Stock Market Trends during the Crisis: An Analysis based on Taylor's Methodology

Adrián Fernández-Pérez
Department of Quantitative Methods in Economics and Management
University of Las Palmas de Gran Canaria
Campus de Tafira, Facultad de Economía
Empresa y Turismo, 35017 Las Palmas de Gran Canaria
Spain

Fernando Fernández-Rodríguez*
Department of Quantitative Methods in Economics and Management
University of Las Palmas de Gran Canaria
Campus de Tafira, Facultad de Economía
Empresa y Turismo, 35017 Las Palmas de Gran Canaria
Spain
E-mail: ffernandez@dmc.ulpgc.es, Phone: +34928451802

Julián Andrada-Félix
Department of Quantitative Methods in Economics and Management
University of Las Palmas de Gran Canaria
Campus de Tafira, Facultad de Economía
Empresa y Turismo, 35017 Las Palmas de Gran Canaria
Spain

Abstract

We have tested the random walk hypothesis against the existence of trends in the main stock market indexes before and during the 2008 financial crisis. With that end, Taylor's (1980) trend price model was employed. In the indexes where there is evidence of trend patterns, a technical trading strategy, proposed by Taylor to obtain extraordinary profits for trend markets, was implemented. Due to the complexity of the log likelihood function of the model, in order to estimate the parameters, a genetic algorithm was employed. In the case of developed, BRIC and Asian-Pacific indexes, our results show that before the crisis, Sharpe's ratios of Taylor's strategy are lower than the results of the B&H strategy. During the crisis the results are opposites and Sharpe's ratios of Taylor's strategy improve the results of the B&H strategy. For the rest of developing economies the results are diverse.

Keywords: Financial Markets, Trends, Financial Crisis

1 Introduction

The efficient market hypothesis (EMH), a theme long discussed in financial literature, was developed by Fama (1965) and asserts that financial markets are "informationally efficient". In its weak form, the EMH establishes that current prices reflect all available public information in the past and investors are only compensated by taking risks. It means that the new information arriving on the market is instantaneously translated to prices and employing any technical trading strategy it is impossible to obtain an abnormal profit above the market. In an alternative way, the defenders of technical analysis maintain that prices move following trends. It means that when new information arrives on the market it does not immediately translate into prices and a certain amount of time is necessary until the market incorporates this information. This situation reflects that the market will move through trends which may be used in a profitable way using a technical strategy based on the correlations of past returns.

There was a seminal paper by Taylor (1980) casting doubt over the random walk hypothesis and introducing a price trend model which provided profitable rules in commodity and currency markets. Until the end of the eighties literature defended the EMH which supports that no technical trading rule may be able to make extra profits over the naïve buy and hold strategy, taking into account transaction costs. Nevertheless, recent studies reveal that there are situations where future returns are predictable from past returns.

So, Lo and MacKinlay (1988) found positive autocorrelations of weekly returns on portfolios of New York Stock Exchenge (NYSE) stocks. Fama and French (1988) discovered negative serial correlation in returns of individual stocks and various portfolios of small and large firms. Brock, Lakonishok and LeBaron (1992) reported that most common technical trading rules as moving average and trading rank break have predictive power in the Dow Jones index. Similar conclusions have been reached by Gencay (1996) who found strong evidence of nonlinear predictability in daily returns of the Dow Jones index. Finally, Kwan et al. (2000) found predictability and profitability considering the price trend model by Taylor (1980) in the Hang Seng Index Futures in Hong Kong. In this paper we have tested for the random walk hypothesis against the existence of trends before and during the 2008 financial crisis in the main stock markets all over the world. With that end, Taylor's (1980) trend price model and Taylor's U^* statistic was employed. The parameters defining the trend were estimated by maximum likelihood by mean of a genetic algorithm. Finally, a technical strategy, proposed by Taylor, devoted to obtaining extraordinary profits in the case of trends in the assets, was implemented.

2. Taylor's trend model

Taylor's trend model for a prices time series P_t is defined as

$$\begin{aligned} &x_t = \log(P_t) - \log(P_{t-1}) = \mu_t + \varepsilon_t, \\ &E(\varepsilon_t) = E(\varepsilon_t \varepsilon_{t+i}) = 0,\ i \neq 0, \operatorname{cov}(\mu_s, \varepsilon_t) = 0\ \ \forall s,t \end{aligned} \qquad (1)$$

where the white noise series ε_t is uncorrelated with the stochastic process μ_t representing the trend in the model and it is interpreted as the response to anticipated changes in the supply and demand of the assets. This μ_t may be positive or negative giving rise to increasing or decreasing price trends. We also define σ^2 as the variance of ε_t, v^2 as the variance of μ_t and $\bar{\mu}$ as the expectation of μ_t.

