capture other factors that could explain stock market returns on a given day and controlled for the following variables: local returns of the previous trading day; the performance of the U.S. stock market (S&P 500), as part of the network of interrelations between markets across the globe. This is based on the premise that, due to the size of the U.S. stock market, shifts in the price of its assets affect the pricing of assets in other stock markets as well. Due to differences in trading hours between stock exchanges in the United States and the rest of the world, we controlled for the daily return of the S&P 500 on both the same and the preceding trading days.

Model Regression (2) takes possible day-of-the week anomalies, such as the "Monday effect" and "weekend effect" (see e.g. Thaler, 1987), into account. We expected to find negative average excess returns for the first trading day of the week. Since time shifts almost invariably take place over weekends, (most often on the night between Saturday and Sunday), the first trading day following the time shift is usually the first trading day of the week. To isolate the estimated effect of the time shift beyond the effect of the day itself, we controlled for the "accompanying" seasonality that occurs on the first trading day of the week.

In Model Regression (3), we control for the additional seasonal effects. Standard time replaces DST because of the natural shortening of daylight hours, and therefore the switch tends to occur in autumn. Various seasonal effects impact average stock returns at various times of the year (see e.g. Kamstra et al., 2003), and therefore abnormal returns might be observed throughout the entire fall season, in which daylight continues to gradually diminish. To isolate the possible effects of the time shift beyond that explained by seasonal trends, we controlled for the overall fall season effect on the stock market.

4. The effect of the time switch on the stock markets

We started with estimating Regression Models 1–3 for all 45 countries in the sample together, for the years 2000–2017. The dependent variable was the daily return of the stock market on day *t*; the estimator for the variable DST represents the estimated effect of *t* being the first trading day following the transition to standard time on the returns of the indexes on that day.

Our key results are presented in Table 3. It is evident that in all the three models we employed, the transition to standard time had a statistically significant negative impact on the average daily share price index returns, across all sample countries.

[6] In addition, we checked the robustness of the results employing day fixed effects. The results, available from the authors upon request, are qualitatively and quantitatively similar to our main results.

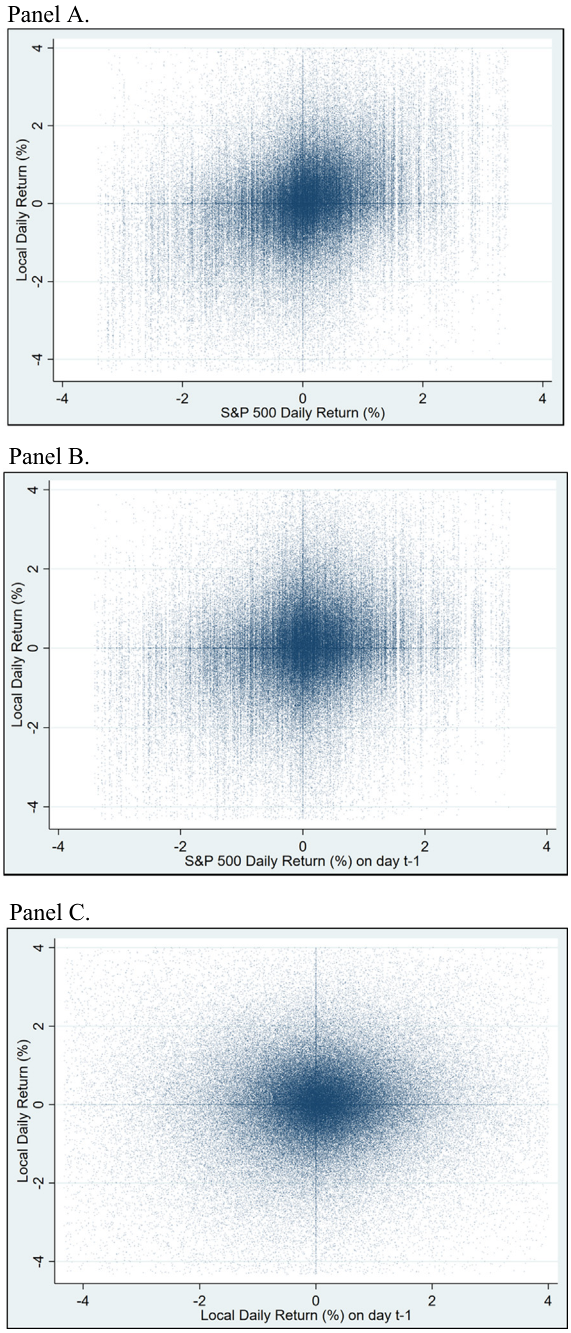


Fig. 2. Scatterplot of the associations in the years 2000–2017 between (Panel A) S&P 500 returns on day *t* (US_t) and local daily returns on day *t* (R_t) (Panel B) S&P 500 returns on day *t*-1 (US_{t-1}) and local returns on day *t* (R_t), and (Panel C) local returns returns on day *t*-1 (R_{t-1}) and local returns on day *t* (R_t). We scatter daily return in local markets on day *t* (vertical axis) and A) the S&P 500 on day *t*, B) the S&P 500 on day *t-1*, and C) local markets on day *t-1* (horizontal axis) in the years 2000–2017. All the returns are trimmed at the 2% (1% on each side). Trimming is performed in the overall sample. The daily returns for each index were calculated according to the formula $R_t = \ln (P_t / P_{t-1})$, where Pt is the price of the index on day t, and where P_{t-1} is the price of the index on day t-1.

Even when time shift effect was controlled for day-of-the week, and the season-of- the-year (fall) effects, the negative value of the estimator remained significant (Columns 2 and 3).

Unsurprisingly, we found positive correlations between the returns of local stock markets and S&P 500 returns. Additional findings confirm the existence and persistence of previously recorded anomalies regarding the lower than average returns at the beginning of the trading week and throughout autumn.

Table 1
Sample descriptive statistics, 2000–2017.

Variable	Observations	% of observations	Mean	*SD*	Minimum	Maximum
R_t	190,103		0.036%	1.133%	−4.332%	4.005%
US_t	4,452		0.020%	0.971%	−3.403%	3.415%
DST[a]	667	0.351%	−0.119%	1.134%	−4.298%	3.991%
D_{Monday}[b]	38,889	20.457%	0.013%	1.177%	−4.332%	4.005%
D_{fall}[c]	47,409	24.939%	0.029%	1.133%	−4.306%	4.005%

Note. R_t = Daily returns for each index; US_t = daily S&P 500 returns.
[a] *DST* is an indicator variable that receives a value of 1 for dates (the first trading day following the time shift) on which there is a switch from DST to standard time, and 0 otherwise.
[b] D_{Monday} is a dummy variable that receives a value of 1 for observations on the first trading day of the week (typically Monday), otherwise 0.
[c] D_{fall} is a dummy variable that receives a value of 1 for observations during the fall season (In the northern hemisphere: observations in September, October, and November; in the southern hemisphere: observations in March, April, and May); otherwise 0.

