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THE DAY-OF-THE-WEEK EFFECT IS WEAK: EVIDENCE FROM THE EUROPEAN REAL ESTATE SECTOR

The day-of-the-week effect is weak: Evidence from the European Real Estate Sector

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Abstract

The day-of-the-week effect for the securitized real estate indices is investigated by employing daily data at the global, European and country level for the period 1990 to 2010. We test for daily seasonality in 12 countries using both full sample and rolling-regression techniques. While the evidence for the former is in line with the literature, the results for the latter cast severe doubts concerning the existence of any persistent day-of-the-week effects. Once we allow our sample to vary over time, the average proportion of significant coefficients per day ranges between 15% and 24%. We show that higher average Friday returns evident in previous literature, remain significant in 21% of the rolling samples. We conclude that daily seasonality in the European Real Estate sector is subject to the data mining and sample selection bias criticism.

Keywords: day-of-the-week effect, real estate indices, rolling regressions, GARCH, data mining

1. Introduction

The existence of seasonality in financial asset returns would defy market efficiency if investors could exploit them by consistently implementing profitable trading strategies. Since the seminal works of Fields (1931) and Osborne (1962) many studies have documented the day-of-the-week effect (or the weekend effect) in financial assets (Cross, 1973; French, 1980; Keim and Stambaugh, 1983; Jaffe and Westerfield, 1985 among others). The day-of-the-week effect refers to the finding whereby the mean rates of returns are significantly higher on some days of the week.[1] Indeed, only partial justification of these intraweek patterns has been presented so far. Potential explanations include

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[1]The 'traditional' weekend effect refers to the case where assets display significantly lower returns over the period between Friday's close and Monday's close.

settlement procedures and measurement errors (Gibbons and Hess, 1981), systematic movements between the bid-ask spread (Keim, 1989), the distinction between trading and non-trading periods (Fortune, 1991; Penman, 1987), differences in trading behavior of individual and institutional investors (Lakonishok and Maberly, 1990; Sias and Starks, 1995) and investors' speculative short sales (Chen and Singal, 2003).

The European market for publicly traded real estate companies has come into prominence over the course of the last two decades. According to the European Public Real Estate Association (EPRA), the market capitalization of European real estate companies has increased from around €6.6bn in 1990 to €321bn in the middle of 2011.[2] Investigating the day-of-the-week effect in the European real estate market is interesting for more than one reasons. First, investing in real estate has become an attractive strategy in Europe, especially after the influx of REITs in the beginning of the last decade which resulted in a marked expansion in the listed real estate sector.[3] This phenomenon is reflected in the increased growth of European securitized real estate market which in November 2013 totaled an aggregate market capitalization of €325bn, accounting for 25% of the global listed property market. The outperformance of listed real estate in both their REITs and corporate forms, led to increasing investor's awareness for this segment of the market.[4] With this increased attention, a further insight into the market anomalies of securitized real estate returns is of crucial importance. Second, whilst a large array of literature examines the calendar effects for stock market indices, there has been less interest on more disaggregated segments of the market. Considering that real estate securities are traded on major stock exchanges it would be insightful to examine whether the anomalous patterns observed in stock markets are also presented in real estate market.[5] Likewise, recent evidence provided by Kaplanski and Levy (2012) in

[2]EPRA represents the European publicly traded real estate sector and 90% of the market capitalization of the FTSE EPRA/NAREIT Europe Index. Its members manage commercial and residential property assets, with the vast majority being located in the major cities in Europe. Their membership also includes the institutional investors such as pension funds, investment managers and insurance companies that manage investments in real estate indirectly via these listed property companies.

[3]Real estate investment Trusts (REITs) are tax transparent entities. Whilst the detailed regulatory structure varies across countries and, in most of cases REITs have to comply with a number of restrictions regarding a minimum dividend payout ratio and the imposition of constraints concerning the proportion of the firm's assets and income derived from real estate activity. Other limitations imposed in areas such as gearing, international operations and development activity.

[4]The introduction of REITs by national governments in Europe was made in order to enable retail investors' access to a high quality, transparent and liquid form of real estate investment. Nevertheless, the development of REIT regimes occurred at different stages around the globe and within Europe. Many differences still exist in the detailed legislation of REIT regimes, as individual governments impose their own specific requirements and policy objectives for investment vehicles residing in and investing in their own jurisdiction.

[5]Chan et al. (2005) support the claim that the change in the US REIT market structure and the increase in institutional participation in the 1990s make US REIT stocks behave more like other equities in the

favour of seasonality in real estate prices raises the question on whether the seasonality that is present in prices is also reflected on real estate indices. Third, despite the large growth of the European real estate companies, most studies thus far have concentrated on the US real estate market (Redman et al., 1997; Friday and Higgins, 2000; Hardin et al., 2005 among others). This study builds upon previous research on European real estate including Lenkkeri et al. (2006) which is closer to our approach.[6]

The first goal of this paper is to examine the existence of the day-of-the-week effect at both aggregate (global and European level) and country specific level, by using an extended dataset. The existence of calendar anomalies implies that investors could develop trading strategies based on seasonal patterns in order to gain abnormal returns.[7] Some recent studies assert that the day-of-the-week effect for stock returns has disappeared in some countries since early 1990s due to improvements in market efficiency (Kohers et al., 2004; Steeley, 2001). As Lakonishok and Smidt (1988) pointed out in their 90-year period study, one must be very skeptical of what is considered an anomaly. To confirm an anomaly, supporting evidence is required in various data sets over different periods of time.

