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RETURN AUTOCORRELATION ANOMALIES IN TWO EUROPEAN STOCK MARKETS

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Abstract

The autocorrelation in stock returns is one of the most important anomalies in financial markets worldwide. In this paper, we have investigated differences in return autocorrelation on a day-to-day basis in the Spanish and French stock markets. Our research provides strong evidence of the importance of non-trading periods, not only weekends and holidays but also overnight closings, to explain return autocorrelation anomalies. While close-to-close stock returns are highly autocorrelated, specially on Mondays, when we compute daily returns on an open-to-close basis they do not exhibit a significant level of autocorrelation.

Keywords: *Return Autocorrelation, Stock Market Anomalies, Non-trading Periods.*

JEL Classification: *G10.*

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I. Introduction

In the last twenty years, an increasing number of papers have investigated stock market anomalies, reporting strong evidence that daily stock returns show empirical regularities that are difficult to explain from asset pricing theories. The investigation of these anomalies has generated conflicting opinions among researchers. The day-of-the-week and the turn-of-the-year effects are two of the best-documented regularities. In the first case, it consists in a negative equity return on Monday and an abnormally high return on the last trading day of the week (usually Friday). The January effect refers to the regular tendency shown, especially by prices of small capitalization stocks, to increase in January. In addition, some papers have found that daily stock returns show a significantly positive first order autocorrelation, and thus, tomorrow expected return is not independent of the computed return today. These findings suggest that the use of historical data could be of some help to predict future returns, with obvious implications for the efficiency of equity markets.[1] Most researchers have suggested explanations based on non-synchronous trading as the cause of the positive return autocorrelation observed across international stock markets. Accordingly, since daily returns are usually computed through a stock market index, the inclusion in the index of securities that are subjected to infrequent trading could cause positive stock return autocorrelation. However, since a significant level of first-order serial correlation has been found on common stock portfolios of large and actively traded firms (eg. Perry, 1985), non-synchronous trading seems to be not the only cause of correlation in daily market indexes.

More strikingly, several authors have found that return autocorrelation varies significantly through the week, being especially strong on Mondays. Thus, the reported differences in mean returns through weekdays (the weekend effect) seem to be due, at least to a certain extent, to a strong level of autocorrelation on Monday stock return. In a pioneer paper, Cross (1973) finds that an increase in the S&P 500 index on Monday was twice as likely if the index had increased rather than decreased the previous Friday. Later, Keim and Stambaugh (1984), and Jaffe and Westerfield (1985) show that return autocorrelation between Friday and Monday was the highest of any pair of successive days. In the first case the authors investigate the US market while in the second they investigate return autocorrelation in the US, Australia, Japan, Canada and the United Kingdom. More recently, Bessembinder and Hertzel (1993) documents a similar pattern in the serial dependence of security returns not only around weekends but also around holidays. The authors find that the tendency for Monday returns to reinforce Friday returns is a part of a wider process that applies to holidays as well as Friday closings.

Nevertheless, in spite of the attention devoted, a well accepted explanation to justify the existing differences in return autocorrelation depending on the day of the week does not exist yet. As Keim and Stambaugh (1984) point, if the low Monday returns were due to measurement errors in prices on Friday, and if these errors varied over time, the higher than average errors on Fridays would tend to produce lower than average errors on Mondays. Thus, this behavior would imply a positive but lower, or even a negative correlation between Friday and Monday returns.

The abnormal strong autocorrelation on Mondays seems to be due to the existence of the weekend non-trading period. Lakonishok and Maberly (1990) report some evidence supporting a day-of-the-week effect in the trading pattern of individual investors, in the same way as Ritter (1988) proposes "the parking of the proceeds hypothesis" to explain the January effect.[2] While the observed tendency by individual investors to increase the trading activity on Mondays can be explained in terms of the unique costs individuals face in evaluating their portfolios compared to institutional investors, it is more difficult to explain the well-documented evidence of an asymmetric activity between buying and selling operations. The reason is that, as some studies show, financial analysts produce much more buying than selling recommendations. (see Groth, *et al.*, 1979; and Dimson and Marsh, 1986). Following this line of research, Abraham and Ikenberry (1994) discuss that because individual investors typically work during the weekdays, they will tend to use the weekends to analyze financial information and to decide about financial operations (the information-processing-hypothesis). They argue that while investors with liquidity needs will place selling orders independently of the previous market conditions, positive feedback traders will show a more aggressive selling pressure following the receipt of negative market information on Fridays. The examination of conditional versus unconditional mean returns on a day-to-day basis supports individual investors being, at least partially, the responsible for the weekend effect.