So, the trend model may be formulated with probability as

$$\mu_t = \begin{cases} \mu_{t-1} & \textit{with probability} \quad p \\ \bar{\mu} + \eta_t & \textit{with probability} \quad 1-p \end{cases} \qquad (2)$$

where η_t is white noise with mean zero and independent of the past trend values μ_s for $s < t$.

In order to find out the number of days that the duration of the trend is expected, a parameter *m* which is called the mean trend duration is defined as the averages the different durations of possible trends

$$m = \sum_{i=1}^{\infty} i(1-p)p^{i-1} = (1-p)^{-1} \qquad (3)$$

Omitting technical details which can be found in Taylor and Kingsman (1978), Taylor (1980) and Taylor (1986), the base of the price trend test is the existence of positive correlations between daily rescaled returns $x_t / \hat{a}_t$ with several lags, where $\hat{a}_t$ represents the estimation of the mean absolute deviation which is considered a proxy of the variance of the returns x_t and it is estimated using an exponential weighted moving average of the past absolute returns

$$\hat{a}_t = \gamma \sum_{i=0}^{\infty} (1-\gamma)^i \, | x_{t-1-i} | = (1-\gamma)\hat{a}_{t-1} + \gamma \, | x_{t-1} | \ , \qquad (4)$$

and the parameter γ, which is obtained by the maximum likelihood method, is equal to 0.04 for stock prices. On the contrary, in the random walk model, all correlations will be zero for any lag. The correlations of daily rescaled returns are defined as $\rho_i = cor(x_t / \hat{a}_t, x_{t+1} / \hat{a}_{t+1})$. Taylor shows that model (1) with μ_t variable as in (2) provides the following correlation expression for rescaled returns

$$\rho_i = \frac{p^i v^2}{v^2 + \sigma^2} = Ap^i, \qquad (5)$$

where $A = v^2 / (v^2 + \sigma^2)$.

So Taylor (1980) formulates a hypothesis test where the null corresponds to the random walk:

$$H_0 : \rho_i = 0, \text{ for each i>0} \qquad (6)$$

meanwhile the alternative hypothesis to the random walk model is:

$H_1 : \rho_i = Ap^i$, for some $A \geq 0$, $0 \leq p \leq 1$, for each i>0 (7)

The parameter A is a measure of information that is not instantaneously reflected in the market prices, meanwhile p measures the speed at which the information is reflected in them. If A or p were very close to zero, the information would be used perfectly by the market. But when the trend is accepted, A has a small value, around 3%, and p is close to 1. It means that the market has a slow interpretation of the relevant information that arrives.

In order to reject the presence of trends in the financial series Taylor (1980) proposes a statistic U^* based on the likelihood ratio, using the sample autocorrelations r_t of rescaled returns $x_t / \hat{a}_t$

$$U^* = \frac{\sum_{i=2}^{30} 0.92^i r_i}{\sum_{i=2}^{30} (0.92^{2i} n^{-1})^{\frac{1}{2}}} = 0.4649\sqrt{n}\sum_{i=2}^{30} 0.92^i r_i \qquad (8)$$

If H_0 is accepted, the statistic U^* has N(0,1) asymptotic distribution.

3 Parameters estimation and prediction

Once the trends are detected by the U^* statistic, the trend parameters *A*, *p* and *m* are going to be estimated in all series. In order to estimate the trend parameters it is possible to use several methods. So Taylor (1980) employed the generalized method of moments. On the other hand Kwan et al. (2000) used the quasi-maximum likelihood in order to estimate the trend parameters in daily returns for Hang Seng Index Futures. In this paper we will employ the maximum likelihood method in estimating the trend parameters. Following Taylor we try to match the theoretical Ap^i and observed r_i autocorrelations, assuming the differences between them is $N(0,\sigma_r^2)$ distributed, that is

$$\begin{aligned} & r_i = Ap^i + \varepsilon_i \,,\, \varepsilon_i \approx N(0,\sigma_r^2)\,,\, i = 1,...,n_r \\ & E(r_i) = Ap^i,\, \mathrm{var}(r_i) = \sigma_r^2, \end{aligned} \qquad (9)$$