Table 2
Sample descriptive statistics (daily returns, conditional on DST), 2000–2017.

Return	Observations	Mean	*Standard Err*	*t*
Unconditional	190,103	0.036	0.0026	
Return|DST = 0	189,436	0.037	0.0026	
Return|DST = 1	667	−0.119	0.0439	
Difference		0.156		3.549

Note. DST is an indicator variable that receives a value of 1 for dates (the first trading day following the time shift) on which there is a switch from DST to standard time, and 0 otherwise.

Table 3
The effect of ending Daylight Saving Time (DST) on the stock markets.

Variable	Regression model		
	1	2	3
DST	−0.144***(0.039)	−0.103***(0.039)	−0.103***(0.033)
US_t	0.354*** (0.003)	0.354*** (0.003)	0.353*** (0.038)
US_{t-1}	0.235*** (0.003)	0.235*** (0.003)	0.234*** (0.016)
D_{Monday}		−0.024*** (0.006)	−0.024** (0.011)
D_{fall}		−0.030*** (0.006)	−0.034*** (0.006)
Country, and year FE	No	No	Yes
Number of observations	190,103	190,103	190,103
Adjusted R^2 (%)	12.03	12.05	12.28

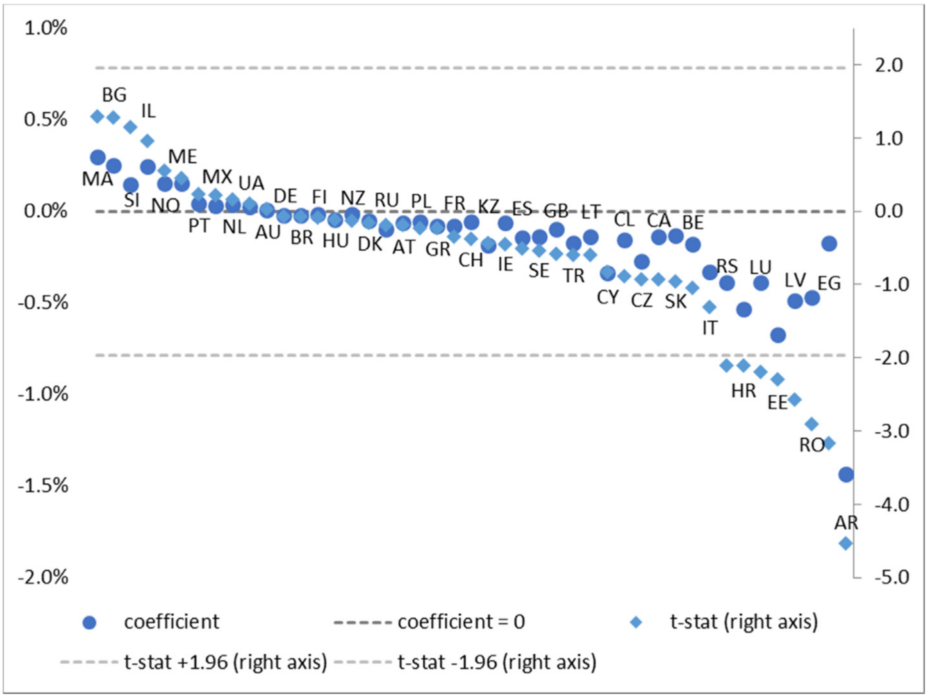
Note. Results of OLS regressions of stock market returns on day *t* (R_t) on the indicator of the day DST ends and some controls. US_t = Daily return of the S&P 500 index on day *t*; US_{t-1} = daily return of the S&P 500 index on day *t*-1; D_{Monday} is a dummy variable that receives a value of 1 for observations on the first trading day of the week in a certain country (typically Monday), otherwise 0; D_{fall} is a dummy variable that receives a value of 1 for observations during the fall season, otherwise 0. Trimming was performed on the overall returns data at the 1% and 99% levels. Robust standard errors clustered at the country level (Column 3) are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

We turned next to examining the impact of the transition to standard time on the returns of the individual share price indices in each country. To this end, we ran Regression Model 3 for 45 different subsamples. Fig. 3 illustrates the results.

We found that for 34 of the 45 sample countries, the time shift to standard time was accompanied by negative share price index returns. Moreover, we observed a statistically significant effect (compare to t = −1.645, and t = −1.96) of the time shift in eight countries—Croatia, Romania, Serbia, Estonia, Latvia, Luxembourg, Egypt and Argentina—where for the last of these, the effect was remarkably high in both its intensity and its significance level. There are several countries for the time shift was correlated with positive daily returns. In all of these cases, however, the estimators were found to be statistically insignificant.

In this study we concentrated on investor behavioral biases. Thus, it was important to exclude from our sample large markets where market participants may be globally dispersed and not necessarily affected by a local time shift.

The results of Regressions (1)–(3), this time applied to a subsample devoid of the share price indexes of the "large global markets" Canada, France, Germany, and the United Kingdom, are presented in Table 4. This exclusion is based on USD 2 trillion threshold, as of 12/2007. For the robustness, we checked another cutoff of USD 1 trillion. In addition to Canada, France, Germany, the United Kingdom, this also excludes Spain, Brazil, Australia, Switzerland, and Italy; leaving a total of 36 markets in this sample. The results, available from the authors upon request, are qualitatively and quantitatively similar to our main results.



Different markets (see Appendix C for country abbreviations)

Fig. 3. The effect of ending Daylight Saving Time (DST), by country, on the first trading day after DST ends, 2000–2017. The figure shows the coefficient (right vertical axis) and t statistic (left vertical axes) of regression coefficient β_1 from Regression Model 3. We run 45 regressions separately for each market. Different markets (see Appendix C for country abbreviations).

Table 4
The effect of ending Daylight Saving Time (DST) on the stock markets excluding large markets.

