Published in : Managerial finance (1995), vol. 21, iss. 8, pp. 32-43
Status : Postprint (Author's version)

On the Presence of a Day-of-the-Week Effect in the Foreign Exchange Market

Albert Corhay[(1)], Ali M. Fatemi[(2)], Alireza Tourani Rad[(3)]

[(1)] University of Liege and University of Limburg;
[(2)] KansasState University;
[(3)] University of Limburg

Abstract

The purpose of this paper is to study the presence of the day-of-the-week effect in the foreign exchange market using an extensive data set of six exchange rates and employing two alternative types of distributional assumptions and also distribution-free tests. Our findings support the hypotheses of higher Wednesday returns prior to October 1, 1981, for the British pound, the Canadian dollar, the Deutsch mark, the French franc, the Swiss franc and the Japanese yen. Pursuant to the change in the settlement procedures which took effect October 1, 1981, the differential Wednesday returns disappear.

Introduction

The presence of anomalous empirical regularities, also called market anomalies, has been documented for the last two decades in the financial markets. Despite efforts and time devoted by academics and professionals to their study, they remain a puzzle insofar as suggested explanations are not unanimous and do not explain, at least not completely, their existence. Generally speaking, these anomalies can be classified into cross-sectional empirical regularities and seasonal regularities. The anomalous cross-sectional regularities, or anomalies related to some Firm or market attributes, are systematic and persistent deviations from an equilibrium pricing model such as the Capital Asset Pricing Model (CAPM) for the equities. A well-known example of cross-sectional empirical regularity in the equities market is the size effect discovered by Banz (1981). According to which firms with a relatively lower market value of equity seem to achieve returns above those warranted by the CAPM. The existence of such market anomaly can be interpreted as a misspecification of the pricing models.
As to the seasonal empirical regularities, the most common ones are the January Effect and the Weekend or Monday Effect. The January effect as found by Rozeff and Kinney (1976) and Gultekin and Gultekin (1983) in equities markets indicate that the average monthly stock returns are larger in January relatively to the other months of the year. The same January effect has also been documented in the foreign exchange market over the period of 1980 to 1989 for the dollar. It appreciated against a basket of foreign currencies in every January except 1986 and 1987. It has also been observed that the January performance of the dollar generally tended to predict its performance for the rest of the year. More specifically, if one boughtthe dollar index on the last day of the preceding year and sold it on the last day of January, he would have made on average a profit of 3.2% in each year if the dollar was appreciated in January (Tucker, Madura and Chiang (1991, p.52)).
The day-of-the-week effect in the financial markets which indicates that the average return on Monday is significantly less than the average return over the other days of the week was first documented by Cross (1973). Using the S&P composite index data for the 1953-1970 period, Cross found significantly negative average returns for Mondays (Friday close to Monday close) and abnormally high returns for Fridays. Essentially the same results were subsequently reported by French (1980), Gibbons and Hess (1981), Lakonishok and Levi, (1982), Keim and Stambaugh (1984), Rogalski (1984) and Smirlock and Starks (1986) among others.
Even if a daily seasonality in the daily prices exists, can it be considered as an inefficiency? Any seasonal regularity should, under the efficient market hypothesis, disappear rather quite quickly. Under this hypothesis, the markets are supposed to reflect all available information. Therefore, as soon as a seasonality is detected, one could expect the investors to make profit of it by using appropriate trading strategies. This should compete away the seasonal regularity. The persistence of these seasonal patterns in the return distribution contradict the efficient market hypothesis insofar as they would permit investors systematically to obtain abnormal returns from trading strategies based on anomalous price behaviour. It has, however, often been argued that, due to the importance of the cost of transaction, a daily seasonality cannot easily be used in order to generate profit and therefore should not be considered as an inefficiency. It can nevertheless be considered as an indirect inefficiency insofar as an investor can postpone his selling to Friday and his buying to Monday.