The second goal of this paper is to establish the robustness of the day-of-the-week effect using the returns of the European securitized real estate indices, as this anomaly could be the result of data snooping or data mining bias. Sullivan et al. (2001) argue that the practice of using the same data set to formulate and test hypotheses introduces data-mining biases that, if not accounted for, invalidate the assumptions of underlying classical statistical inference. They used 100 years of daily data and a bootstrap procedure to show that although nominal p-values for individual calendar rules are extremely significant, once evaluated in the context of the full universe from which rules were drawn, calendar effects significance faded. Additional critical evidence is provided by Hansen et al. (2005) who claim that this phenomenon has diminished in the late 1980s (with the exception of small-cap stock indices). They inspect the time path of p-values that account for data-mining biases and find significant calendar effects only in specific sub-samples of DJIA returns and standardized returns during the 20th century. Following Hansen et al. (2005), the robustness of our findings is also assessed via sub-sample analysis based on rolling regressions. Recently, Zhang and Jacobsen (2013) provide evidence that monthly seasonality for the UK stock prices

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stock market.

[6]To the best of our knowledge only Lenkkeri et al. (2006) have employed the same dataset for calendar anomalies.

[7]Gregoriou et al. (2004) support that the small average excess returns documented by researchers is not likely to generate net gains when employed in a trading strategy once the transaction costs have been taken into account.

strongly depends on the sample period considered. They show that many calendar months significantly alter their performance relative to the market, but few have done it persistently over their 300 years sample period. In that respect, the day-of-the-week effect could also be an apparent but not real phenomenon.[8]

Our contribution is twofold: (i) we employ a dataset that has not been widely used in testing for calendar effects, given the recent evidence of Kaplanski and Levy (2012) in favour of seasonality in real estate prices and (ii) we attribute the apparent evidence for the day-of-the-week effect to sample dependence by employing rolling regression techniques. We find that six out of twelve European real estate indexes exhibit positive Friday returns. Particularly, the Friday anomaly is present in Finland, France, Netherlands, Spain, Sweden, Switzerland and in the European and global indices. We also find a significant positive Monday effect for Denmark, Finland and Sweden and a Wednesday effect for Sweden and Switzerland. When a rolling regression approach is adopted, very weak evidence (if any) in favour of the day-of-the-week effect is found. The rolling *p*-values analysis suggests that significant daily seasonality is not an economically important phenomenon in European securitized real estate returns. This result is valid for both the individual European markets and the European and global indexes. It is also robust to alternative distributions of the error term. The weak day-of-the-week effect evidence abides the claim that data mining, noise and selection bias could drive this market anomaly.

The rest of the paper is organized as follows: Section 2 summarizes the relevant literature, Section 3 presents data, Section 4 describes the econometric methodology and Section 5 discusses the results. Finally, section 6 concludes.

2. Literature

The empirical literature on calendar anomalies is extensive. A substantial part it focuses on the various calendar effects covering a large array of countries, several time periods, different empirical methodologies, and various data sets. The majority of these studies support the existence of seasonal behavior in stock returns (see also the review in Zhang and Jacobsen, 2013). Albeit, most of the literature examines the day-of-the-week effect in terms of aggregate stock indices with little attention given in specialized market segments, such us the real estate. Real estate indices should be the most favorable for the presence of seasonality (Kaplanski and Levy 2012). The returns of REITs were first examined for evidence of the day-of-the-week effect by Redman et al.

[8] Schwert (2003) provides a survey on data mining in relation to returns anomalies, including the calendar specific anomalies.

(1997). Other studies include Friday and Higgins (2000), Connors et al. (2002), Hardin et al. (2005), Brounen and Yair (2009) and Lee and Ou (2010). The day-of-the-week anomaly for Europe securitized real estate indices has also been studied, although less extensively (e.g., Lenkkeri et al., 2006). A summary review for studies with a real estate focus is presented in Panel A of Table 1.

Chang et al. (1993) and Dubois and Louvet (1996) advocated that although a day-of-the-week effect still exists in many countries, the effect has recently disappeared in the US. Together these studies suggest that this effect may not always exist simultaneously in different markets. Moreover, Brusa et al. (2000) support that the weekend effect has reversed in US with Monday returns significantly positive and higher than the returns on other days of the week. Other studies in stock returns where the day-of-the-week effect diminishes or reverses over time are summarized in Panel B of Table 1. Overall, these studies indicate that seasonality in returns is more of an evolving phenomenon rather than a static one.

3. Data

We employ a data set of log returns on European securitized real estate indices provided by the European Public Real Estate Association (EPRA). The data consist of daily closing prices from the following 12 European countries: Belgium, Denmark, Finland, France, Germany, Greece, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. Our dataset for most countries spans from January 15, 1990 to May 11, 2010. For Finland, Denmark, Greece, and Spain, a shorter time span is available.[9] In addition to individual countries, we also consider a European real estate index and a global real estate index. The EPRA Europe index consists of all countries that join the European Union, weighted according to the market capitalization of individual securitized real estate markets. We also consider the EPRA/NAREIT Global index, consisting of all world-participating countries. All indices used are value-weighted and the entire amount of issued shares of a constituent company is included in the calculation of the company's market capitalization, and adjusted by the free float weighting of the company. Given that the data are derived from more than one countries, there are different holidays for each market. Following Savva et al. (2006), we replace the missing value by the closing price on the day before the holiday. Hence, the sample for each country contains all days of the week except weekends. Log returns in each market (R_t) are expressed in euros and are calculated as percentage changes of the level of price index

[9]In the case of Spain the data series exhibit discontinuities from 09/30/2006 to 12/17/2006. In order to overcome this problem, linear interpolation was employed.

at time t.

