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Profitability of the Moving Average Strategy and the Episodic Dependencies: Empirical Evidence from European Stock Markets

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Abstract:

Numerous recent studies are emphasizing the existence of different stock price behaviors, namely long random walk sub periods alternating with short ones characterized by strong linear and/or nonlinear correlations. All these studies suggest that these serial dependencies have an episodic nature. In this paper we investigate the profitability of an optimum moving average strategy selected from 15,000 combinations on the main European capital markets considering the episodic character of linear and/or nonlinear dependencies, the period under study being 1997-2008. The empirical results are consistent the assumptions made by the Adaptive Markets Hypothesis (AMH) of Lo (2004) regarding the fact that profit opportunities do exist from time to time. More than that, the paper proves that the profitability of those strategies is mainly due to nonlinear episodic dependencies.

Keywords: *Nonlinear dependence; Bi-correlation; Market Efficiency; Technical Analysis.*
JEL Classification: C15, G11, G14

1. Introduction

The main characteristic of classical studies testing the capital markets' informational efficiency hypothesis is that they draw inferences on the level of the aggregate investigated sample. In that sense it is known that classical tests of the random walk hypothesis are being appreciated among the most popular tests of the weak form efficiency, their objective being to verify the unpredictability of security returns using past price changes. During the last decade, a series of studies highlighted the fact that the rejection of the random walk hypothesis

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(henceforth RWH) for the whole sample could be caused by strong linear and nonlinear correlations manifested in short subs periods of time. For example, Lim and Hinich (2005) in Asian Stock Markets, Bonilla et *al*. (2006) in Latin American Stock Markets, Thalassinos (2006 and 2008) in European Stock Markets and Todea or Zoicaş-Ienciu (2007) in Central and Eastern Europe stock markets are emphasizing the existence of different stock price behaviors with an episodic nature, namely long random walk sub periods alternating with short ones characterized by strong linear and/or nonlinear correlations.

The identification of such behaviors was achieved using the "windowed" methodology of Hinich and Patterson (1995). The methodology requires a division of the sample in sub periods (windows) of same size in which are run portmanteau tests of linear and nonlinear correlation. The existence of the episodic behavior over the evolutionary process of the stock market prices being a reality, a series of very recent studies investigate its ground. Lim, Brooks and Hinich (2007) found that the cross-country differences in nonlinear departure from market efficiency can be explained by market size and trading activity, while the transient burst of nonlinear periods in each market can be attributed to the occurrence of significant economic and political events. The high potential of this methodology is reflected by its use in different research areas. Lim, Brooks and Kim (2007) investigated the effects of the Asian financial crisis on the efficiency of eight Asian markets, while Lim (2007) developed market rankings using the percentage of windows in which RWH is rejected, a technique based on the notion of relative market efficiency defined in Campbell et al. (1997). Using a similar tackling, Cajueiro and Tabak (2006) employed a rolling sample approach to compute the Hurst exponent, for testing the presence of long-term predictability in Asian equity markets using the medians of these rolling Hurst exponents.

It is important to stress the fact that the random walk test of the stock market prices is not a direct test of the weak form efficiency hypothesis but an associated one. Under these circumstances, the acceptance of the RWH implies the informational efficiency, but its rejection is not synonymous to informational inefficiency because only the successful exploration of the dependencies is equivalent with the inefficiency. For this reason random walk tests are often followed by direct informational efficiency tests, usually technical analysis' tests. Even if generally these tests are applied separately, there are exceptions like the study of Lagoarde-Segot and Lucey (2006) which combines them by developing an index of efficiency in order to evaluate the relative market efficiency for seven emerging Middle-Eastern North African stock markets.

By its topics and findings this article contributes to the existing literature in two ways. Firstly, considering the episodic dependencies of linear and nonlinear dependencies it develops a methodology that allows the evaluation of the profitability of the technical analysis strategies in sub periods of acceptance and rejection of the RWH. Intuitively, we expect that the technical analysis strategies to be more profitable in the sub periods in which the RWH is rejected compared to the ones in which is accepted. More than that, it is interesting to study which are dependencies that generate the profitability of these strategies: the

linear or the nonlinear ones? Secondly, this article contributes by highlighting the findings related to the informational efficiency of some European stock markets.
The remainder of the paper is structured as follows: section 2 discusses the methodology; section 3 provides a short description of the data and section 4 analyses the empirical results and assesses their financial significance. Finally, section 5 succinctly clarifies the results' implications and the paper contribution in the research area.