Published in : Managerial finance (1995), vol. 21, iss. 8, pp. 32-43
Status : Postprint (Author's version)

The day of the week regularity is, apparently, not limited to the equities market. It is found to be present in the Federal Funds market by Saunders and Urich (1984), in the T-Bill market by Flannery and Protopapadakis (1988), in commodity markets by Chiang and Tapely (1983), in the metals market by Ball, Torous and Tschoegl (1982) and in commodity futures markets by Gay and Kim (1987). Further, it is not limited to the US financial markets, as Jaffe and Westerfield (1985) find it present in Australia, Canada, Japan, and the UK.

Although the existence of seasonal anomalies has been tested on many financial markets, little attention has been, up to now, devoted to their study on currency markets. Jaffe and Westerfield investigated the presence of the day of the week effect in the foreign exchange market. Using data ending in September, 1981, and beginning in March, 1973 for the British pound, December, 1974 for the Japanese yen, February, 1976 for the Canadian dollar and December, 1975 for the Australian dollar, they found Wednesday returns higher than average and Friday returns lower than average. This day of the week effect was significantly for the British pound and the Japanese yen but not for the Canadian dollar and the Australian dollar. Jaffe and Westerfield's results are not fully compatible with the earlier results of McFarland, Pettit and Sung (1982). Using the data for seven currencies: the British pound, the German mark, the Japanese yen, the Swiss franc, the Australian dollar, the Spanish peseta and the Swedish krona, over the period January, 1975-June, 1979 McFarland, Pettit and Sung found that Monday and Wednesday returns are higher than Thursday and Friday returns in both the spot market (for all currencies) and the forward market (for the four major currencies leading the list above). More weight should, however, be attached to the findings of McFarland, Pettit and Sung because of their careful approach in assessing the distributional properties of the data and their use of distribution-free test statistics. Despite the presence of evidence from the McFarland, Pettit and Sung study that the distribution of daily price changes are highly non-normal, Jaffe and Westerfield use the regression analysis technique with its attendant assumption of normality. Nonetheless, the discrepancy between the two sets of results are unsettling and requires further investigation. Moreover, more recent studies show the presence of conditional heteroskedasticity, ie. time varying volatility, in the time series of foreign exchange rates, among others see Hsieh (1989). This allows for volatility clustering, that is, large changes are followed by large changes and small by small, which has been recognized as an important feature of the foreign exchange rates behaviour. Furthermore, settlement procedures in effect for the periods covered by these studies are no longer in effect and a re-investigation may be worthwhile. In this paper we analyse the day-of-the-week seasonal using an updated sample and applying two alternative distributional assumptions and non-parametric tests.

Data and Methodology

To examine the day of the week effect in the foreign exchange market we use an extensive data set. It consists of the daily spot rates for the British pound, the Canadian dollar, the Deutsch mark, the French franc, the Japanese yen and the Swiss franc over the period January, 1973 through December, 1992. Our sample includes 5218 observations. The data were collected from Data Stream International, a UK based data service company. Daily returns (R_t) were calculated as $1n(E_t/E_{t-1})$ where E_t denotes the exchange rate, in US dollar per unit of foreign currency.

In order to examine the Day-of-the-week effect the following model is used:

$$R_t = \gamma_w + \gamma D_t + \varepsilon_t \qquad (1)$$

where γ_W, the intercept, is the average return on Wednesday, y is the difference between the returns of the other days of the week and Wednesday and D_t is the dummy variable identifying days that are not Wednesdays. We first apply a standard OLS where residuals are assumed to have a mean of zero and a constant variance. However, it is unlikely that any of the variances are constant over the sample period. As such, we adjust the model for conditionally heteroskedasticity that captures the time variation of the variance in the exchange rate series. More specifically, the model corrected for GARCH is the following:

$$\varepsilon_t \mid \Psi_{t-1} \sim \Phi(0, h_t, d)$$
$$h_t = a_0 + \sum_{i=1}^{p} a_i \varepsilon_{t-1}^2 + \sum_{j=1}^{q} b_j h_{t-j} \qquad (\mathbf{2})$$

where Ψ_t is the information set of all information through time t, h_t is the conditional variance, and Φ is a student-t distribution with d degrees of freedom, and with $p > 0$; $a_i \geq 0$, $i=0,...,p; q>0; b_j \geq 0, j=0,...,q$.