Variable	Regression model		
	1	2	3
DST	−0.154***(0.041)	−0.109***(0.041)	−0.109***(0.037)
US_t	0.322***(0.003)	0.322***(0.003)	0.321***(0.038)
$US_{t\text{-}1}$	0.236***(0.003)	0.235***(0.003)	0.234***(0.017)
D_{Monday}		−0.030***(0.007)	−0.029**(0.011)
D_{fall}		−0.030***(0.006)	−0.035***(0.006)
Country, year fixed effects	No	No	Yes
Number of observations	172,696	172,696	172,696
Adjusted R^2 *(%)*	10.52	10.55	10.81

Note. Results of ordinary least squares regressions of stock market returns on day t (R_t) on the indicator of the day DST ends and some controls. The sample was restricted to markets with total market cap of less than USD 2 trillion, as of 12/2007 (41 markets in this sample). US_t = Daily return of the S&P 500 index on day t; $US_{t\text{-}1}$ = daily return of the S&P 500 index on day t-1; D_{Monday} is a dummy variable that receives a value of 1 for observations on the first trading day of the week in a certain country (typically Monday), otherwise 0; D_{fall} is a dummy variable that receives a value of 1 for observations during the fall season, otherwise 0. Trimming was performed on the overall returns data at the 1% and 99% levels. Robust standard errors clustered at the country level (Column 3) are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Here, too, the time shift estimator remains negative and statistically significant at the 1% level, and even increases by 0.6 basis points. This finding may indicate weaker efficiency in small markets, leaving them more susceptible to the behavioral biases of investors. The estimators for the impact of the S&P 500, the first trading day of the week, and the fall season remain at similar levels to before.

In the following section we present our first attempt to identify the underlying mechanism for the autumn time shift effect. The origin of the effect could be seasonal depression as it relates to fewer active daylight hours. Appendix D provides in-depth statistics of this argument for each of all 45 markets. As the Appendix shows, in all 45 markets, trading starts (deeply) in light and ends primarily in the dark or in the dim light. In more than seventy percent of the markets, the dim light falls before the end of the trading day. We assume a period of fifty minutes before the sunset as dim light time. This estimation is based on the differences in the lunisolar calendar. Note, however, this could differ from country to country. An alternative explanation is the desynchronization of the internal human clock.

5. Identifying the underlying mechanism of the clock switch

The physiological and psychological literature suggest there are two competing, though not mutually exclusive, underlying mechanisms[7] that can explain negative market returns following the transition from DST to standard time.

Seasonal depression is related to hours of daylight, and thus its impact is thought to be more prominent in countries with higher latitudes (e.g. Young et al., 1997). Fig. 4 illustrates this hypothesis.

As Fig. 4 shows, in our study, the correlation between the stock market latitude (in absolute value) and the estimated t statistic (from Regression Model 3) is extremely low, R^2 = 0.001. This correlation is computed between the absolute value of the latitude and the t statistic of the regression coefficient. For the sake of convenience, Fig. 4B presents the real latitudes and not the absolute values. Moreover, the correlation, if any, is positive, which is inconsistent with the hypothesis predictions. It should be stated, however, that the sample did not incorporate substantial variation in latitude values.

Our next step was the check whether the autumn time shift effect was persistent. The winter blues effect is tracked over a protracted period of time, whereas *desynchronosis* is relatively short-lived. To gauge the persistence of the effect, we examined the impact of the transition to standard time on the daily returns of the share price indexes during the week (5 business days) following the date of the shift, using a regression model similar to Regression Model 3—controlling for the returns of the S&P 500, and the season—with the following differences:

- Dummy variables were assigned to each of the five business days following the transition from DST to standard time, rather than solely to the first day immediately following the transition.
- Dummy variables were assigned to every day of the week, rather than Monday alone.

Fig. 5 presents the results. As we have already shown, on the first trading day following the shift (DST variable), a significant −0.10% effect is observed on the index returns (−0.11% when the large markets are excluded). On subsequent days of the week following the time shift, no statistically significant effect in daily returns could be discerned. Hence, we can conclude that this effect fades away immediately on the following day: The effect on returns were insignificant (−0.01%, −0.02% excluding the large markets). On the third (DST + 2), and the forth (DST + 3) trading days following the shift, it appears that the markets partially "correct" the change, posting positive returns of 0.05%. Interestingly, on Friday, the final trading day during the week following the shift, the stock markets tended to perform poorly relative to other autumn Fridays, and the coefficient of this day is −0.05%.

While the evidence supporting the transience of the autumn time shift anomaly could support the hypothesis that *desynchronosis* is the mechanism underlying the effect it does not necessarily rule out the alternative explanation of a temporary "fall funk" brought on the suddenly truncated day.

Finally, to determine if the autumn time shift effect is exclusive to the transition from DST to standard time, we tested for a possible spring transition "DST effect". We employed this as a placebo test of the "impending winter blues" hypothesis, which is not relevant to the spring time shift. Table 5 demonstrates the findings of the following set of regressions, through which we examined the impact of a dummy variable representing the day of the spring time shift (the first trading day following the spring time shift) on the daily returns of the key share price index: $R_{i,t} = \alpha_0 + \beta_1 * DST_{i,t} + \varepsilon_{it}$:

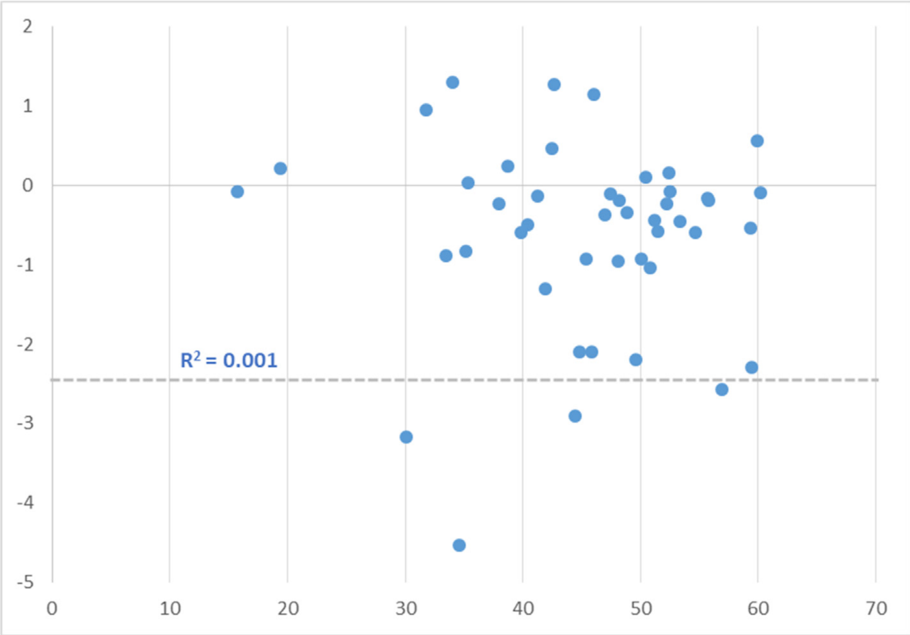
$$R_{i,t} = \alpha_0 + \beta_1 * DST_{i,t} + \beta_2 * SS_{i,t} + \beta_3 * US_t + \beta_3 * US_{t-1} + \gamma_1 * Dmonday_{i,t} + \varepsilon_{it}$$