2. Methodology

The methodology applied in this paper implies a study of the profitability of the moving average strategy over linear and nonlinear correlation windows, as well as over non-correlation windows. These windows are identified using an improved version of the "windowed" methodology of Hinich and Patterson (1995), which is the rolling sample approach. Such a different approach was used by Lim (2007) in ranking market efficiency for stock markets or by Lim, Brooks and Kim (2007) in investigating the effects of the 1997 financial crisis on the Asian stock markets. As a matter of fact, Todea and Zoicaş-Ienciu (2007) showed that the original Hinich-Patterson methodology can be suspected of inaccurate identification of sub-periods exhibiting linear/nonlinear dependencies, because the test results depend on how the first day of the sample is chosen.

Correlations identification is made using the portmanteau test (C) for linear correlations and the bi-correlation test (H) for the nonlinear ones. In the rolling sample approach, C and H statistics are computed for the first window of a specified length (n), and then the sample is rolled forward eliminating the first observation and including the next one for a re-estimation of C and H statistics. The procedure is repeated until the last observation of sample is used. The return sample $\{R(t)\}$ is considered to be the realization of a stochastic process, where t (integer) is the time unit. In each window the data are standardized to have a sample mean of zero and a sample standard deviation of one, as follows:

$$Z(t) = \frac{R(t) - m_R}{\sigma_R} \tag{1}$$

where t takes values from 1 to n and m_R, σ_R are the mean and standard deviation within each window. The null hypothesis is that $\{Z(t)\}$ is the realization of a white noise process with null correlations and bi-correlations, described by $C_{RR}(r) = E[R(t)R(t+r)]$ and $C_{RRR}(r,s) = E[R(t)R(t+r)R(t+s)]$, where r and s are integers satisfying $0 < r < s < L$ with L being the number of the lags. The correlations and bi-correlations are then given by:

$$C_{RR}(r) = (n-r)^{-1/2} \sum_{t=1}^{n-r} Z(t)Z(t+r) \tag{2}$$

$$C_{RRR}(r,s) = (n-s)^{-1} \sum_{t=1}^{n-s} Z(t)Z(t+r)Z(t+s) \text{ for } 0 \le r \le s \tag{3}$$

C and H statistics are distributed according to a χ^2 law of probability with L respectively $(L-1)(L/2)$ degrees of freedom, having the following formulas:

$$C = \sum_{r=1}^{L} \left[C_{RR}(r) \right]^2 \tag{4}$$

$$H = \sum_{s=2}^{L} \sum_{r=1}^{s-1} G^2(r,s), \text{ where } G(r,s) = (n-s)^{1/2} C_{RRR}(r,s) \tag{5}$$

Lim, Brooks and Hinich (2007) draw the attention regarding the fact that the determination of the H bi-correlation statistics requires a prior filtration of the linear component, reason for which, this study also filters out the autocorrelation structure by an autoregressive AR(p) fit. The AR fitting is employed as a pre-whitening operation, and not to obtain a model of best fit. The p order of the AR(p) model is chosen between 1 and 10 as the smallest value for which the Ljung-Box Q(10) statistic is insignificant at the 10% level. Brooks and Hinich (2001) showed that it is not necessary to filter the returns through an AR-GARCH model in order to determine the statistics of the bi-correlation test, because the presence of GARCH effects will not cause a rejection of the null hypothesis of pure white noise. C statistics are being computed on the basis of unfiltered returns, while H statistics are computed using unfiltered residuum resulted after the linear component filtration. The null hypothesis of linear/nonlinear correlation is accepted or rejected in each window at a risk level of 1%.

The number of lags (L) is specified as $L = n^b$, with $0 < b < 0{,}5$. Based on Monte-Carlo simulations, Hinich and Patterson (1995) recommends the usage of $b = 0{,}4$ in order to maximize the power of the test assuring in the same time a good asymptotical approximation. In addition, the window's length must be long enough to offer a robust statistical power but short enough for the test to be able to identify the arrival and disappearance of transient dependencies, as changes in the variables behavior. Despite the fact that in the previously mentioned studies the window's volume was of 50 or even 35 trading sessions, in this study we use windows of 200 observations, volume that is recommended by Patterson and Ashley (2000) as a result of the Monte Carlo simulations achieved for six popular nonlinearity tests including the bi-correlation test.