Strategic behavior models with heterogeneous investors provide other explanations for day-of-the week anomalies (see Admati and Pfleiderer, 1989; and Foster and Viswanathan, 1990). In the first case, the authors develop a model in which the interaction among potentially informed traders, discretionary liquidity traders and market makers are the responsible for the patterns in expected prices changes. On the other hand, Foster and Viswanathan suggest that information asymmetries, which are higher when the market first opens after a period of non-trading, can cause the abnormal behavior in stock returns around weekends. Following this approach, Campbell, Grossman and Wang (1993) observe that for stock indexes as well as for individual large stocks, the first order daily return autocorrelation declines with trading volume. The authors explain this fact with a model where the interaction among different groups of investors causes that price changes followed by high trading volume tend to be reversed.

In this paper, we investigate daily stock autocorrelation in the Spanish and French equity markets following Bessembinder and Hertzel (1993) approach. In fact, our investigation constitutes a natural extension of their research. They showed the importance of non-trading periods (weekends and holidays) to explain differences in daily stock autocorrelation. However, non-trading periods also include overnight closings. Therefore, if non-trading was the cause of the reported differences in returns autocorrelation during the week, we should expect that these differences would disappear if only daily trading returns were computed. Accordingly, we have carried out our analysis with close-to-close as well as open-to-close returns. Although investments generates returns over trading and non-trading periods, and thus investors are interested in close-to-close returns and in close-to-close returns autocorrelation, the use of open-to-close returns will allow a better understanding of the nature of stock market anomalies.

In addition, the fact that the research on stock market anomalies is strongly concentrated in the US case, jointly with the reasons argued by Lakonishok and Smidt (1988) for being skeptical about documented return anomalies obtained from a database that has been widely examined by other researchers, provide additional interest to our research.

The remainder of the paper is organized as follows. In section II, we present the methodology and data employed in the analysis. Section III shows the empirical results. Finally, section IV contains a summary of the paper and the main conclusions.

II. Methodology and Data

2.1 Methodology

We have followed Bessembinder and Hertzel (1993) approach investigating the effect of weekends and holidays on the level of stock return autocorrelation. In a similar way, we have proposed a regression model where daily return autocorrelation has been allowed to vary on a day-to-day basis. Thus, we regress daily stock returns on prior day return, employing indicator variables to allow coefficient estimates to vary according to the day of the week. To evaluate if the potential differences in return autocorrelation are produced during the trading time or during the non-trading period, we have estimated model one and model two. In model one (represented by equation (3)), we have computed daily returns in the usual way as close-to-close returns, while in model two (represented by equation (4)) we have used open-to-close returns.

To provide a basis for comparison, we first estimate the first order autocorrelation coefficient *(β)*, using all days in the sample, with close-to-close return from equation (1).

$$R_{cc,t} = \alpha_0 + \sum_{i=1}^{n-1} \alpha_i d_{it} + \beta R_{cc,t-1} + \mu_t \tag{1}$$

Equation (2) reproduces equation (1) but with returns calculated on an open-to-close basis,

$$R_{oc,t} = \alpha_0 + \sum_{i=1}^{n-1} \alpha_i d_{it} + \beta R_{oc,t-1} + \mu_t \tag{2}$$

where $R_{cc,t}$ is the daily index return computed from the closing of day t-1 to the closing of day t, $R_{oc,t}$ is the daily index return computed from the opening of day t to the closing of day t, being n = 5 days of the week. Variables d_1, d_2, d_3, *and* d_4 are the indicator variables that represent Monday, Tuesday, Thursday and Friday, respectively. Therefore, intercepts are allowed to vary depending on the day of the week in equations (1) and (2) in order to control for differences in mean returns. Evidence reported by García Blandón (2001) supports the inclusion of these indicator variables.