Even though GARCH models with conditional normal distribution allow unconditional error

Published in : Managerial finance (1995), vol. 21, iss. 8, pp. 32-43
Status : Postprint (Author's version)

distribution to be keptokurtic, they might not fully explain the high level of kurtosis observed in the distributions of the returns series. Several leptokurtic conditional distribution have been applied in the literature, eg. Baillie and Bollerslev (1989) and Hsieh (1989); it is generally accepted that the t-distribution performs better.

In conditional heteroskedastic models, the stability condition of the variance process requires that the sum of the estimated parameters, ie. $\sum_{i=1}^{p} \alpha_i - \sum_{j=1}^{q} \beta_j$, which measures the persistence of the volatility, to be less than one. If this sum is equal to one, the process becomes an integrated GARCH or IGARCH process (Engle and Bollerslev (1986)). Such integrated processes imply the persistence of a forecast of the conditional variance over all future horizons and also an infinite variance of the unconditional distribution of ε_t.

The GARCH model is estimated using a FORTRAN program which employs the non-linear optimization technique of Berndt et al (1974) to compute maximum likelihood estimates. Given the return series and initial values of E_1 and h_1, for 1=0,...,r and with r = max(p,q), the log-likelihood function we have to maximize for a GARCH(p,q) model with t-distributed conditional errors as follows:

$$L(\Phi \mid p, q) = \sum_{t=1}^{T} \left[\log \left(\Gamma \left(\frac{\upsilon + 1}{2} \right) \right) - \log \left(\Gamma \frac{\upsilon}{2} \right) - \frac{1}{2} \log((\upsilon - 2)\, h_t) - \left[\frac{1}{2} (\upsilon + 1) \log(1 + \varepsilon_t^2\, h_t^{-1} (\upsilon - 2)^{-1}) \right] \right] \quad (3)$$

where T is the number of observations, Γ(●) denotes the gama function and υ is the degrees of freedom.

We only apply a GARCH(1,1) process as it has often been proved that it fits better exchange rates series than do GARCH(p,q) models with $p+q \geq 3$.

Empirical Findings

The characteristics of the daily rates of return for the British pound are shown in Table I. The three panels present the sample moments: mean daily returns, their variance, minimum and maximum values, skewness and kurtosis measures for the entire sample period and for the period preceding and following October 1, 1981, when the settlement procedure was changed.

An examination of the results in Table I indicates that while the overall daily change in the value of the currency was negative, the mean Wednesday change in its value was positive. However, it does not appear that the variability of Wednesday returns is any different than other days of the week. The distribution of Wednesday returns is skewed to the left (when those of the other weekdays are skewed to the right) and more peaked than others.

The difference between Wednesday returns and the rest of the week is tested using dummy regression (1) where Wednesday return is the intercept and Di is a dummy variable identifying the other days of the week. The estimated coefficients for the British pound are reported in table II for the three periods. The results indicate that the average Wednesday return is significantly different from the average return of the other days of the week for the entire period and the period preceding October 1, 1981. Interestingly, there is no evidence of a difference between Wednesday return and the rest of the week after the settlement date change. Similar results are observed for the other currencies in our sample except the Swiss franc for which the significance level for the entire period was ten percents.