$$R_{s,i,t} = \alpha_0 + \beta_1 * DST_{i,t} + \beta_2 * SS_{i,t} + \beta_3 * US_t + \beta_3 * US_{t-1} + \gamma_1 * Dmonday_{i,t} + \gamma_s * Dseason_s + \delta_i * Dcountry_i + \theta_t * Dyear_t + \varepsilon_{sit}$$

where $R_{i,t}/R_{s,i,t}$ is the daily return of the share price index in season n, in country i on day t; $DST_{i,t}$ is an indicator variable that receives a value of 1 for dates (the first trading day following the time shift) on which country i shifted from DST to standard time, and 0 otherwise; $SS_{i,t}$ is an indicator variable that receives a value of 1 for dates (the first trading day following the time shift) on which country i shifted from standard time to DST, and 0 otherwise; US_t is the daily return of the S&P 500 index on day t; US_{t-1} is the daily return of the S&P 500 index on day t-1; $Dmonday_{i,t}$ is a dummy variable that receives a value of 1 for observations on the first trading day of the week in country i (typically Monday; in Israel, the first trading day of the week is Sunday. In such a case, variable Monday receives a value of 1 on Sundays), otherwise 0; $Dseason_s$ is a dummy variable for season s (four divisions of the year fixed effects); $Dcountry_i$ is a dummy variable for country i (country fixed effects); and, finally, $Dyear_t$ is a dummy variable for year t (time fixed effects). We cluster standard errors at the country level.

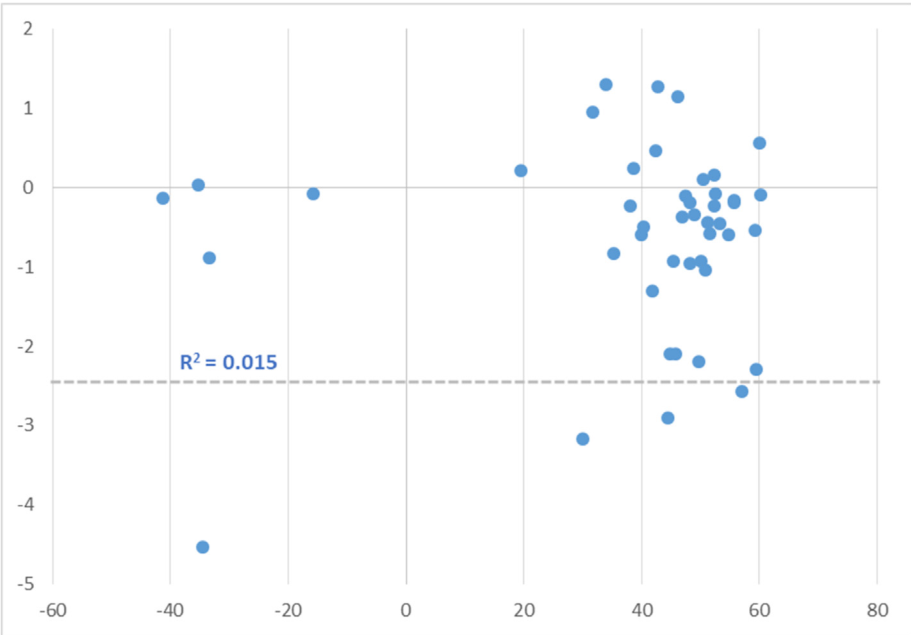
[7] Again, these two mechanisms include: seasonal depression triggered by the sudden lower exposure to sunlight signaling the impending winter and/or the desynchronization of the internal human clock.

Panel A.



Latitude (absolute value; see Appendix C for country abbreviations)

Panel B.



Latitude (see Appendix C for country abbreviations)

Fig. 4. The association between the effect of ending Daylight Saving Time (DST) and the distance from the equator of a country's capital city (Panel A: latitude in absolute values; Panel B: actual latitude), for the first trading day after DST ends. The figure shows the association between the *t* statistic (vertical axis) of regression coefficient β_1 for each local market from Regression Model 3, and the latitude of the country's capital city. We ran 45 regressions separately for each market.

The findings are summarized in Table 5, which presents a statistically significant negative effect associated with the spring transition to DST. While not decisively vindicating the *desynchronosis* hypothesis, given that other factors, such as drowsiness from sleep loss, could come to play, this effect does not support the "winter blues" hypothesis.

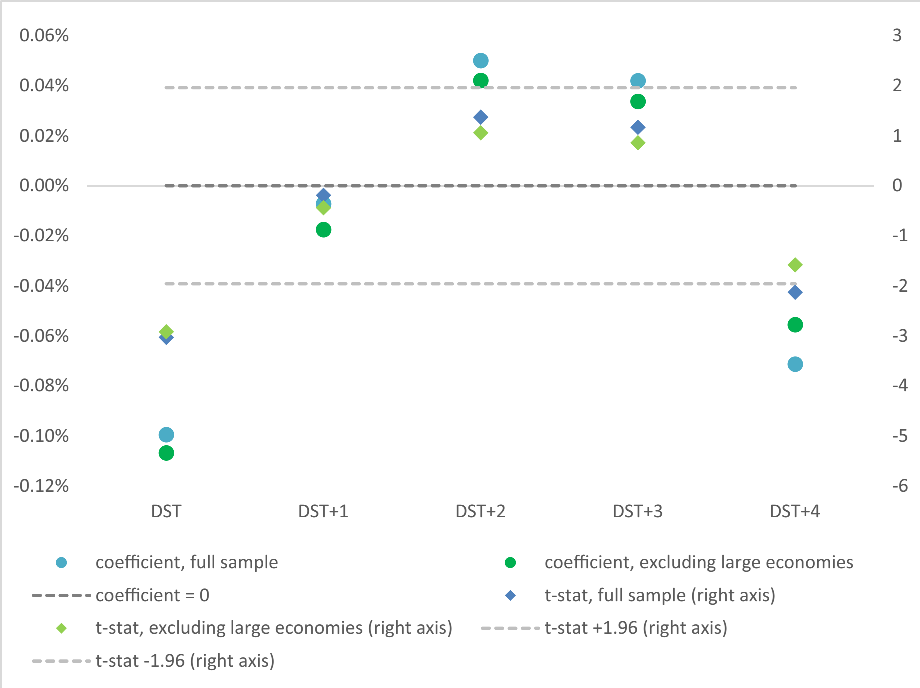


Fig. 5. Effect of ending Daylight Saving Time (DST) over five business days following the shift to standard time. Shown are the coefficient (right vertical axis) and the *t* statistic (left vertical axis) of regression coefficient β_1 from Regression Model 3. The results are presented for the overall sample (in blue), and for the subsample that excludes the large markets (in green). We ran five regressions separately for each day following the time shift. In each regression we controlled, *inter-alia*, for the respective day of the week (instead of the first day of the week). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 5
The effect of starting (SS) and ending (DST) Daylight Saving Time on the stock markets.

