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Citation as book chapter: Atsalakis, G., Valavanis K., (2013). *Surveying stock market forecasting techniques - Part I: Conventional methods*. In Zopounidis C., Computation Optimization in Economics and Finance Research Compendium, p.p. 49-104, Nova Science Publishers, Inc, New York

Chapter

SURVEYING STOCK MARKET FORECASTING TECHNIQUES - PART I: CONVENTIONAL METHODS

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ABSTRACT

The key to achieving successful stock market forecasting is obtaining the best possible results with the minimum required input data.

The central objectivesfor acquiring accurate forecasting include the ability of the model/method to capture the nonlinear relations of the stock market thereby returning significant forecasting results despite the existence or lack of prior knowledge of input data statistical distributions.

Conventional models widely utilized to forecast stock markets include auto-regressive (AR), Auto-Regressive Moving Average (ARMA), Auto-Regressive Integrated Moving Average (ARIMA), Generalized Auto-Regressive Conditional Heteroscedasticity (GARCH) and Stochastic Volatility (SV) ones. This study surveys and classifies 150 papers based on stock market models which have been applied to data preprocessing, frequency and size of data, type of forecasting model, comparison of the applied model to other forecasting models, and each model's performance measures as well as a comparison to determine the best model.

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The results indicate that conventional techniques will continue to be a challenging tool for future research.

Keywords: Stock market prediction, stock market volatility, stock price forecasting

1. INTRODUCTION

Stock market forecasters focus on developing approaches to successfully forecast / predict index values or stock prices, aiming at high profits using well defined trading strategies. The central idea bechind successful stock market prediction is achieving best results using minimum required input data and the least complex stock market model.

Undoubtedly, forecasting stock returns is challenging because of market volatility that needs be captured in used and implemented models. Accurate modeling requires, among other factors, consideration of phenomena characterized, for instance, by recession or expansion periods, and high- or low- volatility periods. Observed volatility in stock market returns / prices arises from the fact that desirable (required) rates of return are in themselves highly volatile, and driven by cyclical and other short-term fluctuations in aggregate demand. Recent advances in soft computing techniques offer useful tools in forecasting noisy environments like stock markets, while capturing their nonlinear behavior.

This study surveys 150 scientific articles using conventional models/techniques to forecasting stock markets. Such models/techniques include Autoregressive (AR), Moving Average (MA), Autoregressive Moving Average (ARMA), Autoregressive Integrated Moving Average (ARIMA), Generalized Autoregressive Conditional Heteroskedasticity models (GARCH), Buying and Hold (BandH) strategy, Random Walk (RW), Stochastic Volatility (SV) models.

Most of the surveyed papers follow similar structures: specific stock market, utilized model including input variables (from actual data), a comparison with other models, and empirical results. Researchers may focus on forecasting a particular stock market while others focus on presenting a particular forecasting model.

This paper provides a more in-depth review of conventional techniques used to forecast stock returns and compare results among alternative parametric methods applied as benchmarks reported in the academic journals. The presentation is highlighted on summary tables compiling a variety of data sets, type of modeling, modeling benchmarks, and performance measurements adopted in the literature.

The rest of the paper is organized as follows: Section 2 presents the list of stock markets. Section 3 discusses model input variables extracted from actual data. Section 4 describes models and methods employed along with data preprocessing, data frequency and size. Section 5 puts forward model comparisons, while Section 6 introduces the best forecasting model and performance measures. Finally, Section 7 discusses the discussions derived from this study.

2. SURVEYED STOCK MARKETS

Surveyed stock market and stock market indexes include Standard and Poor's 500, 100 (SandP500, SandP 100), the New York Stock Exchange (NYSE), Dow Jones Industrial Average (DJIA) from the USA, the Tokyo Stock Exchange Price in Japan (TOPIX), the Financial Times Stock Exchange 100 Share (FTSE) in London, and the German main Stock Exchange index Deutscher Aktienindex (DAX).

Table 1. Surveyed studies of single or multiple stock markets

Stock markets	Article
Nigerian Stock Exchange -NSE, Johannesburg Stock Exchange, Egypt and Nairobi Stock Exchange	Nwokoma, N. (2005)
Alfa External Stock Fund	Zontos, Skiadas and Valvis (2000)
Amsterdam (EOE), Frankfurt (DAX), Hong Kong (Hang Seng), London (FTSE100), New York (SandP500), Paris (CAC40), Singapore (Singapore All Shares) and Tokyo (Nikkei)	Taylor, J. (2003)
Asian stock markets	Liew, K., S. et al. (2003) Cornelis A. Los, Ph.D. (2000)
ST-GOBAIN, TOTAL fina elf, FRANCETEL, BNP, CARREFOUR, LOREAL, FTSE, CAC40 and SBF	Dufrenot, G. et al. (2005)
Athens Stock Exchange (ASE)	Kirikos andTerzakis (1999), Kavussanos and Visvikis (2005), Barkoulas, J. et al. (2000), Maris, K. et al. (2004)
Australian Stock Exchange (ASX)	Worthington and Valadkhani (2004), Yao, J. et al. (2005)
Bogotá Stock Market (IBB)	Arango, L.-E.et al. (2002)
Bombay Stock Exchange (BSE)	Batra, A. (2004)
Brazilian Stock Market (BSM)	Cavalcante and Assaf (2004)
Bulgarian stock market (SOFIX index)	Patev and Kanaryan (2004)
Various stock markets	Ciccone S. (2003), Kearney and Potì (2004), Spann and Skiera (2003), Ghysels, E. et al. (2005), Miyahara and Novikov (2002)
Chicago Board Option Exchange (CBOE)	Hol, E. et al. (2002) Bali and Lu (2004) Corrado et al. (2004)
Chinese stock exchanges (Shanghai and Shenzhen)	Darrat and Zhong (2001), Zhang, D. et al. (2005)
CRSP equal-weighted index	Jegadeesh, N. (1990)
CRSP value-weight market portfolio (CPI), (United State, United Kingdom, Canada and Japan)	Balvers, R. et al. (1990)
DAX and FTSE300	Beran J. et al. (2003)

DAX and NYSE	Eisler and Kertesz (2004)
Deutsche Aktien Index (DAX)	Bluhm and Yu (2001)
Dhaka Stock Market of Bangladesh	Mobarek and Keasey (2000)
Dow Jones Industrial Average	Andersen, T. et al. (2002), Stentoft, L. (2005)

Table 1. (Continued)

Stock markets	Article
Dow Jones, Nasdaq, SP500, Nikkei, Ftse, DAX, CAC, AEX, Hangseng	Franses and Leij (2003)
DowJones, CAC40, DAX100, BCI, TSX, FTSE100, Nikkei225	Jawadi and Koubaa (2004)
Eight major EC stock exchanges: Belgium, Britain, Denmark, France, Germany, Italy, Netherlands, and Spain	Friedman and Shachmurove (1997)
Federal Reserve Board's Index (U.S.A)	Hamilton J. and Lin G. (1996), Jansen and Wang (2006), Chiarella, C. et al. (2005)
Financial time series (general)	Tauchen, G. (2001)
Financial Times Stock Exchange 100 Share (FTSE 100), London	Oomen, R. (2001), Oomen, R. (2002), Areal and Taylor (2000), Gemmill and Saflekos (1998)
Finnish stock market	Tolvi, J. (2002)
French CAC40 and US SP500 indexes	Giot and Laurent (2004)
French Stock Market (CAC40)	Fillol, J. (2003)
FTSE 100 (London) and DAX 30 (Frankfurt) indices	Peters, J-P (2001)
German Stock Exchange (DAX)	Claessen-Mittnik (2002), Niglio, M. (2002), Sibbertsen, P. (2004), Wallmeier, M. (2005)
Global database (US stocks, SandP stocks, EU stocks, JP stocks and UK ones.)	Guedj, O. et al. (2006)
Global Stock Market (30 Stock Markets: U.S., Canada, U.K., Belgium Denmark, France, German, Italy, Norway, Spain, Australia, India, Mexico etc.)	Jorion, P. (2003)
Global Stock Market (39 Stock Markets)	Jorion and Goetzmann (1999)
Helsinki Stock Exchange (Unitas index) in Finland	Virtanen and Yli-Olli (1987)
Hong Kong Stock Market	Liu and Lee (1997)
Hong Kong stock market, All Ordinaries Index (AOI) of Australia, FTSE of United Kingdom, Jakarta Composite (JSX) of Indonesia, Kuala Lumpur Composite Price Index (KLSE) of Malaysia, KOSPI of South Korea, NASDAQ of US, Nikkei 225 Index (NIKKEI) of Japan, Stock Exchange of Thailand Daily Index (SET) of Thailand, Standard	Yu and So (2003)

and Poor 500 Index (SP500) of US, Straits Times Industrial Index (STII) of Singapore and Taiwan Stock Exchange	
International Stock Markets (Canada, France, German, Italy, Japan, United Kingdom, United States)	Drobetz and Wegmann (2000)

Stock markets	Article
Istanbul Stock Exchange (ISE)	Aktas, R. et al. (2003)
Istanbul's stock market of Turkey, Egypt, Jordan, and Morocco stock markets.	Assaf, A. (2006)
Italian Stock Market	Jamaleh, A. (2001)
Japan Stock Exchange	Park and Lee (2003), Lin and Wang (2005), Lux et al. (2004), Tse, Y.K. (1991)
Korea Stock Exchange (KSE) and Korean Securities Dealers Automated Quotation (KOSDAQ),	Lee, S-J. et al. (2005), Lee, J. et al. (2000)
Latin America Stock Markets (Argentina Brazil, Chile, Columbia, Mexico and Venezuela	Garrett, I. et al. (2004)
London Stock Exchange (LSE) in England	Lillo and Farmer (2004)
Nairobi Sock Exchange (NSE) in Kenya	Ogum et al. (2002)
NASDAQ–100 Index, VXN Index	Cecconi, M. et al. (2002), Bajari and Krainer (2004)
National Stock Exchange of India. (SandP CNX Nifty index)	Karmakar, M. (2004)
New York Stock Exchange (NYSE)	Bulkley and Holt (1999), Jungbacker and Koopman (2005), Skaradzinski, D. (2003), Felix, J. et al. (2004), Ogden, J. (2003), Avramov, D. (2000), Guidolin and Timmermann (2006), Hueng and McDonald (2005), Chen et al. (2000), Wolf, M. (2000)
New Zealand stock market (NZSE)	Yu, Jun (2002)
Nikkei 225 stock index	Watanabe and Yamaguchi (2005), Huang et al. (2004)
Osaka Stock Exchange (OSE)	Sarno, L. et al. (2005)
Oslo Stock Exchange (OSE)	Naes, R. (2004)
Portudal Stock Index (PSI)	Pereira, R (2004)
SandP 100 index	Blair, B et al. (2001), Taylor, S. (2001), Daouk and Guo (2003), Marcucci, J. (2003), Faugere and Shawky (2002)
SandP 500, Dow Jones transportation (DJT) and Dow Jones utility (DJU) stock price indices. (U.S.A.)	DeStefano, M. (2004)

SandP 500 index (U.S.A.) and other indices from 18 countries, obtained from MSCI	Guo, H. (2003)
SandP 500 index, Chicago Board Option Exchange (volatility index)	Dueker, M. (1997)