However, applying both parametric (Bera-Jarques) and non-parametric (Kolmo-gorov-Smirnov) tests of normality to all series of exchange rates in our sample for the three periods indicate that they are all non-normally distributed. For that reason we also apply the distribution free test of Kruskall-Wallis to test the equality of mean daily returns. The results for the British pound are presented in table III. It indicates that Wednesday returns are indeed significantly larger than the overall mean daily returns as well as all other weekday returns for the entire period and the period preceding the settlement change, but not for the one following the change. These results are consistent with those obtained on the basis of the regression analysis technique reported above. The results for the other currencies, though not reported, are in accordance with those of the British pound.

Next we apply the GARCH model to account for time variation in the variance of the exchange rate series as this might cause the seasonal behaviour observed in the exchange rate series. Table IV reports the results of the GARCH(1,1) model with t-distributed conditional errors. As expected, these show the model captures the distributional properties of the daily exchange rate returns. All parameters of the

GARCH model and the estimated value of 1/υ , the inverse of the degrees of freedom parameter in the t-distribu-tion, are highly significant. The summation of GARCH parameters is rather close to one, indicating a long persistence of shocks in volatility. To examine if the GARCH model eliminates the seasonality in the exchange rate series, the same dummy regression model is applied to the residuals obtained from the GARCH model for the three periods and all countries. The results of this model for the British pound are reported in table V. Again, the same pattern can be observed, that is, there is still a Wednesday seasonality for the entire period and the first one. This indicates that the seasonality is not due to the presence of conditional heteroskedasticity in the time series of exchange rates, but due to the settlement procedure which existed until October 1, 1981.[1]

Conclusions

Current evidence on the day of the week effect in the foreign exchange market is both contradictory and deficient. McFarland, Pettit and Sung find that Monday and Wednesday returns are higher than Thursday and Friday returns in both the spot and the forward market. Jaffe and Westerfield, however, report that Wednesday returns are higher and Friday returns are lower than average. Additionally, the settlement procedure in effect for the periods covered by these studies are no longer applicable. Using an extensive data set and employing two alternative types of distributional assumptions and also distribution-free tests, we find support for the hypotheses of higher Wednesday returns prior to October 1, 1981, for the British pound, the Canadian dollar, the Deutsch mark, the French franc, the Swiss franc and the Japanese yen. Pursuant to the change in the settlement procedures which took effect October 1, 1981, the differential Wednesday returns disappear.

For the foreign exchange market to be weak-form efficient, the differential Wednesday returns observed before the change in the settlement procedure has to be economically explainable. As previously discussed by McFarland, Pettit and Sung, higher Wednesday returns can be observed, if transactions completed on Wednesday clear for "good value" in the foreign currency on Friday and in the dollar on Monday. Such were the settelment procedures in effect until October 1,1981 for all currencies included. Since then, however, the settlement procedure call for delivery in two days on both sides of the transaction. Therefore, differential Wednesday returns should have disappeared following the change in the settlement procedure. The results of this study using pre- and post-period to the change in the settlement procedure supports this hypothesis. Considering results for the entire period, the differential Wednesday returns reported above is driven by those for the pre-October 1981 period.

Notes

1. Tables I to V for all other currencies we constructed and are available from the authors.

References

Ball, C, T. Walter, and Tschoegl, A. "Gold and the 'Weekend Effect'," *Journal of Futures Markets* (1982): 175-182.

Berndt, E.K., B.H. Hall, R.E. Hall and Hausman, J.A., "Estimation and Inference in Nonlinear Structural Models," *Annals of Economics and Social Measurement* 4, (1974): 653-665.

Bollerslev, T., "Generalized Autoregressive Conditional Heteroskedasticity," *Journal of Econometrics,* 31 (1986): 307-327.

Bollerslev, T., "A Conditionally Heteroskedastic Time Series Model for Security Prices and Rates of Return Data," *Review of Economic and Statistics,* 59 (1987): 542-547.

Chiang, R. and Tapley, C, "Day-of-the-week Effects and the Futures Markets," *Review of Research in Futures Markets, 2,* (1983): 356-410.