Table 2 provides descriptive statistics of logarithmic returns. Over the entire sample period most countries exhibit negative average mean returns with the exception of Finland, France and Switzerland. Positive mean returns are reported for the European and the global index. Denmark is the country with the lowest mean returns and the highest unconditional volatility. All countries are negatively skewed, but Belgium. The Jarque-Bera statistic rejects the null hypothesis of normally distributed returns. All series are leptokurtic.[10] Unit root tests indicate stationarity of returns (Table 2).

4. Methodology

We use both unconditional and conditional tests to examine the day-of-the-week effect. The unconditional tests of the day-of-the-week effects include the Kruskal-Wallis test for ranks that examines weekly patterns in the median, and the Brown-Forsythe (modified Levene) test for weekly patterns in the volatility. Conditional tests rely on regression analysis. We use daily dummies and the models employed can be written as:

$$R_t = \varphi_1 D_{1t} + \varphi_2 D_{2t} + \varphi_3 D_{3t} + \varphi_4 D_{4t} + \varphi_5 D_{5t} + \sum_{i=1}^{n} \eta R_{t-i} + e_t \tag{1}$$

$$e_t \setminus \Omega_{t-1} \sim N(0, h_t) \tag{2}$$

$$h_t = \omega + \alpha e_{t-1}^2 + \beta h_{t-1} \tag{3}$$

$$h_t = \omega + \alpha e_{t-1}^2 + \gamma e_{t-1}^2 I_{t-1} + \beta h_{t-1} \tag{4}$$

$$log(h_t) = \omega + \alpha \left[\frac{| e_{t-1} |}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}} \right] + \gamma \frac{e_{t-1}}{\sqrt{h_{t-1}}} + \beta log(h_{t-1}) \tag{5}$$

where R_t is the continuously compounded daily index return; φ_1, φ_2, φ_3, φ_4 and φ_5 are parameters, e_t is the random error term assumed conditionally normal and D_{1t}, $D_{2t}\ldots$, D_{5t} are dummy variables for Monday, Tuesday…, Friday (i.e., $D_{1t} = 1$, if t is Monday, and zero otherwise). Depending on their significance, AR terms are also added in

[10]The finding of leptokurtosis and skewness in securitized real estate returns has been discussed by Bond and Patel (2002).

Eq.(1).[11] We omit the constant term to avoid the dummy variable trap. Equation (3) is the conditional variance equation of a GARCH(1,1) model. The $\alpha + \beta$ sum, should be less than unity to ensure the stationarity of the conditional variance. To capture the possibility of asymmetric effects of returns on volatility, we also consider the GJR-GARCH model, introduced by Glosten et al. (1993) and the EGARCH model, proposed by Nelson (1991), presented in equations (4) and (5), respectively. All estimations are carried out using the quasi maximum likelihood estimation method (QMLE).[12] Choudhry (2000) provides evidence of the day-of-the-week effect in emerging Asian countries using a GARCH model that assumes the error distribution follows a conditional Student's t density function. Nelson (1991) indicates that a generalized error distribution (GED) is preferred for GARCH models. We consider both, but report only the former since the results are similar.[13]

5. Empirical results

5.1. Unconditional models and tests

We start by analyzing the unconditional day-of-the-week patterns in the fourteen return series. For testing daily differences in the median, we use the Kruskal-Wallis one-way ANOVA for ranks. This test generalizes the Mann-Whitney test with more than two sub-groups. Additionally, we perform the Brown-Forsythe test (Brown and Forsythe, 1974) to test for the constancy of the variances across the days of the week. This test is used to determine whether k samples have equal variance where the absolute mean difference is replaced by the absolute median difference and is, hence, expected to be more robust.[14] Panel A in Table 3 presents the statistics and their corresponding p-values from the tests for a significant day-of-the-week pattern in median and variance of the unconditional distributions. Applying the Kruskal-Wallis test, we find evidence for a significant weekly pattern in the median for France, Sweden, the European index, and the global index (at the 1%), for Italy (at the 5%), and for Spain (at the 10% level). The Brown-Forsythe test null hypothesis that the variance is constant across the days

[11] The autoregressive term accounts for statistically significant but economically minor autocorrelation and correct for possible effects of non-synchronous trading.

[12] Bollerslev and Wooldridge (1992), pointed out that the assumption of the normality of the standardized conditional errors may be too strong and can cause misspecification of the likelihood function. To deal with this, Bollerslev and Wooldridge (1992) suggest the use of Quasi Maximum Likelihood Estimation (QMLE).

[13] The results for the GED distribution are availble from the authors upon request.

[14] Most tests for equal variances appear to be sensitive to departures from normality or to the presence of outliers and heteroskedasticity. Conover et al. (1981) list and compare 60 methods for testing the homogeneity of variance assumptions and show that Brown-Forsythe procedure outperforms all the other procedures.

of the week, is rejected for Germany and the global index at the 1%, and for Italy and Sweden at the 5% and 10% level, respectively.