Variable	Regression model	
	4	5
DST	−0.125***(0.033)	−0.129***(0.033)
SS	−0.062*(0.033)	−0.056*(0.032)
US_t	0.354***(0.003)	0.353***(0.038)
$US_{t\text{-}1}$	0.234***(0.003)	0.233***(0.016)
D_{Monday}	−0.023**(0.011)	−0.023**(0.011)
Country, and year FE	No	Yes
Season FE	No	Yes
Number of observations	190,103	190,103
Adjusted R^2 (%)	12.04	12.25

Note. Results of OLS regressions of stock market returns on day *t* (R_t) on the indicator of the day DST starts (SS), and ends (DST) and some controls. US_t = Daily return of the S&P 500 index on day *t*; $US_{t\text{-}1}$ = daily return of the S&P 500 index on day *t*-1; D_{Monday} is a dummy variable that receives a value of 1 for observations on the first trading day of the week in a certain country (typically Monday), otherwise 0. Trimming was performed on the overall returns data at the 1% and 99% levels. Robust standard errors clustered at the country level (Column 2) are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Overall, the results in this section point to the relative explanatory weakness of the winter blues hypothesis in our setting.

6. Robustness tests

It is important to note that a positive β_1 indicator in Eq. (3) may not necessarily be accurately measure the causal effect of a time shift on stock market returns. In this section, we summarize the battery of robustness tests we conducted to support our findings.

Table 6
The effect of ending Daylight Saving Time (DST) on the stock markets excluding the Argentine market.

Variable	Regression model		
	1	2	3
DST	−0.138***(0.039)	−0.099***(0.038)	−0.100***(0.033)
US_t	0.347***(0.003)	0.347***(0.003)	0.347***(0.038)
US_{t-1}	0.238***(0.003)	0.238***(0.003)	0.237***(0.016)
D_{Monday}		−0.024***(0.006)	−0.023**(0.011)
D_{fall}		−0.028***(0.006)	−0.032***(0.005)
Country, year fixed effects	No	No	Yes
Number of observations	186,068	186,068	186,068
Adjusted R^2 (%)	12.04	12.05	12.29

Note. Results of ordinary least squares regressions of stock market returns on day t (R_t) on the indicator of the day DST ends and some controls. This sample excludes the Argentine market (44 markets in this sample). US_t = Daily return of the S&P 500 index on day t; R_{t-1} = stock market return on day t-1; US_{t-1} = daily return of the S&P 500 index on day t-1; D_{Monday} is a dummy variable that receives a value of 1 for observations on the first trading day of the week in a certain country (typically Monday), otherwise 0; D_{fall} is a dummy variable that receives a value of 1 for observations during the fall season, otherwise 0. Trimming was performed on the overall returns data at the 1% and 99% levels. Robust standard errors clustered at the country level (Column 3) are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Table 7
The effect of ending Daylight Saving Time (DST) on the stock markets, 2008–2017.

Variable	Regression model		
	1	2	3
DST	−0.207***(0.048)	−0.168***(0.049)	−0.169***(0.054)
US_t	0.411***(0.004)	0.412***(0.004)	0.410***(0.042)
US_{t-1}	0.241***(0.004)	0.241***(0.004)	0.239***(0.017)
D_{Monday}		−0.021***(0.008)	−0.020(0.013)
D_{fall}		−0.026***(0.007)	−0.031***(0.006)
Country, and year FE	No	No	Yes
Number of observations	107,483	107,483	107,483
Adjusted R^2 (%)	14.93	14.95	15.15

Note. Results of OLS regressions of stock market returns on day t (R_t) on the indicator of the day DST ends and some controls. The data is restricted to the 2008–2017 period. US_t = Daily return of the S&P 500 index on day t; US_{t-1} = daily return of the S&P 500 index on day t-1; D_{Monday} is a dummy variable that receives a value of 1 for observations on the first trading day of the week in a certain country (typically Monday), otherwise 0; D_{fall} is a dummy variable that receives a value of 1 for observations during the fall season, otherwise 0. Trimming was performed on the overall returns data at the 1% and 99% levels. Robust standard errors clustered at the country level (Column 3) are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

One issue arising from the study is the Argentine market, which is an apparent outlier in our investigation. As seen in Fig. 3, the Argentinean share price index posts abnormal results following the transition to standard time. To ensure that the general results we obtained do not derive from this outlier, we repeated the set of regressions for a sample that excluded Argentina but otherwise included all of the remaining 44 countries. We found that the results remain very similar to those of the entire sample; in particular, the time shift effect coefficients maintain virtually identical levels of intensity and statistical significance (Table 6).

Next, we examined the sensitivity of the findings to the range of years selected. Hence, we tested the sensitivity of our results to a different time frame, notably the past decade. Table 7 shows the estimations of Regression Models 1–3 where the subsample is restricted to 2008–2017.[8] The number of observations drops, roughly, to half. The results, however, remain unchanged for the most part across all specifications. Surprisingly, it appears that the estimator even increases, which indicates an apparent strengthening of the effect in recent years.

In addition, we performed simulation analyses, changing the trading day, dynamically, from trading day DST−120 to trading day DST+120, respective to the actual time shift. For every day chosen, we estimated the following regression model:

$$R_{i,t} = \alpha_0 + \beta_1 * Dday_{i,t} + \beta_2 * US_t + \beta_3 * US_{t-1} + \gamma_1 * Dweekday_{i,t} + \gamma_2 * Dseason_{i,t} + \delta_i * Dcountry_i + \theta_t * Dyear_t + \varepsilon_{it}$$

where $R_{i,t}$ is the daily return on the share price index in country i on day t; $Dday_{i,t}$ is a vector of 240 indicator variables that each time receives a value of 1 for a certain day, respective to the end of DST in a range ±120, and 0 otherwise; US_t is the daily return of the S&P 500 index on day t; US_{t-1} is the daily return of the S&P 500 index on day t-1; $Dweekday_{i,t}$ is a trading day of the week fixed effect; $Dseason_{i,t}$ is season fixed effects; and $Dcountry_i$ is a dummy variable for country i (country fixed effects); and, finally, $Dyear_t$ is a dummy variable for year t (time fixed effects). Standard errors are clustered at the country level.