To evaluate the existence of differences in close-to-close return autocorrelation around non-trading periods depending on the day of the week, we have estimated equation (3).

$$R_{cc,t} = \alpha_0 + \sum_{i=1}^{n-1} \alpha_i d_{it} + \beta_0 R_{cc,t-1} + \sum_{i=1}^{n-1} \beta_i d_{it} R_{cc,t-1} + \mu_t \quad (3)$$

As we did before, equation (4) reproduces equation (3) but with returns computed on an open-to-close basis.

$$R_{oc,t} = \alpha_0 + \sum_{i=1}^{n-1} \alpha_i d_{it} + \beta_0 R_{oc,t-1} + \sum_{i=1}^{n-1} \beta_i d_{it} R_{oc,t-1} + \mu_t \quad (4)$$

As it can be seen, intercepts as well as slopes are allowed to vary across the day of the week. Now, the β coefficients account for differences in daily return autocorrelation depending on the day of the week. Thus, β_1 measures if the autocorrelation between Monday and previous Friday returns, after controlling for differences in daily mean returns, is significantly different from the autocorrelation between other two consecutive days of the week.

Diagnostic tests, indicate that the residuals from estimating equations (1), (2), (3) and (4) are both heteroscedastic and autocorrelated.[3] When this is the case, OLS estimators are biased and inefficient. However, the Newey-West approach provides heteroscedasticity and autocorrelation consistent standard errors for the OLS estimators, since the estimation of the variance-covariance matrix is robust against heteroscedasticity and autocorrelation. At the level of daily returns one might wonder whether the results depend on the lag order used in the Newey-West correction of the t-statistics. We have performed calculations with different lag orders, and finally we have used 20 lags to compute the Newey-West matrix or the results reported. However, the results do not change using other lags in the range 6-25.

To determine whether the return autocorrelation pattern can be due to the existence of some anomalous returns in our dataset, we have tested the sensitivity of our results, to the presence of influential observations. Accordingly, we have re-estimated equations (1), (2), (3) and (4) after the removal of the 1 percent largest and 1 percent smallest returns. The return autocorrelation pattern remains largely unchanged.

2.2 Data

The investigation carried in this paper uses daily price data from the IBEX-35 and the CAC-40 indexes during the period comprised from the second of January of 1992 to the first of December of 2000. Although, the IBEX-35 index is calculated since December 1989, information publicly available at the Sociedad de Bolsas website does not include the period December 1989-December 1991. Therefore, our analysis covers a period of 9 years with 2.250 observations for the Spanish and 2.224 for the French case. We have calculated daily returns as: $R_{cc,t} = (P_{c,t}-P_{c,t-1})/ P_{c,t-1}$, where $P_{c,t}$ represents the closing price of the index on day t, in the analysis of close-to-close returns, and as $R_{oc,t} = (P_{c,t}-P_{o,t})/P_{o,t}$ where $P_{o,t}$ represents the opening price of day t, in the analysis of open-to-close returns. Regarding the French stock market, CAC-40 is the French equivalent to the Spanish IBEX-35 index. It consists of the 40 most liquid companies in the Paris Stock Exchange with a base value of 1000 on December 31, 1987.

III. Results

Table 1 reports the estimated coefficients of equations (1) and (2) with the Newey-West standard errors in parentheses for Spain and France. The F value of the model jointly with its significance level is also provided. For the Spanish case results show important differences and similarities in the pattern of daily return depending on how returns have been computed. Coefficients associated to the indicator variables, α_1 (Mondays), α_2 (Tuesdays), α_3 (Thursdays) and α_4 (Fridays) show the same day-of-the-week effect no matter whether returns are computed in close-to-close or open-to-close terms. In both equations, only α_2 and α_4 are statistically significant at conventional levels. Since both coefficients show a positive sign in both equations, it would indicate that returns are significantly higher on Tuesdays and Fridays compared with the other days of the week. Thus, an interesting finding is that differences in daily stock returns through the week do not depend on how returns have been calculated. Surprisingly, the coefficient of the indicator variable introduced to compute for differences on Monday average return α_1 is not statistically significant no matter how daily returns have been computed. As for the French case, none of the α coefficients is statistically significant either in the model with close-to-close (equation (1)) or open-to-close returns (equation (2)).