Cross, F., "The Behavior of Stock Prices on Friday and Mondays," *Financial Analysts Journal* (1973): 67-69.

Engle, R.F., "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of UK inflation," *Econometrica,* 50 (1982): 987-1008.

Engle, R.F. and Bollerslev, T., "Modelling the Persistence of Conditional Variances," *Econometric Reviews,* 5 (1986): 1- 50.

Flannery, M.J. and Protopapadakis, A.A., "From T-Bills to Common Stocks: Investigating the Generality of Intra-Week Return Seasonality," *Journal of Finance* (1988): 431-449.

French, K.R., "Stock Returns and the Weekend Effect," *Journal of Financial Economics* (1980): 55-69.

Gay, G. and Kim, T., "An Investigation into Seasonality in the Futures Market," *Journal ofFutures Market,!* (1987): 169-181.

Gibbons, M.R. and Hess, P., "Day of the Week Effects and Asset Returns," *Journal of Business (1981): 579-596.*

Gultekin, M.N. and Gultekin, N.B., "Stock Market Seasonality: International Evidence," *Journal of Financial Economics* 12 (1983), 469-481.

Hsieh, D.A., "Modelling Heteroskedasticity in Daily Foreign- Exchange Rates," *Journal of Business & Economics Statistics,* 7 (1989): 307-317.

Jaffe, J. and Westerfield, R., "The Week-End Effect in Common Stock Returns, The International Evidence," *Journal of Finance* (1985): 433-454.

Keim, D.B. and Stambaugh, R.F., "A Further Investigation of the Weekend Effect in Stock Returns," *Journal of Finance* (1984): 819-835.

Lakonishok, J. and Levi, M., "Weekend Effects on Stock Returns: A Note," *Journal of Finance* 37 (1982): 883-889.

McFarland, J., R. Pettit, and Sung, S., "Distribution of Foreign Exchange Price Changes: Trading Day Effects and Risk Measurement," *Journal of Finance* (1982): 693-715.

Rogalski, R.J., "New Findings Regarding Day-of-the-Week Returns Over Trading and Non Trading Periods: A Note," *Journal of Finance* (1984): 1603-1614.

Rozeff, M.S. and Kinney, W.R., "Capital Market Seasonality: The Case of Stock Returns," *Journal of Financial Economics* 3 (1976): 379-402.

Saunders and Urich, T., "Seasonality in the Federal Funds Market: The Weekend Game and Other Effects," Unpublished manuscript, New York University, Graduate School of Business, (1984).

Smirlock, M., and Starks, L., "Day-of-the-Week and Intraday Effects in Stock Returns," *Journal of Financial Economics* (1986): 197-210.

Tucker, A.L., J. Madura, and Chiang, T.C, *International Financial Markets* 1991, West Publishing Company, New York.

Published in : Managerial finance (1995), vol. 21, iss. 8, pp. 32-43
Status : Postprint (Author's version)

Annexes

Table I Sample Statistics on British pound

	Obs.	Mean	Var.	Min.	Max.	Skew.	Kurt.
Whole period							
Overall	5219	-0.008	0.393	-3.866	4.667	-0.079	4.001
Monday	1043	-0.020	0.490	-2.936	2.776	-0.064	3.570
Tuesday	1044	0.019	0.403	-2.872	2.789	-0.106	2.528
Wednesday	1044	0.055	0.366	-3.286	4.667	0.308	5.853
Thursday	1044	-0.046	0.335	-3.866	3.121	-0.200	4.707
Friday	1043	-0.050	0.371	-2.936	2.776	-0.366	3.445
Period before October 1,1981							
Overall	2283	-0.011	0.268	-3.866	3.500	-0.369	7.419
Monday	456	-0.017	0.358	-3.299	3.450	-0.665	8.122
Tuesday	457	0.006	0.286	-2.872	2.789	-0343	6.410
Wednesday	457	0.080	0.268	-2.686	2.309	0.095	3.196
Thursday	457	-0.079	0.229	-3.866	1.976	-1.122	10.409
Friday	456	-0.044	0.186	-1.602	2.777	0.383	6.465
Period after October 1,1981							
Overall	2935	-0.649	0.489	-3.286	4.667	0.011	2.587
Monday	587	-0.022	0.594	-2.407	4.076	0.159	1.867
Tuesday	587	0.029	0.494	-2.483	2.764	-0.040	1.102
Wednesday	587	0.036	0.442	-3.286	4.667	0.414	5.907
Thursday	587	-0.020	0.399	-2.558	3.121	0.066	2.605
Friday	587	-0.054	0.516	-2.936	2.517	-0.451	1.991