[8] This specification allows at least 10 years of data. When the sample is restricted solely to the last five years (2013–2017), the DST estimators remain significant at 5% during this period (tstat= −2.23 in Regression Model 3 specification).

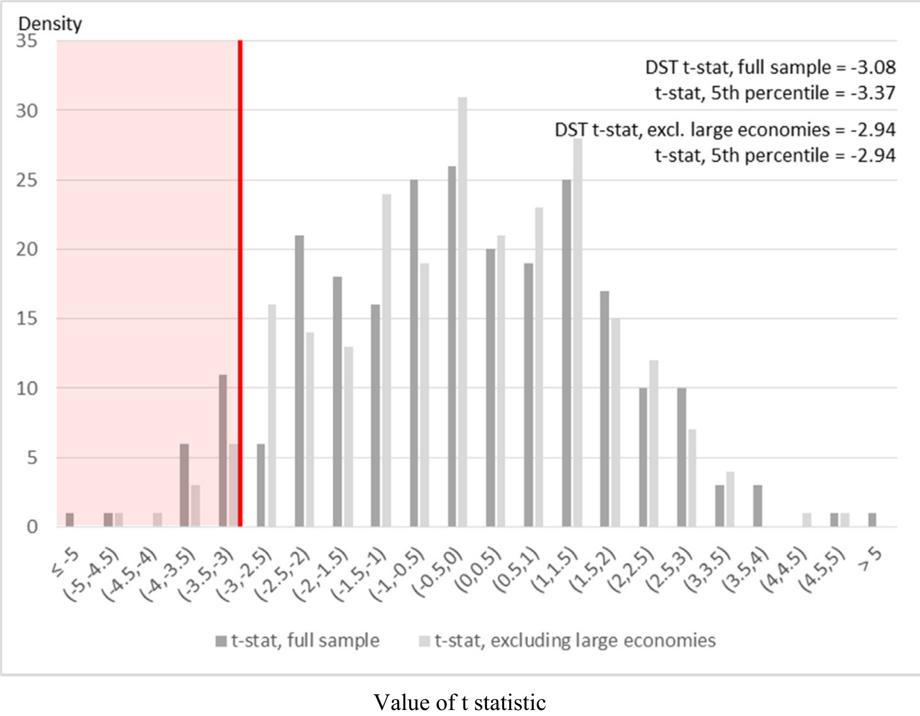


Fig. 6. Market daily returns, 120 days before and after the end of Daylight Saving Time (DST). We use the Regression Model 6, and ran 480 different regressions from day −120 through day +120, respective to the time shift (240 days, for 2 different subsamples: overall, and excluding the large markets); each time we saved the *t* statistic of the β_1 estimator. The figure depicts the distribution of this statistic, respective to the day DST ended.

Fig. 6 portrays the simulation-generated histogram of the *t* statistic of the β_1 estimator from Regression Model 4. The *t* statistic of our actual DST estimator lies in the 7.4th percentile left tail of the simulation distribution (the 4.9th percentile left tail, excluding the large markets), indicating that our results are not fortuitous.

Following the discussion in Pinegar (2002) and Kamstra et al. (2002) Fig. 7 depicts the distribution of stock market returns following the autumn time shift. It should be noted that the returns' distribution is left skewed (Skewness is −0.36; Median is −0.029). We examined the returns distribution and find some extreme observations. Thus, we winsorized these extreme returns at the 2% level (1% on each side), at the 5% level (2.5% on each side), and at the 10% level (5% on each side). The results for all three specifications, available from the authors upon request, demonstrate that the statistical significance of our results is robust for all these options. Remarkably, the findings are even more striking.

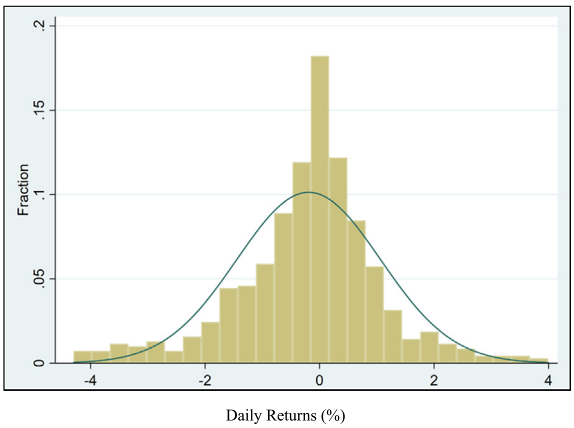


Fig. 7. The distribution of returns, following the DST end. We depict the distribution of the daily return, following the time shift, in the years 2000–2017, trimmed at the 2% (1% on each side). Importantly, trimming is performed in the overall sample (all returns). The daily returns (R_t) for each index were calculated according to the formula $R_t = \ln (P_t / P_{t-1})$, where Pt is the price of the index on day t, and where P_{t-1} is the price of the index on day t-1. The corresponding (same mean and standard deviation) normal distribution is shown as a solid line.

Table 8
The effect of ending Daylight Saving Time (DST) on the stock markets, double-clustering at the country and time levels.

Variable	Regression model	
	1	2
DST	−0.103(0.074)	−0.169**(0.071)
US_t	0.353***(0.043)	0.410***(0.046)
US_{t-1}	0.234***(0.021)	0.239***(0.025)
D_{Monday}	−0.024(0.022)	−0.020(0.035)
D_{fall}	−0.034***(0.011)	−0.031**(0.016)
Country, and year FE	Yes	Yes
Number of observations	190,103	107,483
Adjusted R^2 (%)	12.28	15.15

Note. Results of OLS regressions of stock market returns on day t (R_t) on the indicator of the day DST ends and some controls. Column 1 presents the estimations for the 2000–2017 period, whereas Column 2 restricts the sample for the 2008–2017 period. US_t = Daily return of the S&P 500 index on day t; US_{t-1} = daily return of the S&P 500 index on day t-1; D_{Monday} is a dummy variable that receives a value of 1 for observations on the first trading day of the week in a certain country (typically Monday), otherwise 0; D_{fall} is a dummy variable that receives a value of 1 for observations during the fall season, otherwise 0. Trimming was performed on the overall returns data at the 1% and 99% levels. Robust standard errors double-clustered at the country and the year levels are in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Finally, we recognize that while our main estimation account for fixed country and year effects, standard errors may still be sensitive to the non-fixed effects of both country and year. Thus, following Petersen (2009) we repeated the estimation using double clustering, combining clustering by country with clustering by year. We use the *cluster2*.