Table 1. (Continued)

Stock markets	Article
SandP 500 index. (U.S.A)	Ibbotson and Chen (2003), Rookley C. (1998), Degiannakis and Xekalaki (2001), Killion and Muravytska (2005), Hardle, W. et al. (2001), Cremers, M. (2002) Hyung, N. (2005), Danilov and Magnus (2004), Shaikh, A. (1998), Christoffersen, P. et al. (2005), Engle and Gallo (2006), Koustas and Serletis (2004), Beltratti and Morana (2006), Granger and Hyung (1999), Sharpe, S. (2000), Bhardwaj and Swanson (2006), Manzan, S. (2005), Bond and Cummins (2004), Bradshaw et al.(2005), Krolzig and Toro (2004)
SandP 500, DAX and ATX stock market indices.	Raaij, G. and Raunig, B. (2002)
SandP 500, SandP 100, and NASDAQ indices and volatility indices (VIX, VXO, and VXN)	Bley and Olson (2005)
SandP CNX Nifty, a value-weighted index of 50 stocks traded on the National Stock Exchange (NSE), Mumbai in India	Pandey, A. (2003)
SandP Comp stat industrial tape of 280U.S.firms	McKibben (1971)
SandP Index and Stock Market of Indonesia, South Korea, Argentina, Brazil, Pakistan, and Russia	Hayo and Kutan (2005)
SandP100 index, the FTSE100 index, IBEX35 of the Madrid Stock Exchange and the NIKKEI index	Perez-Cruz, F. et al. (2003)
SandP500 (USA), Nikkei Average (Japan), FT100 (UK) and Hang-Seng (Hong-Kong)	Sanso, A. et al. (2003)
SandP500 and the US 30-day T=BILL	Black et al. (2003)
SandP500, Nasdaq (U.S.A)	Chou, R. et al. (2005)
Singapore Stock Exchange (SES)	Wong et al. (2003)
SP 500 (U.S.A) and Stoxx total market index (TMI) (European market) Chicago Board Options Exchange VXO index.	Mattes, J. (2004)

Spanish stock market (IBEX)	Turiel A. et al. (2005)
Standard and Poor's composite stock price index (S)	Chopin and Zhong (2001)
Standard and Poor's 500 (United States), Topix (Japan), CAC40 (France), FT-100 (United Kingdom), FAZ (Germany) and MIB (Italy) indices	Fornari and Mele (1997)
Stock markets	Article
Stock market of Argentina, Mexico, Malaysia, Philippines, South Korea, Taiwan, Thailand, Brazil, Chile and India	Bacmann and Dubois (2002)
Stock Market of Korea, Malaysia, and Thailand	Füss and Herrmann (2005)
Stockholm Stock exchange (SSE) Swedish (SIX Return Index)	Berg, L. (2003)
Three emerging Arab (Egypt, Jordan, Morocco) stock markets and the US stock market	Guermat, C. et al. (2003)
UK stock market (England)	Lovatt, D. (2000), Lovatt and Parikh (2000), McMillan, D. (2003)
US Stock Market (3-month US T-bill yields from the *CRSP* files, *CRSP* value-weighted index of stock	Handa and Tiwari (2000)
Warsaw Stock Exchange (WSE) Dow Jones Industrial Average (DJIA), NASDAQ, German main index Deutscher Aktienindex DAX and British Financial Times Stock Exchange (FTSE100) index.	Brzeszczynski and Welfe (2004)
14 stock market indices. (Dow Jones, Nikkei (Tokyo), SandP500 (U.S.A.), Nasdaq100, Ftse100 (London), Aex25 (Amsterdam) Cac40 (Paris), Dax30 (Frankfort), etc.)	Charles-Darne (2006)
14 stock markets: Belgium (Brussels All Shares Price Index); Canada (Toronto SE 300 Composite Price Index); Denmark (Copenhagen SE General Price Index); Finland (Hex General Price Index); Germany (Faz General Price Index); Hong Kong (Hang Seng Price Index); Italy (Milan Comit General Price Index); Japan (Nikkei 500 Price Index) and others	Balaban, E. et al. (2006)
17 emerging markets and 18 developed stock markets for comparative purpose.	Bilson, C. et al. (2002)
19 Emerging equity stock markets (Argentina, Chile, Colombia, Greece, India Mexico, Turkey, Portugal)	Aydogan and Gursoy (2000)
19 nominal stock market closing indices	Beran and Ocker (2001)

(Australia, Belgium, Canada, France, Germany et al.) and 9 emerging markets (Brazil, Chile, Greece, Hungary et al.)	
20 emerging Stock markets	Han-Kim and Singal (2000)
46 stock markets	Griffin, J. et al. (2004)
8-Stock Markets (Belgium, Canada, France, Germany, Ireland, Japan, U.K. and the U.S.)	Bredin and Hyde (2005)

Although most surveyed articles analyze indices and stocks from developed countries, emerging equity stock markets have also been studied, such as the African markets (i.e the Nigerian Stock Exchange, the Johannesburg Stock Exchange, stock returns in Egypt, and the Nairobi Stock Exchange in Kenya), Latin American Markets (Bogotá Stock Market in Colombia, Brazil, Argentina, Chile Stock Markets), Asian Markets (Korea stock market (KOSPI), Chinese markets (Shanghai and Shenzhen Stock Exchange), the India Stock Excange (Mumbai) and the European Stock Markets (the Athens Stock Exchange in Greece, the Istanbul Stock Exchange in Turkey, the Portugal Stock Exchange, and the Bulgarian Stock Market).

Popular stock markets are usually characterized by small variances and small increase / decrease levels; thus, predictability seems to be more accurate than in emerging markets. However, emphasis has been given to emerging stock market prediction as has been depicted in studies by Han-Kim and Singal (2000), Füss and Herrmann (2005), Bilson et al. (2002), Bacmann and Dubois (2002), Guermat et al. (2003) and Assaf (2006).

Most of the surveyed papers have focused on exploring the behavior of stock returns with the majority of authors studying a single stock market as in Kiricos and Terzakis (1999), Marcucci (2003), Pereira (2004), Danilov and Magnus (2004), Duker (1997), Berg (2003), Oomen (2001), Lee (2000), Park and Lee (2003), Stentoft (2005), Peters (2001), Eisler and Kertesz (2004). Only very few authors have simultaneously studies two markets.

Several studies have tested the robustness of conventional techniques using multiple stock indices or markets, as in Balaban et al. (2006), Fornari and Mele (1997), Balvers et al. (1990), Guo (2003), Assaf (2006), Yu and So (2003), Bacmann and Dubois (2002), Bilson (2001) and Griffin et al. (2004).

Most surveyed papers have based their predictions on stock market indices. This is because stock indexes represent performance of all stocks listed in a particular market. The choice of indexes is subjective, but it is obvious that the most important criterion is the index power that expresses the rate of the stock market. Few studies, like those conducted by Miyahara and Novikov (2002), Skaradzinski (2003), Dufrenot, et al. (2005), Sibbertsen (2004), Zontos et al. (2000) have focused on individual major stocks from industrial companies (BWM, VODAFONE etc.) or mutual funds; they are the exception to the rule.

Authors have focused their efforts on predicting a stock market at particular points in time offering conclusions regarding related risks. A common subject of research relates to how much financiers can rely on market robustness and invest in the markets with high likelihood of success. All cases can contribute towards of important information about forecasting models, stock markets, and accurate forecasting of stock returns.Table 1 provides the list of studied stock markets.

3. INPUT VARIABLES

Input variables used for forecasting stock returns differ. Modeling (conditional) variances has been one of the most important topics in financial time series. Input variables may be classified as fundamental (financial) variables and technical analysis variables. The first type includes economic data, while the second type is derived from model requirements. According to Cremers (2002), and after studying the surveyed papers, the most widely used and important input variables are:

- Lagged returns (including stock or index returns, value of stocks or indices)
- Dividend yield
- Earnings yield
- Interest rate
- Volume of shares traded over price level
- Credit spread between yields of investment grade and below investment grade bonds
- Yield on a short-term T-Bill
- Change in yield on a short-term T-Bill
- Term spread between yields on long-term government bonds and short-term T-Bill
- Yield spread between yield on an overnight fixed income security and short-term T-Bill
- Growth rate of industrial production
- Cash flow
- Inflation
- Change in inflation or measure of unexpected inflation
- Unemployment rate

Most papers include one or two additional variables in their analysis, such as growth in personal consumption expenditures, oil prices and a book-to-market ratio.

Many authors have used only time series from stock or index prices and returns, and fit their forecasting models without taking into account dividend yield, interest, growth rates, inflation and other variables as in Lux et al. (2004), Charles and Darne (2006), Skaradzinski (2003), Jamaleh (2001), Lovatt (2000), Peters (2001), Beran et al. (2001), Friedman and Shachmurove (1997), Yu Jun (2002), Ogum et al (2002), Nwokoma (2005), Pandey (2003), Daouk and Guo(2003), Eisler and Kertesz (2004).

Most studies like those carried out by Yao et al. (2005), Virtanen and Yli-Olli (1987), Park and Lee (2003), Ogden (2003), Ghysels et al. (2005), Füss and Herrmann (2005), Bilson et al.(2005), Manzan (2005), Bredin and Hyde (2005), McMillan (2003), Jorion and Goetzmann (1999), Handa and Tiwarin (2000), Balvers et al. (2000) and Ibbotson and Chen (2003), have included additional variables.

There are different points of view when selecting (subjectively) appropriate variables for forecasting the behavior of stock returns. This is a reason why most studies have used ad hoc input variables without explanations. Studying performance based on empirically obtained results may be beneficial when choosing certain input variables.

For example, Virtanen and Yli-Olli (1987) measured the performance of a composite / simple ARIMA model using several economic variables, and found that the composite model returned better results.

There is no standard proof or conclusion about which variables are the most appropriate ones. Shaikh (1998) concluded that conventional theoretical models, which typically assume constant required rates of return and constant dividend growth rates, are largely unable to explain movements in stock prices.

Moreover, since the incremental rate of profit (net of interest) is essentially the change in earnings normalized by investment, stock price movements are driven by interest rates and changes in earnings. Yao et al. (2005), after exploring a set of unanticipated components of the economic and financial variables, found that only the derived term-structure variable, interest rate variable and aggregate dividend-yield variable seem to be significant in explaining returns.

Factors like money growth and inflation, found to be significant in previous studies, offer no additional benefit. Yao et al. (2005) also observed that prior information, endorsed in a Bayesian updating process, increased model predictability.

The comparison of results between the multivariate and the univariate method strongly suggested that the correlation structure among industry returns is an important issue to be considered, when examining industrial portfolio returns. Eisler and Kertesz (2004) attempted to fit model parameters to actual data. They introduced a model (extension of the Lux model) to give up-down asymmetry and they also adopted an approach to account for leverage autocorrelations.

A fundamental issue that needs discussion is data preprocessing. Many authors transform actual data in order to obtain better forecasting results. Several different methods have been used to transform prices into returns. There are discussed in detail in the following section. Selecting input variables jointly with selecting the appropriate type of model is a common problem when forecasting stock returns.