5.2. Conditional models and tests

Given the evidence for ARCH effects,[15] we proceed with the estimation of Equation (1) with GARCH errors. Panel B in Table 3 presents the best GARCH model for each country on the basis of the Schwarz information criterion.[16] The asymmetric models (EGARCH, GJR-GARCH) for Denmark, Finland, Netherlands and Switzerland in which the asymmetry term (γ) was found insignificant, were re-estimated as symmetric GARCH(1,1) models. In the top part (Table 3, Panel B), we report results on the return equation for the twelve European indices and the two aggregate indexes. The estimated coefficients of the Monday dummy variables for Denmark, Finland and Sweden are positive and statistically significant.[17] The finding of significant higher average Monday returns contradict this of Lenkkeri et al. (2006) who did not confirm a Monday seasonality in European real estate indices. Chen et al. (2005) also notes that for most time intervals after 1990, the mean Monday return is not significant for US REITs.[18] For Fridays, the estimated coefficients are positive and statistically significant for half of the 12 European countries (Finland, France, Netherlands, Spain, Sweden and Switzerland) and the European and global indices. The negative Belgium Friday returns and the significant positive Friday effect are also reported in Lenkkeri et al. (2006) although more extensively (in seven out of eleven European countries). Tuesday dummy variable is negative and significant only for Italy, Wednesday dummy variable is negative for Germany at the 10% level of significance and positive for Sweden and Switzerland. Positive and significant weekday pattern is observed on Thursday only for Switzerland. The day-of-the-week effect is confirmed by the significant *F*-statistics for about half of the countries in our sample: Finland, France, Italy, Spain, Sweden, Switzerland and the two major aggregate indexes.

In the bottom part of Table 3, we also report the estimates of the conditional variance. The asymmetry term γ is positive and significant for France, Spain and the UK,

[15]Not reported but available from the authors upon request.

[16]Doornik and Ooms (2008) argue that standard estimates in models involving dummy variables in conditional means of GARCH regression models have to be treated with great care because of the danger of multimodality, which is more likely to occur when dummies effects take place before or within volatile periods. In our study, in order to minimize the danger of multimodality, different initial values were considered and the outcome was not qualitatively different. The results are available from the authors upon request.

[17]The level of significance is 5%, unless otherwise noted.

[18]The authors support that the disappearance of Monday seasonality coincides with the increase in institutional investors in the US REIT market during 1990s.

Europe and global index where the GJR-GARCH was the preffered model model. The asymmetry coefficient is negative and significant for Belgium, Germany, Greece, Italy, and Sweden where the EGARCH model was chosen by SIC. We can thus document significant evidence of leverage effect in the GJR-GARCH and EGARCH models, indicating negative news in the eight individual European markets and the two aggregate indices cause volatility to rise by more than positive news of the same magnitude. Both α and β are statistically significant and positive in all cases. For the countries that the $\alpha + \beta$ sum is above unity,[19] three unit root tests for the stationarity of the conditional variances were considered: (i) augmented Dickey and Fuller (1979), (ii) Phillips and Perron (1988) and (iii) the Zivot and Andrews (1992) unit root test with one break. The results (not reported but available upon request) suggest that we can reject the null of unit root for all conditional variance series at 1% level of significance except UK where the null is rejected at the 5% level in all three unit root tests.

5.3. A rolling window regression approach

Recent studies have documented that the evidence on return seasonality obtained in the vast literature could be driven by data mining or could be sample dependent. Sullivan et al. (2001) and Hansen et al. (2005) provide evidence that calendar effects may be the outcome of pure chance and thus disappear once a test conditions on the nuisance of all conceivable effects. Zhang and Jacobsen (2013) also employ a rolling window (OLS) approach to demonstrate that monthly seasonality is sample dependent.

In the spirit of the above three papers, we attempt to evaluate the evidence reported in the previous sections in favor of the day-of-the-week effect. In this regard, we employ rolling regressions using the best GARCH model (in the sense of the SIC) to test for robustness. The window for the rolling-regression estimation is fixed at 70 (a rolling sample of about 3 months of data is taken with a step size of 5 weekdays). The first estimate is based on a regression using observations 1-70, the second, observations 6 to 75, the third, observations 11 to 80, and so on.

The results reported in Tables 4 and 5 correspond to the t-student and the generalized error distributions (GED), respectively. In Table 4, we observe that the significant p-values represent a very low proportion of the total number of the rolling-regressions. For Finland (Table 4), the cases that Monday's p-values are lower than 0.05 are 50. The latter represents only 8.65% of the totally estimated p-values. The same conclusion holds for the rest of the countries (for both distributions), where the significant p-values

[19]For GJR-GARCH models we calculate the sum: $\alpha + \beta + \gamma/2$, for the stationarity of variance.

stand for around 14 to 24% for most cases. For the t-distribution, significant p-values range from a max 23.42% significant Monday coefficients for Belgium to a min 8.65% for Finland. These numbers are relative higher for the GED, with a max of 32.21% for Germany and a min of 16.6% for Finland.

The last line of Tables 4 and 5 reports the average proportion of significant coefficients per day across all markets. Significant coefficients for the Friday dummies are observed on average 21% of the rolling GARCH (GED) windows. The average for the other days is between 22% and 24%. When assuming a t-distribution these numbers are relative lower: 15.37% for Fridays and between 16.5% and 17.5% for the rest. Monday appears to provide, marginally, the higher ratio of significant p-values (17.2% with t and 24.02% with GED). The important implication of these findings is that, although p-values for individual coefficients are significant, once evaluated in a rolling framework, calendar effects no longer remain significant. In other words seasonality in European real estate indices is subject to the sample selection bias criticism.