TABLE 1

ESTIMATES OF EQUATIONS (1) AND (2) FOR THE SPANISH AND FRENCH MARKETS

	Spain		France	
	Equation (1)	Equation (2)	Equation (1)	Equation (2)
α_0	−0.0005699	−0.0005635	0.0001992	−0.0002400
	(0.0005888)	(0.0004781)	(0.0005508)	(0.0004656)
α_1	0.0000777	0.0007905	0.0003342	0.0007990
	(0.0008587)	(0.0006679)	(0.0008075)	(0.0006607)
α_2	0.001987*	0.0018046*	0.0009952	0.0009424
	(0.0008711)	(0.0007384)	(0.0008259)	(0.0007432)
α_3	0.0010069	0.0010595	−0.0001468	−0.0001291
	(0.0009734)	(0.0007438)	(0.0009331)	(0.0007219)
α_4	0.0025468**	0.0027398**	0.0006799	0.0010476
	(0.0008368)	(0.0006444)	(0.0007964)	(0.0006671)
β	0.1004957**	−0.0262649	0.0430664*	−0.0198198
	(0.0211615)	(0.0222798)	(0.0218450)	(0.0259686)
N:	2250	2250	2224	2224
F Value:	7.68	4.05	1.35	1.02
Sig. Level:	0.000	0.001	0.240	0.407

* Significant at a 0.05 level.
** Significant at a 0.01 level.

However, the most interesting point is the examination of daily return autocorrelation. In the estimation of equation (1) for the Spanish market, β is positive and statistically significant at any level, supporting most of the available evidence about a positive and strong daily portfolio return autocorrelation in most national equity markets worldwide. Nevertheless, when we compute returns on an open-to-close basis, the coefficient β although with a negative sign, it is not statistically significant, indicating that portfolio daily open-to-close return does not exhibit a significant autocorrelation. In both cases, the whole model is globally significant, at the usual levels, although the F value of the model with close-to-close returns is almost twice the F value of the model with open-to-close returns. Jointly considered, the significance of β in the estimation of equation (1) and its non-significance in equation (2) would indicate that the cause of daily return autocorrelation is the relationship between closing prices. The estimates for the French market index show that β is only statistically significant in the model with close-to-close returns.

TABLE 2

ESTIMATES OF EQUATION (3)

	Spain	France
α_0	−0.0005117	0.0002777
	(0.000602)	(0.0005626)
α_1	−0.0002471*	0.0001145
	(0.0008666)	(0.0008163)
α_2	−0.0019116	0.0009575
	(0.000858)	(0.0008112)
α_3	0.0009487	−0.0002119
	(0.0009951)	(0.0009494)
α_4	0.0024803**	0.0006148
	(0.0008655)	(0.0008005)
β_0	0.0534507	−0.0220747
	(0.0706904)	(0.0689648)
β_1	0.1956473*	0.183665*
	(0.0819296)	(0.0912846)
β_2	−0.0804325	0.0044507
	(0.1048764)	(0.0900881)
β_3	0.0475778	0.124006
	(0.0994288)	(0.0913098)
β_4	0.0876493	0.1332909
	(0.0970889)	(0.0800612)
N:	2250	2224
F Value:	8.43	2.43
Sig. Level:	.000	.009

* Significant at a 0.05 level.
** Significant at a 0.01 level.

Tables 2 and 3 report the results of the estimation of equations (3) and (4) respectively. As expected, after the estimation of equations (1) and (2) the results show important differences in the estimated coefficients depending on how returns are computed. For the model using close-to-close returns, Table 3 shows that daily return autocorrelation strongly depends on the day of the week. Thus, return autocorrelation between Mondays and Fridays (β_1) is positive and statistically significant at a 0.05 level. The other days of the week do not exhibit a significant return autocorrelation. As Tables 3 and 4 confirm, French stock returns show the same autocorrelation pattern as Spanish returns: close-to-close return autocorrelation is only statistically significant on Mondays, while open-to-close returns do not show any significant level of autocorrelation either on Mondays or other days of the week.