Published in : Managerial finance (1995), vol. 21, iss. 8, pp. 32-43
Status : Postprint (Author's version)

Table II — UK Model Estimates

$R_t = \gamma_w + \gamma D_t + \varepsilon_t$

	Overall period	Before 1/10/81	After 1/10/81
Number of observations	5218	2283	2935
γ_w (Wednesday)	0.0551	0.0803	0.0355
$t(\gamma_w)$	2.844*	3.326*	1.229
γ	-0.794	-0.1139	-0.0524
$t(\gamma)$	-3.665*	-4.222*	-1.626

An asterisk denotes significance at the 5% level.

Table III Test of Equality of Mean on British pound

	Mon.	Tue.	Wed.	Thu.	Fri.	All
Whole period						
Tuesday	0.9048					
Wednesday	7.6486*	2.7277				
Thursday	3.5416	8.1728*	21.8995*			
Friday	3.1861	7.5924*	20.7361*	0.0000		
Overall	0.0003	2.4144	18.6400*	8.8900*	8.260*	30.5648*
Period before October 1, 1981						
Tuesday	0.175					
Wednesday	11.416*	7.561*				
Thursday	5.848*	8.282*	33.039*			
Friday	2.618	4.284*	25.375*	0.710		
Overall	0.001	0.684	28.626*	14.147*	6.213*	39739*
Period after October 1,1981						
Tuesday	1.359					
Wednesday	1.905	0.030				
Thursday	0.049	1.970	2.782			
Friday	0.582	3.652	4.833*	0.449		
Overall	0.244	1.857	2.938	0.688	3.074	7.041

An asterisk denotes significance at the 5% level.

Published in : Managerial finance (1995), vol. 21, iss. 8, pp. 32-43
Status : Postprint (Author's version)

Table IV—UK GARCH(1,1) Model Estimates

	Overall period	Before 1/10/81	After 1/10/81
Number of observations	5218	2283	2935
φ_0(thousands)	-0.2259	0.1309	-0.0111
$t(\varphi_0)$	-7.0622*	3.9596*	-0.1000
α_0(thousands)	0.0000	0.0000	0.0000
$t(\alpha_0)$	0.2105	0.2051	0.0544
α_1	0.1450	0.2090	0.0363
$t(\alpha_1)$	28.6857*	18.3285*	8.9061*
β_1	0.8543	0.7908	0.9632
$t(\beta i)$	229.6288*	102.7393*	231.4620*
$1/\upsilon$	0.0309	0.0908	0.0632
$t(1/\upsilon)$	59.7459*	47.6970*	613.2948*

An asterisk denotes significance at the 5% level.

Table V — UK GARCH(1,1) residuals

$$\varepsilon_t = \gamma_w + \gamma D_t + \varepsilon_t$$

	Overall period	Before 1/10/81	After 1/10/81
Number of observations	5218	2283	2935
γ_w(Wednesday)	0.1944	0.2315	0.0465
$t(\gamma_w)$	5.2912*	3.5903*	1.0899
γ	-0.1910	-0.3531	-0.0742
$t(\gamma)$	-4.6504*	-4.8974*	-1.5558

An asterisk denotes significance at the 5% level.