6. Conclusions

This study investigates the weekday pattern in returns behavior of securitized real estate indices using daily data at the global, European and national (for 12 countries) level for the period 1990-2010. We examine whether daily seasonality is sample dependent.

We first estimate symmetric and asymmetric GARCH models that provide evidence in favour of the day-of-the-week effect. Significant higher Friday returns were found for half of the European country level real estate indices and the two regional indices (European and global). A significant Monday effect for three European countries (Denmark, Finland, Sweden) also arises in contrast to the previous literature. Once a rolling-regression framework is adopted, statistically significant coefficients evaporate. We find that in the overwhelming majority of the countries included in our sample, the significant p-values are between 15 and 24 percent for all estimation periods. A significant Friday effect is observed on average in 15.37% (21%) of the rolling windows when the Student's-t (GED) distribution is employed. The highest proportion of significant p-values emerges for Monday, 17% with t and 24% for GED. Therefore, the evidence provided from the rolling regression approach casts severe doubts concerning the existence of any persistent day-of-the-week effect. This result reinforces the argument that daily seasonality in the European real estate markets is prone to the sample selection criticism.

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Table 1. Literature Review

Author(s)	Data and/or methodology	Empirical Results
Panel A: Day of the week effect in real estate indices		
Redman, Manakyan and Liano (1997)	Daily returns from a portfolio of REITs shares listed in CRSP tapes. AMEX and NYSE stocks. 1986-1993. OLS and Kruskal-Wallis test.	For REITs and small stocks, the average daily returns from Tuesday through Friday were significant and higher relative to Monday's.
Friday and Higgins (2000)	Equally-weighted portfolio from daily returns of all publicly REITs and two subcategories: equity REITs and mortgage REITs. 1970-1995.	Evidence of negative Monday effect. Positive and significant Wednesday, Thursday and Friday returns.
Connors, Jackman, Lamb and Rosemberg (2002)	Daily total average returns of REITs portfolios, the CRSP value-weighted and equally-weighted indices. 1994-1999. OLS.	Friday returns are positive and significant for the whole sample REIT portfolios and for two sub-sectors (the Office/Industrial and the Retail).
Hardin, Liano and Huang (2005)	Daily value-(with daily rebalancing) and equal-weighted REIT returns are retrieved from CRSP. 1994-2002.	Higher and significant average Friday returns compared to Monday only for the equal-weighted index.
Lenkkeri, Marquering and Strunkmann - Meister (2006)	Daily REIT returns of 11 European markets, the U.S. REIT returns, and two European indices. 1990-2004. OLS with White's standard errors.	High Friday returns in eight out of 11 European markets and in the two European indices.
Brounen and Yair (2009)	Daily REIT returns for ten prominent world markets plus South Africa. 1987-2007 and sub period analysis. OLS.	For the equally weighted index 9 out of 11 countries experience significant positive Friday returns. Similar conclusions for value-weighted indices.
Lee and Ou (2010)	Daily mortgage REIT returns for US from the National Association of REITs index. 2001-2007. GARCH.	Mortgage REITs have abnormal positive returns on Tuesday and Friday and abnormal negative returns on Wednesday.
Panel B: Disappearance of day of the week effect		
Board and Sutcliffe (1988)	Daily closing values of FTA index. Sample: 1962-1986 and sub period analysis of six years each. OLS.	Evidence for a weekend effect in the UK market for the period 1962-1986, with the significance of the effect diminishing over time.
Agrawal and Tandon (1994)	Daily stock indices from eighteen countries. Sub period analysis covering the decades 1970-1979 and 1980-1987.	Significant negative Monday(Tuesday) effect in 7 (9) countries during 70s. Disappearance of this negative effect in most countries during 80s.
Arsad and Coutts (1997)	Daily returns of FT-30. 1935-1994. Twelve five-year sub sample analysis of starting from 1939. OLS.	The weekend effect exists for the entire period but it does not exist for all of the twelve five year sub samples.

(continued...)

Table 1. Literature Review (continued)