where n_r is the number of sample autocorrelations r_i and σ_r^2 is the variance of the sample autocorrelations which following Barlett (1946) is given by the expression

$$Var(r_i) = \sigma_r^2 \cong \frac{1}{n}\left(1 + 2\sum_{k=1}^{i-1} r_k^2\right)$$

and n is the sample size of the training period. In carrying out estimations, 200 sample autocorrelations of the rescaled returns are employed. Supposing that the residues $\varepsilon_i = r_i - Ap^i$ are independent, the likelihood function of the n_r residues are

$$L(A, p / r_1, r_2, ..., r_{n_r}) = \prod_{i=1}^{n_r} \frac{e^{-\frac{1}{2\sigma_i^2}(r_i - Ap^i)^2}}{\sqrt{2\pi\sigma_r^2}} = \frac{e^{-\frac{1}{2\sigma_i^2}\sum_{i=1}^{n_r}(r_i - Ap^i)^2}}{(2\pi\sigma_r^2)^{n_r/2}} \qquad (10)$$

Due to the complexity of function (10), in order to estimate the parameters *A* and *p* by maximizing the likelihood function, a genetic algorithm is employed.

A genetic algorithm (GA henceforth) is a class of optimization technique, based on principles of natural evolution developed by Holland (1975) which tries to overcome problems of traditional optimization algorithms, such as an absence of continuity or differentiability of the loss function. A GA starts with a population of randomly generated solution candidates, which apply the principle of fitness to produce better approximations to the optimal solution. Promising solutions, as represented by relatively better performing solutions, are selected and breeding them together through a process of binary recombination referred to as crossover inspired by Mendel's natural genetics. The objective of this process is to generate successive populations of solutions that are better fitted to the optimization problem than the solutions from which they were created. Finally, random mutations are introduced in order to avoid local optima [see Dorsey and Mayer (1995) for the use of genetic algorithms for optimizing complex likelihood functions in econometrics.].

4. Empirical results

Taylor's methodology for testing trends in the markets is applied to four groups of stock indexes:

- Indexes of developed countries (Dow Jones of the US, S&P500 of the US, NASDAQ of the US, FTSE100 of the UK, NIKKEI 225 of Japan, DAX30 of Germany, CAC40 of France, IBEX 35 of Spain, AEX of Holland, ASX of Australia, JSE of South Africa, LuxX of Luxembourg and TA 100 of Israel). This study can't be carried out on the MIB30 index of Italy because it was transformed during the crisis.
- Indexes of BRIC countries (IBrX of Brazil, RTS of Russia, CNX100 of India and Shanghai SE of China).
- Indexes of Asian-Pacific countries (Hang Seng Index of Hong Kong, TAIEX Weighted Index of Taiwan, SGX of Singapore, MESDAQ of Malaysia and VNI of Vietnam).
- Indexes of other emergent countries (MXSE of Mexico, IBC of Venezuela, BASE of Argentina, SOFIX of Bulgaria, IGPA of Chile, IGBC of Colombia, CASE30 of Egypt, ISE of Turkey and NSE20 of Kenya).

All series employed in this work were provided by EcoWin Pro of Reuters and rank from 12-31-1974 to 07-06- 2010. The results are presented in Table 1. The first column shows, in bold, the indexes where the U^* statistic rejects the null hypothesis of random walk ($U^* \geq 1.65$, in a one-tail N(0,1) test with 5% of confidence) against the alternative of tendency. The second column displays the mean trend duration. As it is possible to observe, the null was accepted in 6 out of 13 indexes in the developed countries. The indexes are Dow Jones US, S&P 500 US, NASDAQ 100 US, FTSE 100 UK, DAX 30 GERMANY and SOUTH AFRICA JSE. With respect to the BRIC countries, only in the Brazil index the null of random walk was accepted. In the group of Asia-Pacific Security markets studied, the null was only accepted in the TAIEX TAIWAN and in the MESDAQ MALAYSIA. For the group of remaining emergent market indexes studied, in all of them the U^* statistic rejects the null.