4. MODELING TECHNIQUES

The discussion regarding the aspects of modeling techniques includes data preprocessing, frequency-size of data and model type. Details are presented in Table 3.

Data Preprocessing

Data preprocessing includes cleaning and transforming actual data. Data preprocessing has been employed in 105 out of the 150 surveyed papers. From the remaining 45 papers, 23 have used actual data without preprocessing, while 22 have not made any comment. The most widely used technique in data preprocessing is natural logarithmic transformations of stock prices, employed mainly because of two reasons: i) the empirical fact that there have been considerable changes in the value of the index or stock as in most economic time series, which tend to invalidate the assumption of a constant relationship between original values of variables; ii) when using logarithms, the efficiency of estimates is increased because

heteroscedasticity in regression analysis is reduced. In case of time series analysis, stationarity in variance can be achieved, respectively.

A few researchers such as Oomen (2001), Bluhm and Yu (2001), McMillan, (2003), Dufrenot et al. (2005), Cavalcante and Assaf (2004) and Sibbertsen (2004) have also used exponential, absolute value and square transformations.

Table 2. Choices of input variables

Article	Input Variables
Aktas, R. et al. (2003)	Size of the firm, total proceeds of the IPOs, percentage of total shares offered, cumulative abnormal returns, trend in the market, etc.
Andersen, T. et al. (2002)	Stock returns, *N*-dimensional vector of loadings on the common volatility factor, *N*-dimensional standard Brownian motion with mutually independent elements, *N* individual asset-specific volatilities.
Arango, L.-E. et al. (2002)	Interest rate, stock retutns.
Areal and Taylor (2000)	Returns from FTSE-100.
Assaf, A. (2006)	Returns of stock market indices (Egyptian Stock Exchange index (CCSI), Jordan, Morocco, and Turkey (ISE National 100)).
Avramov, D. (2000)	Market, size, and value premiums, values of size and book-to-market, market capitalization, differences between returns on long-term and short-term government bonds and between low-graded and high graded corporate bonds, dividend yield, term spread, default-risk spread, Treasury bill rate, return on the equal-weighted NYSE index in excess of the return Treasury bill.
Aydogan and Gursoy (2000)	Average market P/E, price-to-book (PBV) ratios, values of the national market indices and exchange rates.
Bacmann and Dubois (2002)	Stock market returns.
Bajari and Krainer (2004)	Recommendations about the futur profitability of a firm, Analyst's private belief about the stock, conflict of interest among research analysts, influence of peers on the recomentation decision etc.
Balaban, E. et al. (2006)	Indices returns
Bali and Lu (2004)	SandP 100, index returns, conditional mean and the conditional standard deviation of returns.
Balvers, R. et al. (1990)	Industrila production, return of shares, output growth, consumptions, dividends of cash flow, returns, capital stocks, prices etc.
Barkoulas, J. et al. (2000)	ASE30 returns (prices of a value-weighted index).
Batra, A. (2004)	Value of the stock price index, returns (BSE sensex and the International Finance Corporation (and SandP) published IFC

	Global (IFCG) index).
Beltratti and Morana (2006)	Interest rates, stock market returns, money growth, the Federal funds rate and industrial production, SandP500 returns.
Beran and Ocker (2001)	19 stock market closing indices and nine emerging market indices.
Beran J. et al. (2003)	Copper prices, cocoa beans, exchange rate.
Berg, L. (2003)	The turnover for the SSE, Dow Jones industrial average, Swedish Exchange rate (SEK/$) and the 6-month Stibor interest rate.

Table 2. (Continued)

Article	Input Variables
Bhardwaj and Swanson (2006)	Stock market data (returns).
Bilson, C. et al. (2002)	Returns change in exchange rate, change in dividend yield, variance in market returns, and change in the political risk index.
Black et al.(2003)	Profits, labour, capital, employment, exponent of employment in the production function, value of the firm (possibly time-varying) rate of return required by shareholders, stock-price index, market capitalization, returns.
Blair, B et al. (2001)	Index returns, implied volatilities, index level, risk free rate, dividends, contractual provisions of the option,
Bley and Olson (2005)	Values of stock indices, compounded returns.
Bluhm and Yu (2001)	Returns
Bond and Cummins (2004)	Capital cost, investment expenditures, sales profits, cash flow, Gross investment, net capital stock, measure of uncertainty, growth rate of real sales, error term.
Bradshaw et al. (2005)	Ratio of target price, analyst firm-specific experience, top decile of the analyst's brokerage, the log of market value 3 days before.
Bredin and Hyde (2005)	Stock returns on the market index, world market returns, dividend yield, changes in the short-term interest rate, changes in the term structure, industrial production growth, difference between the short-term (3 month) interest rate and long term (10 year) interest rates, inflation, changes in oil prices
Brzeszczynski and Welfe (2004)	Indices returns, volume of trade
Bulkley and Richard (1999)	Prices, dividends, ratio of current market, price measure risk, dividend yield
Cavalcante and Assaf (2004)	Returns (index of the São Paulo Stock Exchange (BOVESPA)), voliatility.
Cecconi, M. et al. (2002)	Voliatility of prices of indices
Charles-Darne (2006)	Stock markets indices.
Chen et al. (2000)	Standart deviation of returns, turnover of the market portofolio, past returns.

Chiarella, C. et al. (2005)	SandP 500, interest rate, PE ratio.
Chopin and Zhong (2001)	Stock returns, inflation, real activity, interest rates, and the money base.
Chou, R. et al. (2005)	Returns of SandP500, Nasdaq and 10-year treasury bond rates,
Christoffersen, P. et al. (2005)	SandR500 options returns, underlying asset prices, risk free rates, prices of risk, daily variance, shocks.
Ciccone S. (2003)	Book-to-market ratio, stock returns, forecast property variables, loss dummy variables, and optimism dummy variables.
Article	Input Variables
Claessen-Mittnik (2002)	DAX index returns
Cornelis A. Los, PH.D. (2000)	Stock markets prices changes.
Corrado et al. (2004)	Index returns, conditional volatility, implied volatility, intraday high-low range volatility.
Cremers, M. (2002)	SandP 500 index excess return, SandP 500 index dividend yield and the SandP 500 earnings yield, NYSE volume divided by the NYSE price level, difference between yields the yield on a 3-month maturity Treasury Bill, rate of change of inflation, rate of change in industrial production etc.
Danilov and Magnus (2004)	Dividend yield on SP 500 portfolio, annual changes, price-earnings ratio, annual inflation rate, change in 3-month T-bill rate etc.
Daouk and Guo (2003)	SandP 100 index (SP100) returns
Darrat and Zhong (2001)	Closing index prices of the Shanghai Exchange (SHG) and of the Shenzhen (SHZ) Exchange
Degiannakis and Xekalaki (2001)	Stock index returns, rate of return from trading straddles.
DeStefano, M. (2004)	Expected earnings, level of interest rates, direction of interest rate, SandP 500-stock index, three-month T-bill rate (TB), and IP as measures of stock prices, interest rate and earnings.
Drobetz and Wegmann (2000)	Stock market returns, values of variance ratios for historical stock market data, consumption, x-dividend price of the risky asset, asset's payoff, the coefficient of relative risk aversion, time preference parameter, etc.
Dueker, M. (1997)	Stock index returns.
Dufrenot, G. et al. (2005)	Stock returns, indices returns
Eisler and Kertesz (2004)	Returns of indices
Engle and Gallo (2006)	Absolutle returns, daily range, intra-daily realized volatility, of SandP500
Faugere and Shawky (2002)	Per-unit-of-labor consumption, real investment, capital stock and output, rate of capacity utilization, labor to evolve exogenously over time, total stock returns, and dividend yield.
Felix, J. et al. (2004)	Level of the composite stock index.
Fillol, J. (2003)	Values of the CAC40 index

Fornari and Mele (1997)	Stock market indices
Franses and Leij (2003)	Stock indices returns
Friedman and Shachmurove (1997)	Values of indices
Füss and Herrmann (2005)	Total return indices, dividend yields and capital gains.
Garrett, I. et al. (2004)	Stock price returns and dividend payments.
Gemmill and Saflekos (1998)	Spot price of the underlying asset, prices for each maturity, interest rate

Table 2. (Continued)

Article	Input Variables
Ghysels, E. et al. (2005)	Variance of returns, squared returns, weight given to the squared returns, three-month Treasury bill.
Giot and Laurent (2004)	Stock indexes returns
Granger and Hyung (1999)	Stock returns.
Griffin, J. et al. (2004)	Market returns, total traded value and total market capitalization.
Guedj, O. et al. (2006)	Price of shares, earnings, forecasts made by experts
Guermat, C. et al. (2003)	Stock market price indices (Egypt (EFG), Morocco (SE CFG 25), Jordan (AMMAN SE) and the SandP-500 (COMPOSITE)), compounded returns.
Guidolin and Timmermann (2006)	Stock returns, 10-year T-bonds, 30-day T-bill rate, dividend yields.
Guo, H. (2003)	Consumption, labor income, index return, T-bill yields and money market rates.
Hamilton J. and Lin G. (1996)	Stock price, stock return etc
Handa, P. and Tiwari, A (2000)	Degree of relative risk aversion, three-month T-Bill and the CRSP value-weighted index, lagged portfolio returns, dividend yield and the book-to-market ratio, equity allocation, risk-free rate of return, return on the risky stock portfolio, evolution of stock returns, vector of expected excess returns on the risky assets etc..
Han-Kim and Singal (2000)	Stock returns, excess dollar returns, inflation and standard deviations
Hardle, W. et al. (2001)	Index values, average index,
Hayo and Kutan (2005)	Stock returns for six countries and IMF news dummies.
Hol, E. et al. (2002)	Indexes returns
Huang et al. (2004)	S and P 500 Index, exchange rate of USA dollar against Japanese Yen (JPY)
Hueng and McDonald (2005)	Stock prices returns, trading volumes, shares outstanding, conditional variances of errors term based on informations available, T-bill rates
Hyung, N. (2005)	Returns of SandP 500.
Ibbotson and Chen (2003)	Returns of stock market, income return of long-term bonds, capital gain, income return, earnings per share etc.

Jamaleh, A. (2001)	Return of Italian stock index (MIB30)
Jansen and Wang (2006)	Forward earnings on the SandP 500, SandP 500 price index and 10-years U.S. Treasury bond yield
Jawadi and Koubaa (2004)	Stock returns
Jegadeesh, N. (1990)	Returns on stocks, interest rate on T-bills, return on the market portfolio.