Author(s)	Data and/or methodology	Empirical Results
Davidson and Faff (1999)	Daily share price data for All Ordinaries Accumulation Index. 1983-1996. OLS.	Unable to detect Tuesday effect in the data once sample bias has been taken into account.
Mehdian and Perry (2001)	Daily closing values of five major U.S stock market indices. 1964-1998. OLS, Chow breakpoint tests and recursive estimation are employed.	In 1964-1987 period average returns of NASDAQ and Russell on Mondays are significant (negative) but in 1987-1998 period become insignificant (small cap indexes).
Chen, Kwok and Rui (2001)	Both daily open and close prices of four indices from Shanghai Stock Exchange. 1992-1997. OLS, IGARCH(1,1).	OLS estimation shows negative Tuesday effect. The Tuesday anomaly disappears after accounting for non normality in distribution and spillover effects from other countries.
Steeley (2001)	Daily returns of FTSE100 index and announcement data on macroeconomic information variables. 1991-1998. OLS, Kruskal-Wallis test.	The day-of-the-week effects in the UK equity market have disappeared during the 1990s.
Gu (2004)	Daily closing data of DJIA, S&P500 Composite Index, Russell 1000, Russell 2000 and Russell 3000. All data though 2001. A power ratio method is developed.	The weekend effect exists for over half of the 49 years for DJIA and S&P500, and for 12 of 15 years for Russell2000. A declining trend is found from late 80s to late 90s for DJIA and S&P500 indices, eliminating or reversing the effect.
Hansen, Lunde and Nason (2005)	Daily closing prices of 25 stock indices from ten countries, ranging back (if available) 2002. Account for three calendar effect universes: the full universe and two smaller universes with 17 and 5 effects. The 17 universe contains the day-of-the-week effects. Generalized F-test and rolling sample p-values estimation are employed.	Calendar effects matter for stock returns in full universe. This evidence weakens at the 17 effect universe for the majority of the series. The dynamic p-value analysis reveals that for DJIA there are long periods where none of the calendar effects remain significant.
Wong, Agarwal and Wong (2006)	Daily prices from Straits Time Index. 1993-2005. Sub period analysis in -pre and -post Asian Financial Crisis period. GARCH(1,1).	The day-of-the-week effect may no longer exist in the Singapore market in the post crisis period.
Marquering, Nisser and Valla (2006)	Examination of several well known market anomalies before and after they were published. OLS and a tailor made approach were employed.	The weekend effect has started to diminish right after Cross's study in 1973. Two years after the publication the effect anomaly decreases substantially. The anomaly disappeared recently.
Alagidede and Panagiotidis, (2009)	Daily and monthly closing prices of DSI from the Ghana Stock Exchange. 1994-2004. GARCH models and rolling regression techniques are employed.	Friday's return was found to be the most significant but this seasonality disappears when a rolling window asymmetric GARCH is employed.

Table 2. Summary statistics for logarithmic returns

	Dates (# of Obs.)	Mean	Max.	Min.	Std.Dev.	Skewn.	Kurt.	JB test	ADF[a]	ADF[b]
Global	01/15/1990 (5301)	0.000089	0.07	-0.08	0.01	-0.31	8.99	8026.7*	-66.7*	-66.7*
Europe	01/15/1990 (5301)	0.000013	0.07	-0.07	0.009	-0.46	13.63	25188.8*	-68.8*	-68.8*
Belgium	01/15/1990 (5301)	-0.000063	0.1	-0.07	0.01	0.22	12.86	21533.8*	-46.2*	-46.2*
Denmark	01/01/1992 (4427)	-0.00403	0.17	-0.31	0.024	-2.33	32.88	168771.7*	-60.3*	-60.3*
Finland	01/01/1999 (2962)	0.00014	0.14	-0.11	0.018	-0.005	9.1	4607.1*	-55.6*	-55.6*
France	01/15/1990 (5301)	0.00017	0.08	-0.08	0.01	-0.046	10.5	12449.1*	-72.7*	-72.7*
Germany	01/15/1990 (5301)	-0.000026	0.13	-2.21	0.015	-0.62	20.42	67374.2*	-70.1*	-70.1*
Greece	04/01/2004 (1593)	-0.00063	0.17	-0.28	0.021	-3.06	46.21	126431.6*	-38.9*	-39.0*
Italy	01/15/1990 (5301)	-0.000042	0.17	-0.20	0.017	-0.34	16.68	41489.67*	-73.2*	-73.2*
Netherlands	1/15/1990 (5301)	-0.000028	0.07	-0.07	0.009	-0.36	14.05	27107.39*	-69.1*	-69.1*
Spain	01/15/1990 (5004)	-0.000241	0.18	-0.21	0.019	-0.56	18.96	53444.39*	-64.3*	-64.3*
Sweden	01/15/1990 (5301)	-0.00018	0.13	-0.19	0.018	-0.21	11.27	15154.51*	-69.6*	-69.7*
Switzerland	01/15/1990 (5301)	0.00014	0.07	-0.08	0.001	-0.07	7.12	3757.40*	-57.9*	-57.9*
UK	01/15/1990 (5301)	-0.000076	0.1	-0.1	0.013	-0.23	11.1	14561.05*	-70.7*	-70.7*

Notes: * denote significance at 1% level. JB denotes the Jarque-Bera test statistic which tests the null hypothesis of normality. ADF[a] and ADF[b] stand for the Augmented Dickey-Fuller test with constant and constant and trend, respectively. Ending date for most series is 05/11/2010, except Denmark (12/19/2008) and Spain (03/20/2009).