Insert Table (1) about here

5. Economic evaluation of trends: Taylor's strategy

Taylor (1986) has suggested a technical trading rule which could be profitable for trend series. This strategy is compounded by three control parameters k_1, k_2 and k_t where $k_1 > k_2$. The parameter k_1 controls the initiation of trades, telling us when to change a short position for a long position. The parameter k_2 controls the conclusion of the trades, telling us when to change a long position for a short position. This fact is a crucial part of Taylor's technical strategy in the sense that trading decisions depend on a standardized forecast k_t calculated by assuming the trend model, that is

$$k_t = \frac{f_{t-1,1}}{\hat{\sigma}_{F,t-1}} \qquad (11)$$

where

$$f_{t-1,1} = (\hat{a}_t / \hat{a}_{t-1})\left\{(p-q)x_{t-1} + qf_{t-2,1}\right\} \qquad (12)$$

$$\hat{\sigma}_{F,t-1} = \hat{a}_t \left\{Ap(p-q)/(1-pq)\right\}^{1/2} \qquad (13)$$

with $t = 21,\ldots,n_{rend}$, being n_{rend}, the total number of returns. In the recursion (12), $f_{t,1}$ is the ARMA(1,1) prediction made in the instant t of the return t+1, $\hat{\sigma}_{F,t}$ is its standard deviation, x_t is the non-rescaled return of the series in the instant t and $\hat{a}_t$ is the estimated mean absolute deviation obtained in (4). Taylor's strategy is as follows: we need 20 returns before the beginning in order to estimate the mean absolute deviations ($\hat{a}_t$). The values of $f_{t,1}$ and $\sigma_{F,t}$ are supposed to be zero for $t \leq 20$, and for $t \geq 21$ are estimated recurrently in (12) and (12). After $t \geq 21$, we begin with no market position until $k_t > k_1$ (start a long position) or $k_t < k_2$ (start a short position). When we are inside the market, if we are in a long position we change to a short position when $k_t < k_2$; if we are in a short position we change to a long position when $k_t > k_1$.

For $k_t \in [k_1, k_2]$ don't change the position in any case. When we change our position from long to short or vice versa, a transaction cost of 0.20% is subtracted from the total return. Besides, in order to compute total returns, we assume that, when we are in a short position, the proceeds are invested in a money market account with a risk-free rate of 4% per annum.

In order to select the control parameters k_1 and k_2 an optimization process is carried out. So, k_1 and k_2 are selected, maximizing the Sharpe ratio of Taylor's strategy in the training period. With that end a genetic algorithm is also employed.

To implement this strategy it is necessary to subdivide each series into two parts: a training period and a prediction period. The training period is the first part of a series and inside it the trend parameters *A* and *p* are estimated. These parameters will be employed for trading in the predicting period which is the second part of the series.

We have considered the performance of Taylor's technical strategy before and during the crisis. Before the crisis the training period considered ranks from the beginning of each series until 06-29-2000. The prediction period was from 06-30-2000 to 12-31-2007. During the crisis the training period goes from the beginning of each series until 12-31-2007 and the prediction period was from 01-01-2008 to 07-06-2010.

For the series where the null of random walk is rejected the characteristic parameters of the trend model are estimated and predictions are carried out in the prediction period.

The net return obtained in the period t for the series i is the following

$$R_i^t = \sum_{t=21}^{N_{rend}} (x_t\, buy_t) + \sum_{t=21}^{N_{rend}} \left[\left(x_t - riskf_i \right) sell_t \right] - c_i mov_t \qquad (14)$$

where x_t is the no rescaled return, buy_t stands for a buy signal in the instant t (equal to 1 when we are in a long position and equal to 0 when we are in a short position or we take no market position), c_i is the transaction cost (0.20%), mov_t is the number of times that we change from a short to a long position and vice versa, $riskf_i$ is the risk-free return (4% per annum), and $sell_t$ stands for the sell signals (equal to -1 when we are in a short position and equal to 0 when we are in a long position or we take no market position). In order to compare the mean net return of Taylor's strategy with the mean net return of the buy and hold strategy the Sharpe ratio is employed. It divides the net return by its standard deviation, which for the series i in the period t is defined as

$$Sharpe_i^t = \frac{R_i^t / N_{return}}{\sigma_{R_i^t}} \qquad (15)$$

where N_{return} represents the number of returns considered in the period.