Article	Input Variables
Jorion and Goetzmann (1999)	Local currency, real price index and dollar.
Jorion, P. (2003)	Value of stock price index, capital returns, returns on stocks
Jungbacker and Koopman (2005)	Stock prices.
Karmakar, M. (2004)	Daily price returns.
Kavussanos and Visvikis (2005)	FTSE/ASE-20 and the FTSE/ASE Mid-40 market indices.
Kearney and Potì (2004)	Stock returns and semi-annual capitalization
Killion and Muravytska (2005)	Stock returns, T-Bill rate of return, Payout Ratio, dividend yield, free cash flow, P/E ratio, PEG ratio and yield curve
Kirikos and Terzakis (1999)	Stock price index change, exchange rate, high and low growth state.
Koustas and Serletis (2004)	Dividend yield, stock returns, Dividend-Price Ratio
Krolzig and Toro (2004)	Earning, dividends, stock prices, risk-free interest, cash flows
Lee, J. et al. (2000)	Indices and stocks returns
Lee, S-J. et al. (2005)	Korea Composite Stock Price Index (KOSPI) and KOSDAQ Index
Liew, K-S. et al. (2003)	Stock prices
Lillo and Farmer (2004)	Market orders, limit orders cancellations
Lin and Wang (2005)	Stock prices
Liu and Lee (1997)	Prices, (Up, down, close), average prices, money flow, money ratio etc
Lovatt and Parikh (2000)	Total real return on the value-weighted NYSE portfolio, ratio of the dividend, term and default spread, shocks to the default spread, real growth rate of industrial production, inverted yield curve, expected annual growth, expected annual rate of consumer price inflation.
Lovatt, D. (2000)	Stock Returns
Lux et al.(2004)	Stock prices, volume
Manzan, S. (2005)	Prices, rates.(Price, fundamental value, Price-to-Dividends ratio of SandP5000 index)
Marcucci, J. (2003)	Closing prices, average return etc.
Maris, K et al. (2004)	Values of FTSE/ASE 20 index

Mattes, J. (2004)	Earnings yield, bond yield measure, implied volatilities of index options, returns of indices.
McKibben (1971)	Earnings, dividends, prices, rate of return.
McMillan, D. (2003)	The dividend yield, the 3-month Treasury bill, the 10-year Treasury bond, unemployment, industrial production, private consumption, consumer price index, money supply, stock market returns.
Miyahara and Novikov (2002)	Stock prices

Table 2. (Continued)

Article	Input Variables
Mobarek and Keasey (2000)	Market return, price index, divided per share of individual security.
Naes, R. (2004)	Intra-day change in the transaction price, transaction price, flow, etc.
Niglio, M. (2002)	Stock market index (DAX 30)
Nwokoma, N. (2005)	Market indices.
Ogden, J. (2003)	Growth rates in U.S. real GDB and several of its components, changes in both unadjusted and adjusted industrial production, changes in the adjusted unemployment rate, inflation, returns on long term T-bonds, values of the corporate bond credit spread, yield on T-bill and T-bond, Market excess return, etc.
Ogum et al. (2002)	Index prices
Oomen, R. (2001)	Intra day prices of securities, daily returns,
Oomen, R. (2002)	Stock returns, volume, and short rate.
Pandey, A.(2003)	Index return
Park and Lee (2003)	Sales, earnings, earnings per share (EPS), book value of equity per share, cash flow, stock prices.
Patev and Kanaryan (2004)	Index values and index returns
Pereira, R (2004)	Within-week standard deviation, returns etc.
Perez-Cruz, F.et al.(2003)	Prices, returns (indices, stocks)
Peters, J-P (2001)	Indices returns
Raaij, G. and Raunig, B. (2002).	Level of indices
Rookley C. (1998)	Strike price, time to expiration, index price, expected dividend payments, risk free rate and option prices, t-bill rates
Sanso, A. et al. (2003)	Values for the stock indexes
Sarno, L. et al. (2005)	SandP 500, the NIKKEI 225 and the FTSE 100 indices and future contracts
Shaikh, A. (1998)	Stock price, dividends, interest, and company's earnings.
Sharpe, S. (2002)	Dividends per share, prices of stocks, investor expectations, returns, earnings per share etc.
Sibbertsen, P. (2004)	Stock returns (: BASF, BMW, Daimler, DAX, Deutsche Bank, Dresdner Bank and Hoechst beginning)
Skaradzinski, D. (2003)	Stock Prices.

Spann and Skiera (2003)	Expected values, cash dividend of stocks, price of shares of stocks etc.
Stentoft, L. (2005)	Returns, risk neutralized value of the underlying stock at expiration of the option for path number, risk-free rate of return, return on the asset, cash flow, the strike price, price of the underlying asset.
Tauchen, G. (2001)	Stock prices

Article	Input Variables
Taylor, J. (2003)	Stock market indices
Taylor, S. (2001)	Returns for the S and P 100 index, asset price, risk-free annual interest rate, annual dividend yield, trading periods per annum, contractual parameters – time, risk premium for investment in the asset during the life of the option, conditional expected returns, eight parameters that define the one-period conditional variances etc.
Tolvi, J. (2002)	Stock returns, indices returns.
Tse, Y.K. (1991)	Stock returns computed from prices of the Topix and the Nikkei Stock Average (NSA)
Turiel A. et al. (2005)	Stock indices
Virtanen and Yli-Olli (1987)	Price level, price changes, total returns where current dividend yield is added to the price changes, Lagged endogenous variable, he aggregated future cash-flow of the firms, interest rates of bank deposits or the return of state bonds, the supply of money, inflation.
Wallmeier, M. (2005)	Book-to-market ratio of equity, subperiods, market capitalization, stock return volatility, standard deviation of forecast, number of forecasts included in the consensus.
Watanabe and Yamaguchi (2005)	Prices for intra-day, daily, weekly and monthly volatility, stock returns etc.
Wolf, M. (2000)	Stock prices, dividends yield.
Wong et al. (2003)	Indices prices.
Worthington and Valadkhani (2004)	Stock index returns, accumukation returns.
Yao, J. et al. (2005)	Index of production, Reserve Bank of Australian Commodity-Price Index, the 90-day commercial bill rate, 3-month Treasury bill rate, M3, exchange rates against US$, change in current account balance, unemployment rate and dividend-yield on aggregate index.
Yu and So (2003)	Stock market indices returns
Yu, Jun (2002)	Value of stock market index
Zhang, D. et al. (2005)	Returns of stock market index
Zontos, et al. (2000)	Mutual prices

Data Frequency and Size

Data frequency and size depend mostly on research objectives and availability of the data set. Data frequency is grouped into yearly (Y), quarter-yearly (Q), monthly (M), weekly (W), daily (D) and intra-daily. Size depends on frequency and frequency depends on size of data. Long-term horizon corresponds to yearly, quarterly or monthly frequency data; short-term horizon corresponds to daily or intra-daily frequency data. Researchers do not dispose the exact number of frequency data, but they report the horizon from which they have extracted data. All available data about frequency, size and number of observations are presented in the third column of Table 3. Most authors have used daily data and thousands of observations with impressive magnitudes of data size or high frequency. Some of these studies include, Oomen (2001) who used 25 minute intra-daily observations (about 1.1 million), Areal and Taylor(2000) who used five-minute frequencies and 285,960 observations from a range of 13 year long data, Eisler and Kertesz (2004) who used 15 second frequencies and 1,829,545 observations, Balvers et al. (1990) who employed a variety of frequencies (monthly, quarterly, yearly, 3-yearly and 5-yearky), Bhardwaj and Swanson (2006) who utilized 20,105 daily observations and Ghysels et al. (2005) who applied daily observations from January 1928 to December 2000.

Conventional Models

Conventional models/techniques are reported in the fourth column of Table 3, the majority belonging to the GARCH family models, AR, ARIMA, ARMA, RW, linear and not linear regressive models, BandH strategy, and SV models. They represent the most popular techniques for forecasting stock returns. Extensions to the mentioned models include the ARFIMA model from Barkoulas et al. (2000), Oomen (2001),(2002), Watanabe and Yanaguchi (2005), Bhardwaj and Swanson (2006), Giot and Laurent (2004), the FIGARCH model from Cavalcante and Assaf(2004), Taylor (2001), Yu and So (2003), Cecconi et al.(2002) and the ARFIMA-FIGARCH model from Tolvi (2003). Other extensions / modifications include a smooth transition autoregressive (STAR) model used by Manzan (2005) and Liew et al. (2003), and a Shelf-Exciting Threshold Autoregressive (SETAR) model employed by Jamaleh (2001) and Dufrenot et al. (2005). Less popular techniques refer to vector autoregressive models used by Friedman and Shachmurove (1997), Black et al.(2001), Chopin and Zhong (2001), and the cross-sectional model used by Ciccone (2002), Jegadeesh (1990), Ogden et al.(2003). An additional technique used for forecasting stock returns is the moving average (MA) and its extensions. This approach has been followed by Yu Jun (2002), Bley and Olson (2005), Pereira (2005) and Zontos et al. (2000), as well as the Exponentially-weighted model (EWMA) used by Raaij and Raunig (2002), Patev and Kanaryan (2004) and Tse (1991).

5. BENCHMARK MODELS AND COMPARISONS

Most authors have compared their proposed model to other models in order to better evaluate them. Surveyed papers either propose techniques to forecast stock returns and compare them against other models, or they propose models to forecast a stock market without any comparison with other models. The focus of the first category is on model presentation that can forecast stock markets with success, whereas the focus of the second one is the forecasting of a specific stock market with one or multiple conventional techniques. All models are presented in Table 4.

Table 3. Summary of modeling techniques

Article	Data preprocessing	Frequency: size	Model
Aktas, R. et al. (2003)	Yes	D, W, 15D: 1992-2000 (cumulative abnormal returns)	Multiple regression model, multiple discriminant model, logit model
Andersen, T. et al. (2002)	Log	D: 1366 from January 2, 1993 until May 29, 1998, Five minute: 107,914	Simple multivariate model with an explicit factor structure
Arango, L.-E. et al. (2002)	Yes	D: 1482	ESTR-GARCH model
Areal and Taylor (2000)	No	Five-minute: 285,960 (2 January 1986 until 29 December 1998)	Method to measure daily volatility from intraday returns
Assaf, A. (2006)	Log	D: April 1, 1997 to April 26, 2002.	ARFIMA
Avramov, D. (2000)	N/P	M: 762	Asset pricing model
Aydogan and Gursoy (2000)	No	M: 1986-1999	Time series regression model
Bacmann and Dubois (2002)	Yes, ln	W: 698 M: 160 for Argentina, Malaysia, Mexico, Philippines, South Korea, Taiwan and Thailand, W: 620 M: 143 for Chile, W: 594 M: 137 for India, and W: 359 M: 83 for Brazil.	GARCH (1, 1) model
Bajari and Krainer (2004)	Yes, Exp, log	12,719 recommendations from analyst	An Empirical Model of Stock Analysts' Recommendations
Balaban, E. et al. (2006)	Yes, ln	12/1988-12/1997: W, M.	Eleven models
Bali and Lu (2004)	Yes, ln, $VIX/252^{1/2}$	D: 4029 and high-frequency intra-daily data	SGED-GARCH
Balvers, R. et al. (1990)	Yes, ln	M: 490, Q: 162, Y: 40, 3Y: 38, 5Y: 36	Standard neoclassic growth model with serial correlation

			in aggregate outputs
Barkoulas, J. et al. (2000)	No	W: 521	ARFIMA
Batra, A. (2004)	Log	M: 4/1979 – 3/2003 (sensex) M: 1/1988- 12/2001 (IFCG)	Asymmetric GARCH model (E-GARCH)
Beltratti and Morana (2006)	Log	D: 1/1970-9/2001	The common long memory factor model (Markov switching mean model)
Beran and Ocker (2001)	Yes	W: (1/1/1992 to 10/11/1995)	SEMIFAR model
Beran J. et al. (2003)	N/P	D: (January 2, 1992 to November 10, 1995)	SEMIFAR model