Table 3. Day of the week effect in logarithmic returns

	Global[a]	Europe[a]	Belgium[b]	Denmark	Finland	France[a]	Germany[b]	Greece[b]	Italy[b]	Netherlands	Spain[a]	Sweden[b]	Switzerland	UK[a]
Panel A: Unconditional day of the week patterns														
Tests for equality of medians														
K-W value	1.2**	1.44*	3.49	5.32	6.68	14.64*	6.01	4.61	10.5**	6.67	8.36***	28.62*	5.56	4.54
	(0.01)	(0.00)	(0.47)	(0.25)	(0.15)	(0.00)	(0.19)	(0.32)	(0.03)	(0.15)	(0.07)	(0.00)	(0.23)	(0.33)
Tests for equality of variance														
B-F value	4.48*	1.16	1.03	0.11	0.72	1.08	3.99*	0.47	3.2**	1.74	0.46	2.01***	0.33	0.67
	(0.00)	(0.32)	(0.38)	(0.97)	(0.57)	(0.36)	(0.00)	(0.75)	(0.01)	(0.13)	(0.76)	(0.08)	(0.85)	(0.6)
Panel B: Conditional day of the week patterns														
Mean equation														
Monday	-0.0001	0.00008	0.00007	0.0009*	0.001**	-0.00023	-0.00026	-0.0006	-0.00045	-0.00011	0.0003	0.0007 **	0.0001	0.00001
	(0.62)	(0.61)	(0.68)	(0.00)	(0.04)	(0.29)	(0.14)	(0.19)	(0.15)	(0.49)	(0.31)	(0.02)	(0.63)	(0.95)
Tuesday	0.0002	0.0002	0.00028	0.00003	0.00025	0.00031	0.00015	-0.0006	-0.0007**	0.00007	0.0001	0.00001	0.00008	0.00031
	(0.40)	(0.19)	(0.11)	(0.91)	(0.61)	(0.14)	(0.38)	(0.20)	(0.02)	(0.64)	(0.76)	(0.96)	(0.69)	(0.22)
Wednesday	0.0002	0.0002***	0.0005	-0.00004	0.00029	0.0001	-0.00036***	-0.0006	0.00026	0.00018	0.0003	0.00088 *	0.0005**	0.00023
	(0.32)	(0.09)	(0.78)	(0.91)	(0.55)	(0.61)	(0.05)	(0.19)	(0.40)	(0.21)	(0.33)	(0.00)	(0.01)	(0.36)
Thursday	0.00008	0.00003	0.0001	0.00012	-0.00039	0.00028	-0.00009	-0.0001	0.00037	0.0001	0.0002	-0.00052	0.0005*	-0.00006
	(0.71)	(0.84)	(0.48)	(0.73)	(0.43)	(0.19)	(0.96)	(0.83)	(0.23)	(0.49)	(0.54)	(0.11)	(0.00)	(0.79)
Friday	0.00085*	0.0008*	-0.000	0.0004	0.0014*	0.001*	0.0002	0.00023	0.00033	0.0002**	0.0009*	0.0012*	0.0005*	0.00039
	(0.00)	(0.00)	(0.87)	(0.27)	(0.00)	(0.00)	(0.25)	(0.66)	(0.29)	(0.05)	(0.00)	(0.00)	(0.00)	(0.14)
AR(1)	0.118*	0.086*	-0.13*	-0.043*	-0.088*			0.062*		0.081*	0.079*		-0.0185*	0.02***
	(0.00)	(0.00)	(0.00)	(0.002)	(0.00)			(0.004)		(0.00)	(0.00)		(0.00)	(0.05)
AR(2)		0.048*	-0.02*											-0.04*
		(0.00)	(0.03)											(0.00)

(continued...)

Panel B: *Conditional day of the week pattern* (continued)

	Global[a]	Europe[a]	Belgium[b]	Denmark	Finland	France[a]	Germany[b]	Greece[b]	Italy[b]	Netherlands	Spain[a]	Sweden[b]	Switzerland	UK[a]
Variance equation														
ω	0.000*	0.000*	-0.35*	0.000*	0.000*	0.000*	-0.12*	-0.467*	-0.415*	0.000*	0.000*	-0.24 *	0.000*	0.000*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
α	0.03*	0.069*	0.24*	0.28*	0.10*	0.087*	0.192*	0.30*	0.262*	0.147*	0.121*	0.18*	0.101*	0.037*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
β	0.906*	0.90*	0.979*	0.775*	0.896*	0.88*	0.997*	0.961*	0.972*	0.865*	0.811*	0.987*	0.904*	0.934*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
γ	0.071*	0.038*	-0.04*			0.034**	-0.02**	-0.093*	-0.02**		0.097	-0.02*		0.044*
	(0.00)	(0.00)	(0.00)			(0.01)	(0.01)	(0.00)	(0.01)		(0.00)	(0.00)		(0.00)
SE of reg.	0.008	0.009	0.01	0.024	0.018	0.01	0.01	0.02	0.017	0.009	0.01	0.01	0.01	0.013
Adj.R^2	0.007	0.002	0.013	-0.009	-0.004	0.0008	-0.0004	-0.003	0.000	0.001	0.006	0.001	0.026	0.000
F-test	2.68**	5.85*	0.63	1.67	2.73**	5.45*	1.59	1.02	2.1**	1.28	1.9***	5.9*	4.28*	0.88
	(0.02)	(0.00)	(0.67)	(0.13)	(0.01)	(0.00)	(0.15)	(0.39)	(0.05)	(0.26)	(0.08)	(0.00)	(0.00)	(0.48)
$LBQ^2(10)$	68.5	11.60	0.006*	-0.004	-0.026	-0.01	-0.004	0.008	-0.007	-0.017	-0.00	0.005	-0.003	-0.021
	(0.73)	(0.31)	(0.00)	(1.00)	(0.95)	(0.6)	(1.00)	(0.99)	(0.98)	(0.13)	(0.89)	(0.38)	(0.96)	(0.31)
LM(10)	0.66	1.14	2.35*	0.08	0.38	0.8	0.07	0.15	0.29	1.63***	0.49	1.05	0.35	1.18
	(0.75)	(0.32)	(0.00)	(0.99)	(0.95)	(0.62)	(1.00)	(0.99)	(0.98)	(0.08)	(0.89)	(0.39)	(0.96)	(0.29)

Notes: *, ** and *** denote significance at 1%, 5% and 10% level respectively. The number in the parenthesis denotes the p-values. K-W and B-F denote the Kruskal-Wallis and the Brown-Fortsythe test, respectively. Adj.R^2 denotes R^2 adjusted for the degrees of freedom. The F-test denotes the F-statistic corresponding to the hypothesis that all coefficients of the day of the week are zero simultaneously. LM is the Lagrange Multiplier ARCH test for conditional heteroskedasticity. LBQ^2 is the Ljung-Box test on squared standardized residuals. [a]and [b] denote GJR-GARCH and EGARCH model, respectively.