Stata ado file from Petersen's website. Being aware of the fact that in long panels, clustering can cause standard errors to blow up disproportionately, we applied this double-clustering technique for a shorter period of time (2008–2017) as well (following discussions in Djankov et al., 2007). Table 8 presents the estimation results of Regression Model 3 for the longer (2000–2017) and shorter (2008–2017) periods of time in Columns 1 and 2, respectively. Column 1 of Table 8 posts the results of this estimation for the entire 2000–2017 period. In this specification, the DST coefficient became insignificant (t = −1.4). Remarkably, the effect for the first trading day of the week became insignificant as well. The estimation in Column 2 of Table 8, however, greatly resembles our original specification. The DST coefficient is statistically significant at the 5% level (t = -2.4), again, the *Monday* coefficient is insignificant.

We recognize that the results in this section are subject to the criticism that double-clustering over a longer time period precludes the precise estimation of the DST effect. Still, the consistency of results across various robustness checks is encouraging.

7. Concluding remarks

A solid body of research has exploited different stock market anomalies, and in particular "calendar effects," linking these anomalies to investor behavioral biases. Kamstra et al. (2000) showed the effects of the clock shift in global stock markets—in the United States, Canada, and United Kingdom. Their findings were challenged, however, by subsequent research. Our project contributes to the literature by exploiting a large and detailed cross-country data set that allowed us to shed additional light on the effects of the clock shift to winter time.

Our first finding is that the time shift to standard time causes markets on the first trading day following the shift to perform bearishly, yielding significantly lower-than-average market returns. This result holds after controlling for seasonalities, such as day–of-the-week effects, and season (autumn) effects as well as general global market trends. The economic magnitude of the effect averages 5–6 times the unconditional mean. We also document that the effect is more prominent in recent years. This finding, by itself, is surprising and, somehow, contradicts the efficient market hypothesis, since the anomaly remains "alive" after public discovery. Moreover, we demonstrated that this pattern is even more evident when we exclude large markets from our sample. The latter result is consistent with the notion that small local markets are more vulnerable to the behavioral biases.

Beyond documenting the effect, our findings allow for a deeper investigation into possible underlying mechanisms. This investigation seems to suggest, albeit not conclusively, that the effect is driven by circadian rhythm as investors' internal clock adjust to the time shift.

Many countries are debating whether to change regulatory policy and end the practice of adjusting clocks by an hour in spring and autumn. At the end of March 2019, the European Union moved one step closer to scrapping the DST shift. We believe our study may have important implications for further regulatory measures. Hence, we view our paper also as a contribution to the interface between academic work in behavioral finance and policy making.

CRediT authorship contribution statement

Yevgeny Mugerman: Conceptualization, Methodology, Writing - original draft, Investigation. **Orr Yidov:** Data curation, Software, Validation. **Zvi Wiener:** Supervision, Funding acquisition.

Appendix A. Stock indexes examined

Data set ends	Data set starts	Bloomberg ticker	Index name	Country
2017	2000	MERVAL	MERVAL	Argentina
2017	2000	AS51	ASX 200	Australia
2017	2000	ATX	ATX	Austria
2017	2000	BEL20	BEL20	Belgium
2017	2000	IBOV	Ibovespa	Brazil
2017	2000	SOFIX	SOFIX	Bulgaria
2017	2000	SPTSX60	STX 60	Canada
2017	2000	IPSA	IPSA	Chile
2017	2002	CRO	CROBEX	Croatia
2017	2004	CYSMMAPA	CYSMMAPA	Cyprus
2017	2000	PX	PX	Czech Republic
2017	2000	KFX	OMXC20	Denmark
2017	2000	EGX30	EGX30	Egypt
2017	2000	TALSE	OMXT	Estonia
2017	2000	HEX25	OMXH25	Finland
2017	2000	CAC	CAC 40	France
2017	2000	DAX	DAX	Germany
2017	2000	ASE	ASE	Greece
2017	2000	BUX	BUX	Hungary
2017	2000	ISEQ	ISEQ	Ireland
2017	2000	TA-125	TA-125	Israel
2017	2000	FTSEMIB	FTSE MIB	Italy
2017	2000	KZKAK	KASE	Kazakhstan
2017	2000	RIGSE	OMXR	Latvia
2017	2000	VILSE	OMXV	Lithuania
2017	2000	LUXXX	LuxX	Luxembourg
2017	2000	MEXBOL	IPC	Mexico
2017	2003	MONEX20	MONEX 20	Montenegro
2017	2000	MOSENEW	MASI	Morocco
2017	2000	AEX	AEX	The Netherlands
2017	2001	NZSE50FG	NZX 50	New Zealand
2017	2000	OBX	OBX	Norway
2017	2000	WIG	WIG	Poland
2017	2000	PSI20	PSI-20	Portugal
2017	2000	BET	BET-10	Romania
2017	2000	INDEXCF	MOEX	Russia
2017	2004	BELEXLIN	BELEXline	Serbia
2017	2000	SKSM	SAX	Slovakia
2017	2003	SBITOP	SBI TOP	Slovenia
2017	2000	IBEX	IBEX 35	Spain
2017	2000	OMXS30	OMX	Sweden
2017	2000	SMI	SMI	Switzerland
2017	2000	XU100	ISE-100	Turkey
2017	2000	PFTS	PFTS	Ukraine
2017	2000	UKX	FTSE 100	United Kingdom