The use of the moving average strategy is based on the fact that financial series are volatile and contain certain trends. The crossing of the price line or short term moving average line over the long term moving average line may be a sign that a trend has been initiated. Following this assertion, a buying signal is generated when the short term moving average is greater than the long term moving average, and the selling signal is generated when the inequality is reverse. Around the long term moving average a percentage envelope has been introduced in order to eliminate contingent *« noisy »* signals. The majority of studies are limited to different moving average combinations proposed by Brock et *al*. (1992), but taking into account that this variant is a restrictive one, we developed an informatics application which allows in the case of each market, the selection of the strategy for which the return in excess of the buy-and-hold strategy is maximum. This strategy is selected from 15000 possible strategies resulted from the combination of all short term moving averages (between 1 to 10 days) with all variants of long term moving average (between 50 to 200 days) and of 10 size of envelopes comprised between 0,1% and 1% (integer multiple of 0,1%).

The commission fee differs across markets, and it is considered every time a selling or buying signal appears. In this study the investor is considered to be always on the market in a long or short position.

In each window of volume of 200 observations, the cumulated returns corresponding to the selected moving average strategy and to the buy-and-hold strategy were computed, as well as the cumulated excess return. By dividing these results by 200, the daily average return/excess was computed and grouped together in four sub-samples depending on the results of the C and H tests. Considering the addition property of the average, the daily average excess was computed for each sub-sample and then their significance has been tested. The daily average returns and the daily average excess returns have been annualized and expressed in percents, by multiplying them with 250, respectively 100 in order to offer a clearer image of the results.

3. The Data

The data consists of daily closing prices for six European stock market indices [Austria (ATX Index), Holland (AEX General), France (CAC 40), Germany (CAC 40), Switzerland (Swiss Market Index) and UK (FTSE 100)] analyzed between the 1st of July 1997 and 14 April 2008. All the closing prices obtained from *Yahoo-Finance* are denominated in their respective local currency units. The data was then transformed into a series of continuously compounded percentage returns by taking 100 times the log price relatives, i.e. $r_t = \ln(p_t / p_{t-1}) \cdot 100$, where p_t is the closing price of the index on day t.

4. Empirical Results

Using the informatics application we identified the strategy with the maximum excess return for each market listed in the second column of Table 1. The detection of the most profitable strategy was achieved by using the closing levels of the indices over the period 1/02/1997 – 8/28/2008, but the analysis of the profitability of these strategies over linear/nonlinear correlation and non-correlation sub-periods was made on samples of different volumes depending on the value obtained for the long term moving average. As an example, in the case of Austria, for which the optimum strategy is (2, 105, 0.1%), we investigate the dependences starting with day 105 in the initial sample, so that the first observation in the new sample corresponds to 10 June 1997. In this case the short moving average is 2, the long moving average is 105 and the envelope around the long moving average is 0.1%. For each market the first day of the sample is presented in the third column of Table 1.

***Table 1*. Optimal strategy, first date of sample and returns**

	Optimal Strategy	**Commission (%)**	**First date of sample**	**Buy-and-Hold return**	**Technical analysis return**	**Excess return**
Austria	(2, 105, 0.1%)	0,35	6/10/1997	0.00042** (10,5%)	0.00768** (19,2%)	0.000348** (8,7%)
Holland	(8, 198, 0.7%)	0,33	10/14/1997	-0.00033** (-8,17%)	0,0000914* (2,28%)	0,000419** (10,47%)
France	(10, 127, 0.3%)	0,26	7/8/1997	0,00017** (4,25%)	0,000582** (14,55%)	0,000412** (10,3%)
Germany	(2, 200, 0.8%)	0,3	10/21/1997	0,000135* (3,375%)	0,000483** (12,075%)	0,000349** (8,725%)
Switzerland	(10, 123, 1%)	0,32	7/2/1997	0,0000759 (1,898%)	0,0005** (12,5%)	0,000424** (10,6%)
UK	(8, 135, 1%)	0,38	7/16/1997	0,0004 (1,00%)	0,0001* (2,50%)	0,0000603* (1,508%)

Note. The annualized returns are given in brackets. Numbers marked with * (**) are significant at the 5% (1%) risk levels.