Table 4. Portion of significant day of the week rolling coefficients (Student's t distribution)

		Monday	Tuesday	Wednesday	Thursday	Friday	# of regres.
Global	$p < 0.05$	204	141	114	149	180	1045
	Sign. p-values	19.52%	13.49%	10.09%	14.25%	17.22%	
Europe	$p < 0.05$	202	121	169	151	159	1042
	Sign. p-values	19.33%	11.57%	16.17%	14.44%	15.21%	
Belgium	$p < 0.05$	245	242	239	228	253	1046
	Sign. p-values	23.42%	23.13%	22.84%	21.79%	24.18%	
Denmark	$p < 0.05$	129	57	152	75	148	872
	Sign. p-values	14.79%	6.53%	17.43%	8.60%	16.97%	
Finland	$p < 0.05$	50	56	67	93	65	578
	Sign. p-values	8.65%	9.68%	11.59%	16.08%	11.24%	
France	$p < 0.05$	171	144	171	179	142	1045
	Sign. p-values	16.36%	13.77%	16.36%	17.12%	13.58%	
Germany	$p < 0.05$	223	240	187	174	160	1045
	Sign. p-values	21.33%	22.96%	17.89%	16.65%	15.31%	
Greece	$p < 0.05$	66	95	70	80	65	303
	Sign. p-values	21.78%	31.35%	23.10%	26.40%	21.45%	
Italy	$p < 0.05$	239	192	200	172	189	1045
	Sign. p-values	22.87%	18.37%	19.13%	16.45%	18.08%	
Netherlands	$p < 0.05$	164	126	161	113	118	1045
	Sign. p-values	15.69%	12.05%	15.40%	10.81%	11.29%	
Spain	$p < 0.05$	141	137	128	138	88	975
	Sign. p-values	14.46%	14.05%	13.12%	14.15%	9.02%	
Sweden	$p < 0.05$	214	234	240	243	198	1045
	Sign. p-values	20.47%	22.39%	22.96%	23.25%	18.94%	
Switzerland	$p < 0.05$	165	138	105	140	139	1045
	Sign. p-values	15.78%	13.20%	10.04%	13.39%	13.30%	
UK	$p < 0.05$	114	131	117	128	117	1045
	Sign. p-values	10.9%	12.53%	11.19%	12.24%	11.19%	
Average		17.2%	16.66%	16.75%	16.41%	15.37%	

Table 5. Portion of significant day of the week rolling coefficients (Generalized Error Distribution)

		Monday	Tuesday	Wednesday	Thursday	Friday	# of regres.
Global	$p < 0.05$	209	159	129	155	197	1045
	Sign. p-values	19.98%	15.20%	12.33%	14.81%	18.83%	
Europe	$p < 0.05$	217	159	167	195	21	1042
	Sign. p-values	20.74%	15.20%	15.96%	18.64%	20.65%	
Belgium	$p < 0.05$	242	284	203	265	253	1046
	Sign. p-values	23.15%	27.17%	19.42%	25.35%	24.21%	
Denmark	$p < 0.05$	230	179	246	177	258	872
	Sign. p-values	26.40%	20.55%	28.24%	20.32%	29.62%	
Finland	$p < 0.05$	96	106	99	132	101	578
	Sign. p-values	16.60%	18.33%	17.12%	22.83%	17.47%	
France	$p < 0.05$	206	183	218	219	203	1045
	Sign. p-values	19.69%	17.49%	20.84%	20.93%	19.40%	
Germany	$p < 0.05$	337	357	335	315	264	1045
	Sign. p-values	32.21%	34.13%	32.02%	30.11%	25.23%	
Greece	$p < 0.05$	87	102	97	109	68	303
	Sign. p-values	28.61%	33.55%	31.90%	35.85%	22.36%	
Italy	$p < 0.05$	304	268	255	206	234	1045
	Sign. p-values	29.06%	25.62%	24.37%	19.69%	22.37%	
Netherlands	$p < 0.05$	242	200	214	207	179	1045
	Sign. p-values	23.13%	19.12%	20.45%	19.78%	17.11%	
Spain	$p < 0.05$	212	222	198	233	153	975
	Sign. p-values	21.56%	22.58%	20.14%	23.70%	15.56%	
Sweden	$p < 0.05$	305	273	325	331	276	1045
	Sign. p-values	29.15%	26.09%	31.07%	31.64%	26.38%	
Switzerland	$p < 0.05$	235	211	129	196	186	1045
	Sign. p-values	22.46%	20.17%	12.33%	18.73%	17.78%	
UK	$p < 0.05$	170	166	144	137	152	1045
	Sign. p-values	16.25%	15.86%	13.76%	13.09%	14.53%	
Average		24.02%	23.38%	22.63%	23.5%	21%	