Table 3. (Continued)

Article	Data preprocessing	Frequency: size	Model
Berg, L. (2003)	Yes log	D: 3398	Mixture distribution model, (T-GARCH, MA)
Bhardwaj and Swanson(2006)	Ln, exp et al.	D: 20,105	ARFIMA
Bilson, C. et al. (2002)	Yes (N/A)	M: 1/1984-12/1997	International Market Model (IMM) (Regression model)
Black et al.(2003)	Yes (ln, exp et al.)	Q: 3/1947-12/2000	VAR model
Blair, B et al. (2001)	Ln	D: 1,519 (in sample period from 2 January 1987 to 31 December 1992) D: 1,768 (out-of-sample period from 4 January 1993 to 31 December 1999) Five-minute: N/A	7 ARCH models
Bley and Olson (2005)	Ln	D: 3,643 (VXO and SandP 100 index) D: 3,643 (VIX and SandP 500 index) D: 843 (VXN and NASDAQ 100 index) For W volatility forecasts	Historical standard deviation models, conditional volatility models, and volatility index models (RW, Historical mean method, MA (4 models), Exponential Smoothing, OLS Regression, GARCH(1,1), EGARCH, TARCH, Single-Factor Volatility Index, Multi-Factor Volatility Index, Component ARCH)
Bluhm and Yu (2001)	Yes, squared returns, log	D: 2,876	Historical mean model, EWMA, GARCH, GJR-GARCH, EGARCH, GARCH-M and the SV model.
Bond and Cummins (2004)	N/P	3-M (Q): 1975-2003	An empirical model

Bradshaw et al. (2005)	Natural log	6-M: 12	Descreptive statisitcs
Bredin and Hyde (2005)	Exp	M: 2/1980-12/2001	Smooth transition regression (STR) model
Brzeszczynski and Welfe (2004)	Yes	D: 760	Factor and predictive GARCH models
Bulkley and Richard (1999)	No	Y: 23	Econometric model (regression model)
Cavalcante and Assaf (2004)	Log, squares, absolute prices.	D: 2,063	FIGARCH model with modified rescaled range R/S statistic and the rescaled variance V/S statistic
Article	Data preprocessing	Frequency: size	Model
Cecconi, M. et al. (2002)	No	D: 4,254 (1/101985-18/1/2002)	GARCH TGARCH ANST–GARCH FIGARCH, VXN.
Charles-Darne (2006)	No	D: (3/1/2000-17/5/2002)	CARCH models for outliers corrected data
Chen et al. (2000)	Yes, log	6-M: 66 M: 371	Cross-sectional regression speciffications
Chiarella, C. et al. (2005)	Yes, log	M: 272	Econometric model (spurious regression model)
Chopin and Zhong (2001)	N/A	M: 1/1968-11/1996	A vector autoregressive (VAR) representation in a generalized Vector-Error-Correction Model (VECM)
Chou, R. et al. (2005)	Log	W: 835 (1/4/1988-1/2/2004)	Conditional Autoregressive Range (CARR) model with Range-Based Dynamic Conditional Correlation Model (DCC)
Christoffersen, P. et al. (2005)	Ln	D: 1/1/1963-31/12/1995 (1990-1995 empirical results) used Wednesday options data.	Model investigated through an integrated analysis of returns and options dat (Component model as a natural extension of a rearranged version of the GARCH(1,1) model)
Ciccone S. (2003)	Yes	M: 240	Cross-sectional regression model with added forecast property variables, loss dummy variables, and optimism dummy variables
Claessen-Mittnik (2002)	Yes	D: 982	GARCH
Cornelis A. Los, PH.D. (2000)	No	W: 74-690 (1986-1996)	RW
Corrado et al. (2004)	Natural log	D: 3,544 (SandP 100, SandP 500 indices) D: 2266 (Nasdaq 100 index)	GJR-GARCH

Cremers, M. (2002)	N/P	M: 540	Bayesian model selection perspective
Danilov and Magnus (2004)	Yes, log	Y: (1954-2001)	Econometrics (pretesting on forecasts)
Daouk and Guo (2003)	N/P	D: 3/1/1980-26/3/1999.	Switching regime EGARCH model
Darrat and Zhong (2001)	N/A	W: 402 (for the Shanghai stock index) W: 383 (for the Shenzhen stock index.)	Random-walk (NAÏVE) model

Table 3. (Continued)

Article	Data preprocessing	Frequency: size	Model
Degiannakis and Xekalaki (2001)	N/P	D: 456	Prediction Error Criterion for Model Selection (PEC).
DeStefano, M. (2004)	Log	M: 628 (1948-2001)	Dividend discount model (DDM)
Drobetz and Wegmann (2000)	Ln	Q: 1973-1998	Two-stage regime switching model
Dueker, M. (1997)	Yes, ln.	D: 6/1/1082-31/12/1991 (SandP) D: 1986-1992 (VIX)	GARCH/Markov switching volatility model
Dufrenot, G. et al. (2005)	Log, x^2, x^4	D: 1997-2003.	2-regime SETAR model with a long-memory process in the first regime and a short-memory process in the second regime
Eisler and Kertesz (2004)	Log	15sec: 1,829,545 (1/1999-12/2001) (for DAX) 1min: 266,966 (1/2000-9/2002) (for NYSE200)	Lux model
Engle and Gallo (2006)	Absolute price	IntraD and D: 4/1/1988 – 30/12/1997	Multiplicative Error Model
Faugere and Shawky (2002)	Yes, ln	Q: 128	Stochastic growth model
Felix, J. et al. (2004)	Log	D: 9,312	Nearest neighbour (NN) predictors
Fillol, J. (2003)	No	D: 4,000 (1990/03/01 to 2003/05/20)	MMAR
Fornari and Mele (1997)	N/P	D: 1,494	Volatility-switching ARCH model
Franses and Leij (2003)	Yes, absolute returns	D: 2,000	GARCH-IE (IE: innovation effects) model
Friedman and Shachmurove (1997)	Yes, natural logarithm	D: 1/1/1988 to 12/31/1994.	VAR model

Füss and Herr-mann (2005)	Ln	D: 216 to 218	Power-in-Mean-GARCH model
Garrett, I. et al. (2004)	No	M: 1/1988-12/1999	VECM and (E and L) STR model
Gemmill and Saflekos (1998)	Yes, log	D: from January 1st 1987 to December 31st 1997 (one day per month)	Two-lognormal mixture distribution method (the method does help to reveal market sentiment during elections)
Ghysels, E. et al. (2005)	Yes, squared return, exp	D: January 1928 to December 2000 (W, M, 2M, Q, returns produced from daily data)	Mixed data sampling (or MIDAS) approach. Forecasts the monthly variance with a weighted average of lagged daily squared returns
Article	Data preprocessing	Frequency: size	Model
Giot and Laurent (2004)	Ln, exp	D: 1,249 (CAC40) D: 3,241 (SandP500)	ARFIMAX(0,*d*,1)-skewed Student model, Skewed Student APARCH model
Granger and Hyung (1999)	N/A	D: 17,054	Linear model with occasional breaks in mean
Griffin, J. et al. (2004)	Log	W: 150+	VAR model with turnover returns and GARCH volatility
Guedj, O. et al. (2006)	No	N/A	Bias, herding and gossamer information
Guermat, C. et al. (2003)	Natural logarithm	D: 1,566 (For six years period)	GARCH(1,1)
Guidolin and Timmermann (2006)	Ln	M: 552	A complicated four state Markov-Switcing model with regimes characterized as crash, slow growth, bull and recovery states (Econometric)
Guo, H. (2003)	Yes	Q: (1952-2002)	Capital asset pricing model (CAPM)
Hamilton J. and Lin G. (1996)	Yes, log	M: 339	Markov-switching and variants
Handa, P. and Tiwari, A (2000)	N/P	M, Q: January 1954 to December 1998	Regressin non- Bayesian model
Han-Kim and Singal (2000)	Yes	M: 249 (in 9 countries), 141 (in 7 countries), 81, 117, 128, 81, 213 in total 20 countries	ARCH and GARCH
Hardle, W. et al. (2001)	Exp, ln	D: 5,479	Ergodic diffusion and a deterministic growth process.
Hayo and Kutan (2005)	Log	D: 3,497 (1 July 1997 to 31 December 1999)	GARCH with IMF news
Huang et al. (2004)	N/P	W: 676	Support Vector Machine (SVM) compined model
Hueng and Mc-Donald (2005)	N/P	D: (July 1962 to December	Autoregressive conditional density (ARCD) model

		2000.)	
Hyung, N. (2005)	N/P	D: 5,550	Break-GARCH, volatility components model, Regime-switching GARCH, and FIGARCH
Ibbotson and Chen (2003)	No	Y: 75	Six Methods for decomposing historical equity returns (a. Building
			Blocks Method, b. Capital Gain and Income Method, c. Earnings Model, d. Dividends Model, e. Return on Book Equity Model, f. GDP Per Capita Model)

Table 3. (Continued)

Article	Data preprocessing	Frequency: size	Model
Jamaleh, A. (2001)	Ln	D: (4/1/1994-30/12/1997)	SETAR model
Jansen and Wang (2006)	Natural log	M: 170	Fed model (VECM)
Jawadi and Koubaa (2004)	Log	N/A	STECM model
Jegadeesh, N. (1990)	No	M: 1934-1987	Cross-sectional regression model
Jorion and Goetzmann (1999)	No	M: N/P (1/21-12/96)	Methodology, which calculate returns using the local currency, the price index, and the dollar
Jorion, P. (2003)	Ln	M: 432-912 (obs.)	Methodology that applies variance ratio tests to long term returns
Jungbacker and Koopman (2005)	Yes, log	Sec: 23,400 (one day) D: 61	Model-based framework using high-frequency data (model that takes account of micro-structure noise together with intra-daily volatility patterns and stochastic volatility)
Karmakar, M. (2004)	Log	D: 3,076 (prices) M: 156 (volatility for forecasting))	GARCH
Kavussanos and Visvikis (2005)	Natural log	D: (8/1999-6/2004)	VAR, VECM, SURE-VECM, ARIMA
Kearney and Potì (2004)	Yes	W: (12/1974-3/2004) Computed toY/2: 61 (obs.)	Time-series model similar to Campbell, Lettau, Malkiel and Xu (2001)
Killion and Muravytska (2005)	Log	N/P: 1995-2004	"APT-style" model
Kirikos and Terzakis (1999)	No	M: 109	Markov process
Koustas and Serletis (2004)	Log	M, Y: 1,560, 130 (1871-2000).	ARFIMA