Appendix B. Timing of the end of Daylight Saving time (DST) by Country*

DST ended in months	DST applied in years	Hemisphere	Country
March	2000, 2007–2008	Southern	Argentina
March, April	Whole period	Southern	Australia(DST used in Australian Capital Territory, Jervis Bay Territory, New South Wales, Victoria, Tasmania, South Australia, and Lord Howe Island)
September, October	Whole period	Northern	Austria
September, October, November	Whole period	Northern	Belgium
February, March	Whole period	Southern	Brazil(DST used in Sao Paulo, Rio de Janeiro, Brasilia, Santa Catarina, Paraná, Goiás, Rio Grande do Sul, Mato Grosso do Sul, Espírito Santo, Minas Gerais, and Mato Grosso)
October, November	Whole period	Northern	Bulgaria
October, November	Whole period	Northern	Canada(Some regions in Quebec, Saskatchewan, British Columbia, and Nunavut do not use DST)
March. April, May	Whole period	Southern	Chile
October, November	Whole period	Northern	Croatia
September, October	Whole period	Northern	Cyprus
September, October, November	Whole period	Northern	Czech Republic
September, October, November	Whole period	Northern	Denmark
August, September, October	2000–2010, 2014	Northern	Egypt
October, November	Whole period	Northern	Estonia
September, October, November	Whole period	Northern	Finland
September, October, November	Whole period	Northern	France
September, October, November	Whole period	Northern	Germany
September, October, November	Whole period	Northern	Greece
September, October, November	Whole period	Northern	Hungary
October	Whole period	Northern	Ireland
August, September, October	Whole period	Northern	Israel
October, November	Whole period	Northern	Italy
September, October	2000–2004	Northern	Kazakhstan
October, November	2001–2017	Northern	Latvia
October	2003–2017	Northern	Lithuania
September, October	Whole period	Northern	Luxembourg
October, November	Whole period	Northern	Mexico(Sonora and Quintana Roo ceased using DST in 1997 and 2014, respectively. Baja California uses the U.S. DST schedule)
October, November	Whole period	Northern	Montenegro
July, August, Sept., Oct.	2008–2017	Northern	Morocco(DST stops during Ramadan)
September, October, November	Whole period	Northern	The Netherlands
March, April	Whole period	Southern	New Zealand
October, November	Whole period	Northern	Norway

(*continued on next page*)

Appendix B (*continued*)

DST ended in months	DST applied in years	Hemisphere	Country
September, October	Whole period	Northern	Poland
September, October, November	Whole period	Northern	Portugal
October, November	Whole period	Northern	Romania
October, November	2000–2010	Northern	Russia
October, November	Whole period	Northern	Serbia
September, October, November	Whole period	Northern	Slovakia
October, November	Whole period	Northern	Slovenia
September, October, November	Whole period	Northern	Spain
September, October, November	Whole period	Northern	Sweden
September, October, November	Whole period	Northern	Switzerland
September, October, November	2000–2016	Northern	Turkey
September, October	Whole period	Northern	Ukraine
October, November	Whole period	Northern	United Kingdom

Appendix C. Country abbreviations

Country	Country abbreviations
Argentina	AR
Australia	AU
Austria	AT
Belgium	BE
Brazil	BR
Bulgaria	BG
Canada	CA
Chile	CL
Croatia	HR
Cyprus	CY
Czech	CZ
Denmark	DK
Egypt	EG
Estonia	EE
Finland	FI
France	FR
Germany	DE
Greece	GR
Hungary	HU
Ireland	IE
Israel	IL
Italy	IT
Kazakhstan	KZ
Latvia	LV
Lithuania	LT
Luxembourg	LU
Mexico	MX
Montenegro	ME
Morocco	MA

Appendix C (*continued*)

Country	Country abbreviations
Netherlands	NL
New Zealand	NZ
Norway	NO
Poland	PL
Portugal	PT
Romania	RO
Russia	RU
Serbia	RS
Slovakia	SK
Slovenia	SI
Spain	ES
Sweden	SE
Switzerland	CH
Turkey	TR
Ukraine	UA
United Kingdom	GB

Appendix D. Stock market trading Hours, including Sunrise and sunset

This appendix documents in each market, on the day following the previous time shift (before April 2019; for the Northern Hemisphere – fall 2018, and for the Southern Hemisphere – "spring" 2019), exact times of the local market opens and closes, along with sunrise and sunset specific times on that day..

Country	Sunrise	Sunset	SE opening	SE closing	Dark/Dim light
Argentina	6:54	19:08	11:00	17:00	NO
Australia	6:08	17:47	10:00	16:00	NO
Austria	6:36	16:38	8:55	17:35	YES
Belgium	7:31	17:20	9:00	17:30	YES
Brazil	5:57	18:42	10:00	17:30	NO
Bulgaria	6:58	17:22	9:30	17:30	YES
Canada	7:00	17:01	9:30	16:00	NO
Chile	7:27	17:50	9:30	16:00	NO
Croatia	6:33	16:45	10:00	16:00	YES
Cyprus	6:05	16:54	10:15	17:20	YES
Czech Republic	6:48	16:42	8:00	17:00	YES
Denmark	7:11	16:34	9:00	17:00	YES
Egypt	5:46	17:44	10:00	14:30	NO
Estonia	7:35	16:32	10:00	16:00	YES
Finland	7:38	16:28	10:00	18:30	YES
France	7:34	17:33	9:00	17:30	YES
Germany	6:59	16:40	8:00	20:00	YES
Greece	6:48	17:28	10:30	17:00	YES
Hungary	6:24	16:29	9:00	17:00	YES
Ireland	7:20	16:56	8:00	16:30	YES
Israel	5:55	16:53	9:00	17:30	YES
Italy	6:40	17:06	9:00	17:35	YES
Kazakhstan	8:06	17:48	11:30	17:00	YES
Latvia	7:29	16:44	10:00	16:00	YES
Lithuania	7:17	16:46	10:00	16:00	YES
Luxembourg	7:21	17:16	9:00	17:35	YES
Mexico	6:36	18:03	8:30	15:00	NO
Montenegro	6:13	16:38	8:00	16:00	YES
Morocco	6:46	17:41	8:10	15:55	NO

(*continued on next page*)

Appendix D (*continued*)

Country	Sunrise	Sunset	SE opening	SE closing	Dark/Dim light
Netherlands	7:32	17:14	9:00	17:40	YES
New Zealand	6:38	18:09	10:00	16:45	NO
Norway	7:34	16:26	9:00	16:30	YES
Poland	6:27	16:10	9:00	17:00	YES
Portugal	7:01	17:38	8:00	16:30	NO
Romania	6:50	17:07	9:45	18:00	YES
Russia	7:35	16:50	10:00	18:45	YES
Serbia	6:13	16:29	9:30	14:00	NO
Country	**Sunrise**	**Sunset**	**SE opening**	**SE closing**	**Dark/Dim light**
Slovakia	6:33	16:35	10:30	15:30	NO
Slovenia	6:39	16:50	9:30	13:00	NO
Spain	7:42	18:14	9:00	17:30	YES
Sweden	7:02	15:59	9:00	17:30	YES
Switzerland	7:06	17:11	9:00	17:30	YES
Turkey	6:42	16:52	10:00	18:00	YES
Ukraine	6:45	16:37	10:00	17:30	YES
United Kingdom	6:50	16:36	8:00	16:30	YES

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