The buy and hold strategy returns are obtained by adding the returns of the series from the first to the last, and subtracting two transaction costs corresponding with a buy in the first return and a sale in the last return.
Columns three to six of Table 1 report the values of the Sharpe ratio for the B&H and Taylor's strategies for the countries where the U^* statistic rejected the null hypothesis of random walk, suggesting the possibility of a market trends. The study was carried out before and during the 2008 financial crisis. As it is possible to observe, before the crisis, in whole asset index series where the U^* statistic rejected the null hypothesis of random walk, Sharpe's ratios obtained by B&H strategy are higher than Sharpe's ratios of Taylor's strategy, with just 4 exceptions out of 31. After 01-01-2008 when the crisis broke out, in the set of developed, BRIC and Asian-Pacific countries where the null was rejected, the results are completely opposite. So, with the exception of the Israeli index, in all these countries Sharpe's ratios of Taylor's strategy are higher than Sharpe's ratios of the B&H strategy. For the rest of developing economies the results are diverse.

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Table 1: Taylor's U^* statistics, mean trend parameters and economic evaluation of Taylor's strategy.

Asset Index series	For the entire sample: 12-31-1974 to 07-06-2010		Prediction period from 06-30-2000 to 12-31-2007		Prediction period from 01-01-2008 to 07-06-2010	
	U*	m	Sharpe B&H	Sharpe GA	Sharpe B&H	Sharpe GA
DEVELOPED COUNTRIES						
DOW JONES US	-1.2255	0	0.0271	-	-0.0175	-
S&P 500 US	-0.6900	0	-0.0002	-	-0.0278	-
NASDAQ 100 US	-0.2536	0	-0.0154	-	-0.0142	-
FTSE 100 UK	-0.0170	0	-0.0003	-	-0.0228	-
NIKKEI 225 JAPAN	1.8683*	44	-0.0057	-0.0001	-0.0366	0.0372
DAX 30 GERMANY	0.4431	0	0.0837	-	-0.0334	-
CAC 40 FRANCE	2.3390*	1	-0.0057	0.0021	-0.0374	0.0360
IBEX 35 SPAIN	2.4674*	22	0.0143	-0.0177	-0.0338	0.0127
AEX NETHERLANDS	3.9986*	16	-0.0094	0.0231	-0.0366	0.0287
ASX AUSTRALIA	5.3114*	7	0.0489	-0.0458	-0.0398	0.0546
JSE SOUTH AFRICA	-0.9227	0	0.0957	-	-0.0083	-
LuxX LUXEMBOURG	7.6938*	22	0.0206	0.0154	-0.0432	0.0172
TA 100 ISRAEL	3.0484*	10	0.0342	-0.0190	-0.0139	-0.0269
BRIC						
IBrX BRAZIL	-0.5158	0	0.0653	-	-0.0068	-
RTS RUSSIA	5.2080*	1	0.0710	-0.0471	-0.0249	0.0248
CNX 100 INDIA**	1.6818*	1	0.0929	-0.0729	-0.0101	0.0125
SHANGHAI SE	3.1008*	114	0.0412	0.0061	-0.0506	0.0482
ASIAN-PACIFIC COUNTRIES						
HANG SENG HK	4.7303*	3	0.0228	0.0055	-0.0221	0.0065
TAIEX TAIWAN	-0.5769	0	-0.0025	-	-0.0176	-
SGX SINGAPORE	4.6407*	2	0.0249	-0.0299	-0.0175	0.0108
MESDAQ MALAYSIA	-0.0083	0	0.0235	-	-0.0580	-
VNI VIETNAM	15.0642*	16	0.1125	0.0910	-0.0469	0.0490
EMERGENT COUNTRIES						
MXSE MEXICO	4.2013*	1	0.0568	-0.0324	0.0052	-0.0041
IBC VENEZUELA	7.8934*	4	0.0598	0.0431	0.0861	-0.0360
ARS ARGENTINA	3.5840*	2	0.0547	-0.0086	0.0019	-0.0169
SOFIX BULGARIA	8.4698*	61	0.1214	0.0389	-0.1290	0.1577
IGPA CHILE	13.1471*	3	0.0938	0.0615	0.0413	-0.0076
IGBC COLOMBIA	11.9729*	3	0.0971	0.0036	0.0163	-0.0345
CASE 30 EGYPT	3.3517*	1	0.0798	-0.0127	-0.1618	0.1492
ISE TURKEY	1.9071*	51	0.0276	-0.0123	0.0022	0.0474
NSE 20 KENYA	18.1122*	5	0.0658	0.1408	-0.0311	0.0709

*Null hypothesis of random walk rejected at the 5% level.
**Prediction period from 01-31-2006 to 12-31-2007