Krolzig and Toro (2004)	Ln	N/A: 1926-1985	Stochastic present value model (three -regime Markov-switching vector autoregression model)
Lee, J. et al. (2000)	Log	D: 2,824(KOSPI200) D: 5,751 (KOSPI) W: 1,021	FIGARCH
Lee, S-J. et al. (2005)	No	D: 1,205 (1/1/1997-31/12/2001)	Diffusion model (Lotka–Volterra model)
Liew, K-S. et al. (2003)	No	D: 3,087	AR-GARCH, STAR- GARCH,
Lillo and Farmer (2004)	N/P	N/A: 1999-2002 (market orders, limit orders cancellations)	Long memory proccess (Econometric)
Article	Data preprocessing	Frequency: size	Model
Lin and Wang (2005)	Log multiplied by 100	D: 9/11/1979-5/4/2005.	EGARCH (1, 1) and GJR GARCH (1, 1)
Liu and Lee (1997)	Yes	D: 250	Intelligent system to assist small investors to determine stock trend signals for investment in stock business (RSI, MFI and MA)
Lovatt and Parikh (2000)	N/P	M, Q, Y: 2/1980-12/1994	Phillips-Loretan error-correction model
Lovatt, D. (2000)	Yes	M: (1980-1996)	P-L model (error-correction model proposed by Phillips and Loretan (1991))
Lux et al.(2004)	N/P	D:7,000 (1975-2001)	ARMA, GARCH
Manzan, S. (2005)	Yes, log	Y: (1871-2003)	STAR model
Marcucci, J. (2003)	Yes	D: 2,882	MRS-GARCH
Maris, K et al. (2004)	No	W: 141 (27/8/1999-28/6/2002)	Random walk model, mean model, exponential smoothing model and four models from the ARCH family (ARCH, GARCH, EGARCH, TARCH)
Mattes, J. (2004)	Yes, log	D: 3,000 (1972-2001) M: 359	Regression models
McKibben (1971)	Yes	D: 3,360	Econometric model
McMillan, D. (2003)	exp	Q: 1975Q1-2001Q4	Exponential smooth transition threshold model,
Miyahara and Novikov (2002)	Yes	N/P	Geometric Levy Process Pricing Model (models for stock prices which relates to random processes with independent homogeneous increments)
Mobarek and Keasey (2000)	Yes, ln	D: 2,638	ARIMA (2,0,1)
Naes, R. (2004)	Yes	Every order and trade (597 trading days): 2/1999-5/2001	Panel regression approach (GH-method and GKN-method)

Niglio, M. (2002)	Ln	D: 1,304	Logistic Double Smooth Transition (LDST) model
Nwokoma, N. (2005)	No	Q: 44	Time-series regression model
Ogden, J. (2003)	Yes	M: 1947-2000	Statistics, Asset pricing model by Gibbons and Ferson (1985) (with a cross-sectional regression)
Ogum et al. (2002)	Ln	D: 2,340	EGARCH
Oomen, R. (2001)	Yes, log, squared intra-daily returns	25 mimute Intra-daily: (1.1 milion)	ARFIMA
Oomen, R. (2002)	N/P	(2 May 1990 - 11 January 2000; 2,445 observations)	ARFIMA

Table 3. (Continued)

Article	Data preprocessing	Frequency: size	Model
Pandey, A.(2003)	Ln	D: 736 (1,747 all sample) 5-D: 146 M: 35	GARCH, Empirical performance of various unconditional volatility Estimators
Park and Lee (2003)	Yes	M: 1/1990-12/1999 (from daily prices)	Stock price multiples (industry medians of price earnings ratio (PER), price book value ratio (PBR),
			price sales ratio (PSR), and price cash flow ratio (PCR) to calculate the forecasted stock price)
Patev and Kanaryan (2004)	Yes	D: (24/10/2000 – 19/11/2004)	EWMA with t distributed innovations and EWMA with GED distributed innovations.
Pereira, R (2004)	Yes	W: (1998-2004)	GARCH, MA, RW etc
Perez-Cruz, F.et al. (2003)	Ln	D: 1,480 FTSE100 D: 2,009 IBEX35 D: 1,070 NIKKEI D: 1,220 SandP500, GM, HP.	GARCH model using SVR
Peters, J-P (2001)	Yes, ln	D: 3,935	GARCH, EGARCH, GJR and APARCH models
Raaij, G. and Raunig, B. (2002).	Yes, ln	D: 2,609	(1-4) GARCH-t models, (5) equally weighted moving average (MA) of squared returns, (6) exponentially weighted moving average (EWMA) of squared returns
Rookley C. (1998)	No	D: (1/1989-10/1993)	Put-Call Parity Bias
Sanso, A. et al. (2003)	No	W: 5/1985-4/1995	IGARCH, ARCH (Iterated Cumulative Sum of Squares (ICSS) with k2 test)
Sarno, L. et al. (2005)	Yes, log	W: 734	Vector Equilibrium Correction Model

Shaikh, A. (1998)	Yes	N/P	Theoretical approach
Sharpe, S. (2002)	Yes, log	M and Y: from1979-1998	Extension of a log-linear dividend-price ratio model
Sibbertsen, P. (2004)	Absolute price	D: 9,590 4/1/1960-30/4/1998,	GPH-estimator and tapered GPH-estimator, (TGPH), sample variance and Wavelet Estimation
Skaradzinski, D. (2003)	Yes, log	D: 1,243	AR model with several statistics.
Spann and Skiera (2003)	Yes	D: 152	Internet-based virtual stock markets (VSMs approach)
Stentoft, L. (2005)	100Xln (S1/S2)	N/P: 1989 to 1995	GJR-GARCH, exponential GARCH (denoted as EXPGARCH),
Article	Data preprocessing	Frequency: size	Model
Tauchen, G. (2001)	Yes	N/P	Various models
Taylor, J. (2003)	Log, exp	W: 400	(New) smooth transition exponential smoothing method (that uses a logistic function as adaptive smoothing parameter.)
Taylor, S. (2001)	Yes, ln	Uses D but T is 1, 2, 3, 6, 12, 18 and 24 months. (1989 to 1998) n=504.	FIEGARCH(1, *d*, 1) model and SV model
Tolvi, J. (2002)	Log	D: 1,712-3,761 obs (1/1987-6/2001)	ARFIMA-FIGARCH model
Tse, Y.K. (1991)	Log	D:1,072 (1986-1989)	EWMA, GARCH, ARCH
Turiel A. et al. (2005)	Yes	D: 10 years (48458 points)	Recostructible multifractals
Virtanen and Yli-Olli (1987)	Yes	M: 120, Q: 40 (1975-1984), 1985-1986 (for measure the forecasting)	ARIMA and econometric model, composite model
Wallmeier, M. (2005)	Yes	M: 1991-2000	Wilcoxon Rank-sum test
Watanabe and Yamaguchi (2005)	Ln	Every 2 minutes prices during the period 4 January 2000 to 30 December 2003.	ARFIMA, HAR
Wolf, M. (2000)	Ln	M: 480 (NYSE) M: 577 (SandP 500)	Subsampling method (resampling methods for stationary dependent data) (used VAR model with GARCH innovation)
Wong et al. (2003)	No	D: 21years	Test statistic for measure performance MA, RSI
Worthington and Valadkhani (2004)	Yes, log	D: 4957	ARMA
Yao, J. et al. (2005)	N/P	M: 12/1979-3/2000	Dynamic regression models in both the multivariate and the univariate frameworks (Matrix normal dynamic linear model (DLM))

Yu and So (2003)	Log	D: 1/1980-12/1997 (Hong Kong stock market) D: 1/1980-12/1998 (the rest)	Seven GARCH models, (RiskMetrics model, 2GARCH, 2FIGARCH, 2IGARCH)
Yu, Jun (2002)	Natural logarithm	D : 4,741	SV model, GARCH, RW, Historical average, MA, simple regression, ES, EMA, ARCH, GARCH,
Zhang, D. et al. (2005)	N/P	W: 522	Markov-switching ARCH model and cumulative sum of squares (CUSUM) type tests
Zontos, Skiadas and Valvis (2000)	No	D: (1/1/1993-9/11/1998)	MA (long and short term)

Table 4. Authors' models and comparisons

Article	ARIMA	ARMA	AR	RW	GARCH	SV (Markov)	BandH	Others
Aktas, R. et al. (2003)								Multiple regression, Multiple discriminant, Logit
Andersen, T. et al. (2002)								√
Arango, L.-E. et al. (2002)								Benchmark linear model
Areal and Taylor (2000)								ARMA
Assaf, A. (2006)		√						ARFIMA
Avramov, D. (2000)								i) CAPM; ii) FF; iii) the three FF factors plus WML, iii) plus DEF and TERM; and v) plus WML, DEF, and TERM.
Aydogan and Gursoy (2000)								√
Bacmann and Dubois (2002)					√			
Bajari and Krainer (2004)								√
Balaban, E. et al. (2006)				√	√			A historical mean model, moving average models, weighted moving average models, exponentially weighted moving average models, an exponential smoothing model,
Bali and Lu (2004)	√				√			√
Balvers, R. et al. (1990)								√
Barkoulas, J. et al. (2000)			√	√				ARFIMA
Batra, A. (2004)					√			
Beltratti and Morana (2006)								√
Beran and Ocker (2001)					√			SEMIFAR model

Beran J. et al. (2003)			√					□
Berg, L. (2003)					√			MA, Mixed model
Bhardwaj and Swanson (2006)	√	√	√	√	√			√, STAR
Bilson, C. et al. (2002)								√
Black et al.(2003)								√
Blair, B et al. (2001)					√			
Bley and Olson (2005)				√	√			√

Article	ARIMA	ARMA	AR	RW	GARCH	SV (Markov)	BandH	Others
Bluhm and Yu (2001)					√	v		√
Bond and Cummins (2004)								√
Bradshaw et al. (2005)							√	
Bredin and Hyde (2005)								√
Brzeszczynski and Welfe (2004)					√			
Bulkley and Richard (1999)								√
Cavalcante and Assaf (2004)								√
Cecconi, M. et al. (2002)					√			√
Charles-Darne (2006)			√		√			
Chen et al. (2000)								√
Chiarella, C. et al. (2005)								√
Chopin and Zhong (2001)								√
Chou, R. et al. (2005)								Constant conditional correlat-ion (CCC) model,exponential smoothing method, MA100
Christoffersen, P. et al. (2005)					√			Single-component voliatility model
Ciccone S. (2003)							√	
Claessen-Mittnik (2002)		√	√	√	√			√
Cornelis A. Los,				√				√

PH.D. (2000)								
Corrado et al. (2004)					√			
Cremers, M. (2002)			√					√
Danilov and Magnus (2004)								√
Daouk and Guo (2003)					√			GJR-GARC, EGARCH, SW-GARCH, SW-GJR-GARCH, SW-EGARCH.
Darrat and Zhong (2001)	√			□	√			ANNs
Degiannakis and Xekalaki (2001)								AIC, SBC, PEC et al. (NOT prediction models but criteria for selective model)
DeStefano, M. (2004)								√

Table 4. (Continued)

Article	ARIMA	ARMA	AR	RW	GARCH	SV (Markov)	BandH	Others
Drobetz and Wegmann (2000)								√
Dueker, M. (1997)					√			4 GARCH/Markov switching volatility models 1 GARCH, 1 SWARCH-L
Dufrenot, G. et al. (2005)		√						FARIMA
Eisler and Kertesz (2004)								Lux model
Engle and Gallo (2006)					√			√
Faugere and Shawky (2002)						√		
Felix, J. et al. (2004)	√						√	Risk-adjusted Buy-and-hold (1998)
Fillol, J. (2003)					√	√		FIGARCH
Fornari and Mele (1997)					√			√, GJR GARCH
Franses and Leij (2003)					√			
Friedman and Shachmurove (1997)								√
Füss and Herrmann (2005)					√			EGARCH, PM-GARCH
Garrett, I. et al. (2004)								√
Gemmill and Saflekos (1998)								√ Black/ Scholes model
Ghysels, E. et al. (2005)					√			Rolling window approach, French et al. (1987)
Giot and Laurent								√