Using a passive strategy by the investors during the period under study would have led to diminished annual returns for each market with the exception of the Austrian market where the return is of 10.5%. Under the hypothesis in which all investors had managed to adopt the best moving average strategy the returns adjusted with the commission fees varies between 2.28% in the case of Holland and 19.2% in the case of Austria. The British and Dutch markets distinguish themselves by the lowest profitability of the optimum strategy, sign of a potentially high degree of weak form informational efficiency. This does not mean that other technical analysis strategies applied on these markets could not have led to higher profits. The annualized excess return of the optimum strategy comparative to the buy-and-hold strategy, with the exception of the British market, lies between 8-10%, but this excess varies over time depending on the evolution process of stock market prices.

One of the fundamental hypotheses of technical analysis strategies is that the past tends to repeat, for which reason the existence of an episodic behavior of the linear and nonlinear dependencies certainly influence their profitability over time.

***Table 2*. The average excess return generated by the optimum strategy over sub periods of acceptance and rejection of the random walk hypothesis**

	Total number of windows	**C and H insignificant**		**C or H significant**	
		Number of windows	**Excess return**	**Number of windows**	**Excess return**
Austria	2576	1554	0,000116* (2,90%)	1022	0,000699** (17,475%)
Holland	2572	1260	0,00011** (2,75%)	1312	0,000715** (17,875%)
France	2634	1433	0,000418** (10,45%)	1201	0,000404** (10,10%)
Germany	2547	1331	-0,0000956* (-2,39%)	1216	0,000835** (20,875%)
Switzerland	2603	1313	0,000126** (3,15%)	1290	0,000728** (18,20%)
UK	2602	1159	-0,00028** (-7,00%)	1443	0,000333** (8,325%)

Note. The annualized returns are given in brackets. Numbers marked with * (**) are significant at the 5% (1%) risk levels.

Table 2 shows that the excess return within the windows in which the RWH is rejected due to linear and nonlinear correlations is superior to the excess return over the sub periods of acceptance of RWH, with the exception of the French market. The percentage of windows in which the RWH is rejected at a risk level of 1% varies from a market to another within the 40-60% interval. This percentage is significantly influenced by the window’s length which consists in this study of 200 trading sessions. For the same markets, if the window’s length is 50, the percentage of windows in which the RWH is rejected is less than 10%. It may be observed that in the case of the German and British markets, during the sub periods of acceptance of the RWH, the return generated by the passive strategy is superior to the one corresponding to the optimum moving average strategy. The highest positive excess returns are being generated in the sub periods of linear and nonlinear correlation on the markets of Austria, Holland, Germany and Switzerland.

Table 3 shows that the rejection of the RWH is due especially to the presence of nonlinear dynamics. More than that, the profitability of the moving average strategy seems to be caused by these nonlinear dependencies. Somehow surprising, in the sub periods in which only linear correlation exist, the excess return is negative for all the markets. Practically it is confirmed once more that the strategies of the technical analysis exploit especially the nonlinear dynamics of stock market prices. In sub periods of simultaneously linear and nonlinear correlation, the results are ambiguous, these correlations leading to profitability in the case of the French, Swiss and Dutch markets and negative excess for the German and the British markets.

***Table 3*. The average excess return generated by the optimum strategy in sub-periods of the random walk hypothesis rejection**

	C significant and H insignificant		**H significant and C insignificant**		**C and H significant**	
	Number of windows	**Excess return**	**Number of windows**	**Excess return**	**Number of windows**	**Excess return**
Austria	25	-0,00032** (-7,95%)	766	0,000857** (21,425%)	231	0,000286** (7,15%)
Holland	5	-0,001579** (-39,475%)	1218	0,000703** (17,575%)	89	0,001013** (25,325%)
France	16	-0,000293** (-7,325%)	1147	0,000368** (9,20%)	38	0,001768** (44,20%)
Germany	13	-0,00053** (-13,25%)	1070	0,001033** (25,825%)	133	-0,00062** (-15,575%)
Switzerland	-	-	1284	0,000722** (18,05%)	6	0,002002** (50,05%)
UK	48	-0,00018 (-4,60%)	1035	0,000497** (12,425%)`	360	-0,0000671 (-1,678%)

Note. The annualized returns are given in brackets. Numbers marked with * (**) are significant at the 5% (1%) risk levels

5. Conclusion

This article contributes to the existing literature by validating the hypothesis according to which the existence of episodic dependencies increases the predictability degree of stock market prices. This ex-post validation for several European capital markets was achieved by running a direct test of weak form informational efficiency hypothesis, the moving average strategy. The moving average strategies confirm their profitability only in sub-periods in which the RWH is rejected, and due to the episodic character of these correlations it may be asserted that the degree of market efficiency varies in a cyclical fashion over time and these statistical features are in line with those postulated by the Adaptive Markets Hypothesis (AMH) of Lo (2004).