The reported results support Bessembinder and Hertzel (1993) finding that returns the first day after non-trading periods are more highly correlated to prior-day returns than returns on other days are. We do not observe, however, a price reversal the second trading day of the week. Coefficient β_2, that measures the correlation between Tuesdays and Mondays returns, is not statistically significant either in the Spanish or the French market.

TABLE 3

ESTIMATES OF EQUATION (4)

	Spain	France
α_0	−0.0005629	−0.0002223
	(0.0004816)	(0.0004685)
α_1	0.0006509*	0.0007612
	(0.0006920)	(0.0006740)
α_2	0.0018249	0.0009289
	(0.0007513)	(0.0007383)
α_3	0.0010826	−0.000149
	(0.0007639)	(0.0007310)
α_4	0.0027499**	0.0010398
	(0.0006492)	(0.0006626)
β_0	−0.0267511	−0.0440023
	(0.0476689)	(0.0578051)
β_1	0.0672844	0.0427956
	(0.0721474)	(0.0814949)
β_2	−0.0798121	0.0172194
	(0.0997897)	(0.0873045)
β_3	0.0644776	0.0183219
	(0.0909846)	(0.1080434)
β_4	−0.0323545	0.03974
	(0.065185)	(0.0650022)
N:	2250	2224
F Value:	2.70	0.74
Sig. Level:	0.004	0.677

* Significant at a 0.05 level.
** Significant at a 0.01 level.

Table 3 shows the results of the estimation of equation (4). As we could expect after the results showed by Table 1, none of the estimated β_i coefficients is statistically significant at any level in the model using open-to-close returns, either in Spain or France. This result supports Rogalsky (1984) findings, showing the importance of non-trading periods to explain stock return anomalies. While the author finds that differences in mean returns depending on the day of the week are due to returns generated by differences between the opening and the previous closing price, our results indicate that the anomalies in return autocorrelation disappear when we compute daily returns on an open-to-close basis.

The abnormally high and positive reported return autocorrelation between Mondays and Fridays indicates that a high return on Friday favors a high return on Monday (on a close-to-close basis) much more than, for instance, a high return on Wednesday favors a high return on Thursday. Abraham and Ikenberry (1994) provide evidence that the weekend effect could be explained, at least partially, by the buying-selling behavior of individual investors, which is called the information-processing-hypothesis. Accordingly, if individual investors decide buying and selling transactions during the weekend, Monday returns should show clearly signs of a delayed reaction to information, stronger than in any other day of the week.

Our results indicate that the Monday opening plays a major role in explaining the weekend effect. Such a situation seems to be fully compatible with the information-processing-hypothesis. According to Abraham and Ikenberry (1994) when Friday return was negative, Monday return was negative nearly 80% of the time with an average of – 0.61%, but when Friday return was positive more than half of the following Monday return was positive, with an average of 0.11%. This fact suggests that return autocorrelation on Monday is not independent of the sign of the previous Friday return. Following the information-processing-hypothesis, the weekend effect occurs because individual investors tend to concentrate their selling decisions on Mondays. Two reasons would justify such a behavior: the unique costs individual investors face to evaluate their portfolios and how individual investors receive information and recommendations from the broker community. The first reason justifies that individual investors tend to be more active traders on Mondays compared with the rest of the week because the weekends provide a low cost period for decision analysis. Regarding the second point, individual investors receive most of stock market recommendation from the brokerage community during week trading days. Empirical studies have widely shown that stock market recommendations are strongly biased toward buying recommendations. In such a situation, Miller (1988) and Lakonishok and Maberly (1990) suggest the brokerage community will solicit many buying orders from individual investors during the weekdays but much less selling orders. According to this behavior, while individual investors buying orders responding to brokers solicitations will tend to occur more or less uniformly during the week, sell oriented orders, in most cases without responding to a broker solicitation, will tend to concentrate on Mondays, specially following a stock market decline the previous Friday, if individual investors are positive feedback traders. Therefore, according with the information-processing-hypothesis, we should expect a stronger autocorrelation in stock returns on Mondays following a negative return the previous Friday. In order

to test this hypothesis we have estimated equation (5) where f_t is an indicator variable that takes the score 1 if R_t is negative and zero otherwise.