(2004)								
Granger and Hyung (1999)								√
Griffin, J. et al. (2004)								√
Guedj, O. et al. (2006)								√
Guermat, C. et al. (2003)					√			
Guidolin and Timmermann (2006)								5-factor Fama-French linear model
Guo, H. (2003)								√

Article	ARIMA	ARMA	AR	RW	GARCH	SV (Markov)	BandH	Others
Hamilton J. and Lin G. (1996)			√		√	√		
Handa, P. and Tiwari, A (2000)								√
Han-Kim and Singal (2000)					√			
Hardle, W. et al. (2001)								√
Hayo and Kutan (2005)					√			
Hol, E. et al. (2002)					√			Stochastic Volatility
Huang et al. (2004)				√				SMV, RW, QDA, LDA, EBNNs
Hueng and McDonald (2005)					√			
Hyung, N. (2005)				√	√			GJR-GARCH, Exponential Smoothing (ES), EWMA.
Ibbotson and Chen (2003)								□
Jamaleh, A. (2001)			√	√	√			VaR, GARCH-L, SETAR
Jansen and Wang (2006)			√					Fed model. (VECM), nonlinear model, modified VECM, STAR
Jawadi and Koubaa (2004)								√
Jegadeesh, N. (1990)								√
Jorion and Goetzmann (1999)								√
Jorion, P. (2003)								√
Jungbacker and Koopman (2005)								√
Karmakar, M. (2004)			√	√	√			Simple regression model, historical mean model

Kavussanos and Visvikis (2005)	√			√				VECM, restricted VECM, VAR
Kearney and Potì (2004)								√
Killion and Muravytska (2005)								√
Kirikos and Terzakis (1999)				√		√		□
Koustas and Serletis (2004)								√
Krolzig and Toro (2004)						√		
Lee, J. et al. (2000)					√			IGARCH, √

Table 4. (Continued)

Article	ARIMA	ARMA	AR	RW	GARCH	SV (Markov)	BandH	Others
Lee, S-J. et al. (2005)								√
Liew, K-S. et al. (2003)			√	√	√			STAR, ARG
Lillo and Farmer (2004)								√
Lin and Wang (2005)					√			
Liu and Lee (1997)								N/C
Lovatt and Parikh (2000)								√
Lovatt, D. (2000)								√
Lux et al.(2004)		√			√			FI-GARCH, ARFIMA, MF model
Manzan, S. (2005)					√			
Marcucci, J. (2003)					√			MRS-GARCH
Maris, K et al. (2004)				√	√			√
Mattes, J. (2004)							√	√
McKibben (1971)								Econometric
McMillan, D. (2003)								Linear model, logistic smooth transitions threshold models.
Miyahara and Novikov (2002)								√
Mobarek and Keasey (2000)	√		√	√				
Naes, R. (2004)								□
Niglio, M. (2002)								Double Threshold ARCH (DTARCH) model
Nwokoma, N. (2005)								√
Ogden, J. (2003)								Asset pricing model

Ogum et al. (2002)					√			
Oomen, R. (2001)		√			√			ARFIMA
Oomen, R. (2002)		√						√
Pandey, A.(2003)					√			√
Park and Lee (2003)								√
Patev and Kanaryan (2004)								RiskMetric, EWMA-t, and EWMA-ged.
Pereira, R (2004)				√	√			HIS, MA, WMA, ES, EWMA, ARCH, GJR-GARCH(1, 1), EGARCH(1, 1)
Perez-Cruz, F.et al. (2003)					√			
Peters, J-P (2001)					√			√
Article	ARIMA	ARMA	AR	RW	GARCH	SV (Markov)	BandH	Others
Raaij, G. and Raunig, B. (2002).					√			√
Rookley C. (1998)								√
Sanso, A. et al. (2003)					√			√
Sarno, L. et al. (2005)						√		
Shaikh, A. (1998)								√
Sharpe, S. (2002)								√
Sibbertsen, P. (2004)								√
Skaradzinski, D. (2003)			√					
Spann and Skiera (2003)								√
Stentoft, L. (2005)					√			√
Tauchen, G. (2001)					√	√		EMM, SMM
Taylor, J. (2003)			√		√			√
Taylor, S. (2001)		√	√					ARFIMA.
Tolvi, J. (2002)								√
Tse, Y.K. (1991)					√			EWMA
Turiel A. et al. (2005)								Geometrical method
Virtanen and Yli-Olli (1987)	√							Econometric models, composite models
Wallmeier, M. (2005)								Analysts' Earnings Forecasts, M1, M2, M3, M4, M5
Watanabe and Yamaguchi (2005)			√		√			ARFIMA, HAR
Wolf, M. (2000)								VAR, Generalized method of moments

								(GMM), Bootstrap approach
Wong et al. (2003)								√
Worthington and Valadkhani (2004)		√						
Yao, J. et al. (2005)								√
Yu and So (2003)					√			√
Yu, Jun (2002)			√	√	√	√		√
Zhang, D. et al. (2005)								√
Zontos, et al. (2000)							√	MA

6. PERFORMANCE EVALUATION

Performance evaluation is accomplished in terms of several performance measures. The most widely used are the Mean Absolute Error (MAE), Mean Squared Error (MSE), Mean Square Prediction Error (MSPE), Root Mean Squared Error (RMSE), Mean Absolute Prediction Error (MAPE), Mean Absolute Deviation (MAD), Median Square Prediction Error (MedSPE) and Prediction Mean Error (MEAN). Other techniques have used correlation (CORR), the directional measure (HIT), the Theil inequality coefficient and profitable results like trading returns (RETURNS), deviation of the returns (STD-R) and the Sharpe ratio.

Besides the above measures, other methods used to evaluate the forecasting capability of proposed models include the Standard Maximum Likelihood (SML) procedure or the Log-likelihood ratio, Engle's LaGrange Multiplier test (LM tests), the chi-square test, the Ljung-Box statistic, the Jarque-Bera test, the Dickey-Fuller (ADF) test Q-statistics, F-tests and information criteria like Akaike's information criterion (AIC), Schwarz's information criterion (SIC), and the Bayesian information criterion (BIC). However, it is very difficult to state which method is the clear winner, but some models forecast better than others. For example, Hamilton and Lin (1996) after comparing a Markov-switching model and its variants with an AR and a GARCH model found that the Markov-switching method provides more accurate forecasts. Mobarek and Keasey (2000) found that ARIMA outperforms AR and Random Walk (RW) process. Claessen and Mittnik (2002) found that GARCH outperforms ARMA, AR and RW. Also, Jamaleh (1998) studied many models (AR, RW, GARCH, GARCH-L, SETAR) and discovered that the Shelf-Existing Threshold Aoutoregressive (SETAR) model provides more accurate forecasting results. Other authors reporting major comparisons are Yu Jun (2002), Karmakar (2004) and Bhardwaj and Swanson (2006). From the 150 surveyed papers, only 63 provide definite conclusions about which technique is the best. Some conclusions are of special importance and express the general situation. Bluhm and Yu (2001), conclude the following: "*When option pricing is the primary interest, the SV model and implied volatility should be used. On the other hand, when Value at Risk (VaR) is the objective, the ARCH-type models are useful. Furthermore, a trading strategy suggests that the time series models are not better than the implied volatility in predicting volatility*". Tauchen (2001) argues that a direct approach is better than stochastic volatility. Assaf (2006), Tolvi (2003), Sibbertsen (2004), and Taylor (2001) believe that stock market indices follow a long memory process and they proved that long memory models like ARFIMA and FIGARCH outperform other conventional models. Yu and So (2003) have a

different opinion: "*FIGARCH models do not always outperform GARCH models. This probably tells us that the long memory volatility feature is not very crucial in determining a proper value of VaR.*", and conclude that, "*…the best fitted model according to AIC and SBC does not necessarily lead to better VaR estimates*".

Pereira (2004), states that *"…the best forecasting model depends on the evaluation measure used. Notwithstanding, the numbers pointed out to smooth superiority of (G)ARCH class models, principally when using RMSE and MME(U), which means that this class models normally over-predicts volatility. It is also worth noting the excellent performance of volatility forecasting models based on semi-standard deviation, even when compared with ARCH class models*".

Table 5 presents a comparative study.

Table 5. Summary of performance measures

Article	Model performance measures	Best model
Aktas, R. et al. (2003)	Percentance of correctly classified negative or positive CARs, adj. R^2, Chi square, Wilk,s lamda, F stat, predicted positives and negatives counts, Accumulative abnormal returns	Logit
Andersen, T. et al. (2002)	Mean, St.Dev., Skew., Kurt	Long memory models
Arango, L.-E. et al. (2002)	Coefficient, Standard error, *t*- statistic, *p* – Value. R^2, Standard deviation of dependent variable, Mean of dependent variable, Standard error of regression	ESTR-GARCH model
Areal and Taylor (2000)	Distribution and autocorrelations of stsndarized daily returns, kyrtosis, skewness	Long memory process best describes volatility
Assaf, A. (2006)	Modified rescaled range statistic R/S proposed by Lo (1991), rescaled variance/S statistic developed by Giraitis etc (2003) (for long memory), maximum likelihood method, Box–Ljung statistic, RMSE	ARFIMA
Avramov, D.(2000)	Sharpe ratio	CAPM
Aydogan and Gursoy (2000)	Return, EP coefficient, PBV coefficient, BETA coefficient, t-values	N/C
Bacmann and Dubois (2002)	Lagrange Multiplier Test, t-stat, chi-square test, Likelihood Ratio	N/C
Bajari and Krainer (2004)	Log likelihood, Pseudo- R2 , %DEV, IVBELIEF, RELATION, R2	N/C
Balaban, E. et al. (2006)	MME(U), MME(O) (to penalize under/over-prediction), Mean error, MAE, RMSE, and MAPE	Exponential Smoothing Model

Bali and Lu (2004)	R^2, MAPE, t-statistics, etc	SGED-TGARCH and VIX
Balvers, R. et al. (1990)	F-statistics, Adj R^2	N/C
Barkoulas, J. et al. (2000)	RMSE, MAD	ARFIMA
Batra, A. (2004)	MEAN (%)	N/C
Beltratti and Morana (2006)	BIC, % Correct, univariate, bi-variate and multivariate GPH estimator	N/C
Beran and Ocker (2001)	BIC	SEMIFAR

Table 5. (Continued)