The analysis of the profitability over linear and nonlinear correlation sub-periods confirm, with certain reserves in the case of the French market, the results obtained by Clyde and Osler (1997) and Andrada-Félix et *al.* (2003) according to which the profitability of the technical analysis is given mainly by the existence of nonlinear dynamics of stock prices and not of linear ones. This is supplementary evidence urging on a more exhaustive investigation of nonlinear episodic dependencies.

References

1) Andrada-Félix J., M. Fernandez-Rodriguez et A.S Garcia, 2003, "An Empirical Evaluation of Non-Linear Trading Rules", *Studies in Nonlinear Dynamics & Econometrics* 7(3), 1160-1198.
2) Bonilla, C. A., R. Romero-Meza and M. J. Hinich, 2006, "Episodic nonlinearity in Latin American Stock Market Indices", *Applied Economics Letters* 13, 195–199.
3) Brock W., J. Lakonishok and B. LeBaron, 1992, "Simple technical trading rules and the stochastic properties of stock returns", *Journal of Finance* 47, 1731-1764.
4) Brooks, C. and M. J. Hinich, 2001, "Bicorrelations and cross-bicorrelations as non-linearity tests and tools for exchange rate forecasting", Journal *of Forecasting* 20, 181−196.
5) Cajueiro, D.O. and B.M. Tabak, 2006, "Testing for predictability in equity returns for European transition markets", *Economic Systems*, forthcoming.
6) Campbell, J., A. Lo, and A. MacKinlay, 1997, "The Econometrics of Financial Markets" (Princeton University Press, Princeton).
7) Clyde W.C. , C.L. Osler, 1997, "Charting: chaos theory in disguise?", *Journal of Futures Markets* 17, 489-514.
8) Hinich M. J. and D.M. Patterson, 1995, "Detecting epochs of transient dependence in white noise", *mimeo*, University of Texas, Austin.
9) Lagoarde-Segot, T., B. Lucey, 2008, "Efficiency in emerging markets: evidence from the MENA region", *Journal of International Financial Markets, Institutions and Money* 18(1), 94-105.
10) Lim K.P. and M.J. Hinich, 2005, "Cross-temporal universality of non-linear dependencies in Asian stock markets", *Economics Bulletin* 7(1), 1 - 6.
11) Lim K.P., R.D.Brooks, M.J. Hinich, 2007, "Nonlinear serial dependence and the weak-form efficiency of Asian emerging stock markets", *Journal of International Financial Markets, Institutions & Money*, doi:10.1016/j.intfin.2007.08.001.
12) Lim K. P., R.D. Brooks and J.H. Kim, 2007, "Financial crisis and stock market efficiency: Empirical evidence from Asian countries", *International Review of Financial Analysis*, doi:10.1016/j.irfa.2007.03.001.

13) Lim K. P., 2007, "Ranking of efficiency for stock markets: A nonlinear perspective", *Physica A* 376, 445−454.
14) Lo Andrew W., 2004, "The Adaptive Markets Hypothesis: Market Efficiency from an Evolutionary Perspective", *Journal of Portfolio Management* 30, 15-29.
15) Patterson, D.M. And R.A. Ashley, 2000, "A nonlinear time series workshop: a toolkit for detecting and identifying nonlinear serial dependence" (Kluwer Academic Publishers, Boston).
16) Thalassinos, E., Thalassinos, P., 2006, "Stock Markets' Integration Analysis", *European Research Studies Journal,* Vol. IX, Issue 3-4, pp. 3-14.
17) Thalassinos, E., 2008, "Trends and Developments in the European Financial Sector", *European Financial and Accounting Journal,* vol. 3, no. 3, pp. 51-68.
18) Todea A. and Zoicaş-Ienciu A., 2007, "Episodic dependencies in Central and Eastern Europe stock markets", *Applied Economics Letters* 1-4, doi: 10.1080/13504850600993614.