$$R_{oc,t} = \alpha_0 + \sum_{i=1}^{n-1} \alpha_i d_{it} + \beta_1 d_1 R_{oc,t-1} + \beta_1^* d_1 f_{t-1} R_{oc,t-1} + \mu_t \quad (5)$$

If return autocorrelation on Monday does not depend on the sign of previous Friday return, β_1^* will not be statistically significant. On the contrary, according to Abraham and Ikenberry (1994), we should expect β_1^* to be positive and statistically significant, indicating that Monday return autocorrelation is stronger on Mondays following a decline the previous Friday. The estimates of equation (5) for the Spanish and French stock markets, reported in Table 4, show β_1^* is not statistically significant, questioning the information-processing-hypothesis, at least as observed in the US stock market, as an explanation of the reported stock return autocorrelation pattern in Spain and France.

TABLE 4

ESTIMATES OF EQUATION (5)

	Spain	France
α_0	−0.000445	0.0002794
	(0.0005913)	(0.0005501)
α_1	−0.0003745	0.000131
	(0.0008798)	(0.0008032)
α_2	0.0018489	0.0009766
	(0.0008307)	(0.0008080)
α_3	0.000884	−0.0001628
	(0.0009608)	(0.0009016)
α_4	0.0024428	0.0006343
	(0.0008350)	(0.0007993)
β_1	0.2540253**	0.1613561**
	(0.0466091)	(0.0545021)
β_1^*	0.0007557	0.0374993
	(0.0022645)	(0.0675782)
N:	2250	2224
F Value:	7.83	1.57
Sig. Level:	0.0000	0.1506

* Significant at a 0.05 level.
** Significant at a 0.01 level.

IV. Conclusions

Despite the important attention devoted to the behavior of daily stock returns during the last twenty years, it is still a puzzling issue. Researchers have reported wide evidence supporting the so-called weekend effect, consisting on positive and

abnormally high returns on Fridays followed by negative returns on Mondays, across national equity markets. A question that immediately arises is how such an abnormal behaviour has remained over the years in spite of being widely known. However, the weekend effect is more complex than the reported differences in average daily returns during the week. In this paper, we have reported evidence of an abnormally high autocorrelation between Mondays and Fridays returns in the Spanish and French stock markets. On the contrary, return autocorrelation during the other days of the week is non-significant. This result supports empirical evidence available mostly in the US stock market, especially Bessembinder and Hertzel (1993) investigation of return autocorrelation during non-trading periods. They found that the existence of weekends and holidays was the cause of the observed abnormal return behaviour during trading intervals. One step beyond, our results reveal the importance not only of weekends and holidays but also of overnight closings. Therefore, a stronger support is provided to market closings as the cause of the abnormal autocorrelation behavior.

The absence of autocorrelation in stock return on an open-to-close basis supports Rogalski (1984) findings regarding the importance of distinguishing between trading and non-trading daily returns. Although the author limits the attention to the existing differences in mean stock returns, our results reveal that non-trading is also the cause of the different levels of return autocorrelation across weekdays.

Our results indicate that the Monday opening plays a major role in explaining the weekend effect. Although this fact is fully compatible with the information-processing-hypothesis, we have directly tested this hypothesis for the Spanish and French stock markets, and the results do not support the information-processing-hypothesis being the determinant of the observed autocorrelation in stock returns. Therefore, additional research is needed in order to further understand the causes of autocorrelation in stock return.

Notes

[1] Some papers have discussed the profitability of the use of technical trading rules and price momentum strategies.

[2] In a survey, the authors find evidence of a "parking the proceeds" behavior by individual investors. Only in seventeen per cent of cases the process of a selling operation was reinvested the same day and only in twenty-two per cent of cases, was reinvested within the same week.

[3] The Cook-Weisberg test rejects the hypothesis of constant variance. The Pormanteau test for white noise reveals the existence of autocorrelation in the residuals.

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