Article	Model performance measures	Best model
Beran J. et al. (2003)	S-PLUS function arima mle and the AIC criterion, the ratios between the withs of prediction intervals	SEMIFAR
Berg, L. (2003)	Adj R^2, log likelihood	N/P
Bhardwaj and Swanson (2006)	Average and standard errors, MS(forecasting)E, Diebold and Mariano (DM: 1995) test, Clark and McCracken (CM: 2001) encompassing test	ARFIMA
Bilson, C. et al. (2002)	MEAN, STD Dev, Jarque-Bera test, Skewness, Goodness of fit, MIN, MAX, Excess Kurtosis Adjusted R^2	N/C
Black et al.(2003)	OLS estimated VAR coefficients (standard errors), residual diagnostics, Wald tests, Q, t-statistics, R^2	N/C
Blair, B et al. (2001)	Log-likelihood, MSE, R^2, robust *t*-ratios	Intraday returns more accurate measures of realised volatility than daily returns (in-sample analysis) Out-of-sample *VIX* provides more accurate forecasts than either low-frequency or high-frequency index returns
Bley and Olson (2005)	RMSE, MAE, MAPE, Theil Inequality Coefficient (TIC), and the Bias and Variance proportions of the mean squared forecast error	a) The single-factor volatility index model, b) the exponential smoothing model, c) and the three-week moving average model (a total number of

		14 models)
Bluhm and Yu (2001)	MSPE, MAPE, MAE, bounded violations, and the LINEX loss function	N/P
Bond and Cummins (2004)	Voliatility, Dispersion, squeare of the difference between consensus forecasts of earnings per share, etc	N/C
Bradshaw et al. (2005)	RATIO of target price to actual price, RETURN	N/C
Bredin and Hyde (2005)	AIC, R^2	N/C

Article	Model performance measures	Best model
Brzeszczynski and Welfe (2004)	Direction quality measures (HIT)	N/P
Bulkley and Richard (1999)	Portofolio returns	N/C
Cavalcante and Assaf (2004)	Estimates of d for returns, absolute returns, squared returns, modified long-squared returns.	N/C
Cecconi, M. et al. (2002)	Likelihood ratio, AIC, SIC, R^2	Similar results for all models (estimated volatility using GARCH models on the NASDAQ–100 Index have predictive power for the (implied–based) volatility index)
Charles-Darne (2006)	MSPE, MedSPE	Preferable to use outliers adjusted series than unadjusted whatever the steps-ahead forecasts
Chen et al.(2000)	Daily skewness	N/C
Chiarella, C. et al. (2005)	R^2	N/P
Chopin and Zhong (2001)	Akaike's minimum Final Prediction Error (FPE)	N/C
Chou, R. et al. (2005)	R^2	CARR-DCC model
Christoffersen, P. et al. (2005)	RMSE, MSE, Ratio MSE, ln-likelihood	New variance component model
Ciccone S. (2003)	Earnings decrease, improvment from negative earnings, improvements from positive earnings	N/C
Claessen-Mittnik (2002)	ME, MSE, D (%)	GARCH-IV
Cornelis A. Los,	Chi-square test	N/P

PH.D. (2000)		
Corrado et al. (2004)	RMSE, MAE, P-statistics	N/C
Cremers, M. (2002)	Adjusted R^2, AIC, BIC, SIC, PIC, RMSE, MAD, Bias (the average forecast error), MEAN, STD, CORR. Deviation (the average of the squared difference between the	N/P (compared different variables used for many individual models)
	bias and the forecast errors)	
Danilov and Magnus (2004)	R^2	N/C
Daouk and Guo (2003)	Likelihood ratio (LR) test, AIC, BIC	Switching regime EGARCH model

Table 5. (Continued)

Article	Model performance measures	Best model
Darrat and Zhong (2001)	RMSE, MAE, Theil's U, and encompassing tests	ANN
Degiannakis and Xekalaki (2001)	STD, MEAN, t-ratio	PEC
DeStefano, M. (2004)	R^2	N/C
Drobetz and Wegmann (2000)	Quartely consumption growth rate, standard error, variance ratio	N/C
Dueker, M. (1997)	Chi-square goodness of fit tests, log-likelihood, forecast error variance,	GARCH/Markov switching volatility model
Dufrenot, G. et al. (2005)	AS: Asymptotic test, SI: Sign test, WI: Wilcoxon's test, NB: Naive benchmark test, MGN: Morgan-Granger Newbold's test, MR: Meese-Rogo.'s test, number of times in percent where the residuals coming from the TAR model with a long memory regime are smaller than the residuals coming from a standard long memory model, AIC	SETAR
Eisler and Kertesz (2004)	MSE	SV model with a filter to remove asymmetric leverage autocorrelations
Engle and Gallo (2006)	BIC, LOGLIK, R^2, F-tests	N/C
Faugere and Shawky (2002)	T-values, coefficient, adjusted R^2	N/C
Felix, J. et al. (2004)	Net returns, Sharpe ratio	Nearest neighbor (NN) predictors
Fillol, J. (2003)	Means and confidence intervals of each model	MMAR
Fornari and Mele (1997)	Log-likelihood, Sign Bias test, Negative Sign Bias test, Positive	Volatility-switching ARCH model

	Sign Bias test	
Franses and Leij (2003)	AIC, log-likelihood	GARCH-IE
Friedman and Shachmurove (1997)	Standard deviation	N/C
Füss and Herrmann (2005)	AIC, SIC, log-likelihood Function, RMSE, MAE, MAPE, Theil inequality coefficient	PM-GARCH
Garrett, I. et al. (2004)	AIC, SBC, R^2, residual standard deviation (RSS).	N/P

Article	Model performance measures	Best model
Gemmill and Saflekos (1998)	RMSE, change in spot price, voliatility	Two-lognormal method
Ghysels, E. et al. (2005)	Log-likelihood, R^2 , value Mean, sum of squared forecasting errors divided by the total sum of squared realized variance.	MIDAS
Giot and Laurent (2004)	Failure rate, Kupiec LR test	Both models perform reasonable well
Granger and Hyung (1999)	Squared returns, break process, residual	N/C
Griffin, J. et al. (2004)	Hannan-Quinn Information Criterion (HQC), R^2	N/C
Guedj, O. et al. (2006)	Correlation of forecast erros across different economic sectors	N/C
Guermat, C. et al. (2003)	Number or Proportion of Failures (shortfalls). The Size of Failure (Failure Cost). The Size of Coverage (Coverage Cost). Weighted mean square, The Likelihood Ratio (LR), Z (normal test) statistic, %correct etc	N/C
Guidolin and Timmermann (2006)	Log-likelihood ratio tast, LR test for linearity, Hannan-Quinn information criterion	N/P
Guo, H. (2003)	RMSE, stock returns, R^2 , Wald test	N/C
Hamilton J. and Lin G. (1996)	MSE, MAE	Markov-switching
Handa, P. and Tiwari, A (2000)	Standard deviation, mean return, average return adjusted, sharpe ratio, market timing perfor-mance (HIT), Henrickoson Merton coefficient	N/C
Han-Kim and Singal	z-Statistic, t-Statistic	N/C

(2000)		
Hardle, W. et al. (2001)	Mean, variance, parametric forms – to not parametric	N/C
Hayo and Kutan (2005)	Log-likelihood, normality test, ARCH 1-2 test, Portmanteau (60) test	GARCH with IMF news.
Hol, E. et al. (2002)	R^2, MSE. MAE, Wald, MedSE.	Stochastic Implied Volatility
Huang et al. (2004)	Hit Ratio	SVM combining model
Hueng and Mc-Donald (2005)	Excess returns, turnover ratios	Disagree with Chen et al. (2000)

Table 5. (Continued)

Article	Model performance measures	Best model
Hyung, N. (2005)	MAE, test of significant difference based on Diebold and Mariano (1995)	GJR-GARCH (for short horizon) Long memory models (for long horizon). FIGARCH for long and short horizon
Ibbotson and Chen (2003)	Equity returns	N/C
Jamaleh, A. (2001)	AAD, MSE, Theil index, MEDSE	SETAR
Jansen and Wang (2006)	RMSE, MAE, D-M statistic	Fed model (VEC Model) for long horizon
Jawadi and Koubaa (2004)	Cointegration test, R^2 , DW	N/C
Jegadeesh, N. (1990)	F-statistics, R^2 adj, returns	N/C
Jorion and Goetz-mann (1999)	Index returns	N/C
Jorion, P. (2003)	Long term returns, variance ratio returns	N/C
Jungbacker and Koopman (2005)	Micro-structure noise and stochastic voliatility	N/P
Karmakar, M. (2004)	Mean error (ME), MAE, RMSE, MAPE, R^2	GARCH (1,1)
Kavussanos and Visvikis (2005)	RMSE	VECM models
Kearney and Potì (2004)	Correlation and market returns	N/C
Killion and Muravytska (2005)	Stock returns	N/C
Kirikos and Terzakis (1999)	RMSE	N/C
Koustas and Serletis (2004)	Dickey-Fuller (ADF) test, AIC, KPSS tests, Exact Maximum Likelihood (EML), Non-linear Least Squares (NLS), and Modified Profile	N/C

	Likelihood (MPL) estimators, mean bias, RMSE	
Krolzig and Toro (2004)	Maximum likelihood (ML) estimation (log-likelihood value, AIC, HQC, SIC.), MSE, multiperiod forecast error, return error	N/C
Lee, J. et al. (2000)	Ljung-Box Q-statistics for the standardized residual and squared standardized residual	N/P
Lee, S-J. et al. (2005)	Adj R^2, F-statistic, D-W statistic	N/C
Liew, K-S. et al. (2003)	RMSE	N/P

Article	Model performance measures	Best model
Lillo and Farmer (2004)	Sign of order	N/C
Lin and Wang (2005)	Likelihood Ratio Test	EGARCH
Liu and Lee (1997)	Earning, mean investment, annual return (%), transaction rate, net return (%)	N/P
Lovatt and Parikh (2000)	Newey-West standard errors, CORR, RMSE, Theil, returns	N/C
Lovatt, D. (2000)	Adjusted R^2, log-likelihood, Chi-square test, Correlation Actual and Fitte, Theil's inequality coefficient, RMSE	N/A
Lux et al.(2004)	MSE, MAE	N/P
Manzan, S. (2005)	R-squared, AIC, AR(q), LM	N/C
Marcucci, J. (2003)	MSE, MAD, R^2, Diebold and Mariano (DM) test statistic etc	MRS-GARCH
Maris, K et al. (2004)	MAPE, RMSE	No winner can be nominated. All the models and combinations present very large errors (in most cases over 50%)
Mattes, J. (2004)	Mean monthly (raw) return, monthly stan-dard deviation and Sharpe ratio based on R^2	N/P
McKibben (1971)	R^2	N/C
McMillan, D. (2003)	R^2, log-likelihood function, AIC, BIC, RMSE	Exponential smooth transition threshold model
Miyahara and Novikov (2002)	Returns	N/C
Mobarek and Keasey (2000)	Ljung-Box statistics, SE, T-ratio	ARIMA (2,0,1)

Naes, R. (2004)	R square, F-statitstics	N/C
Niglio, M. (2002)	MAE, HMSE, MME (U)	LDST (significant forecast gain for the conditional variance which is not recognized in the conditional mean case)
Nwokoma, N. (2005)	Chow Breakpoint Test, Log likelihood, F-statistic, R-squared, adjusted R-squared, AIC, SIC, Sum squared residual, etc	N/C
Ogden, J. (2003)	Adj. R^2, difference of actual and forecast excces returns (mean ex, std. dev.)	N/C
Ogum et al. (2002)	No	N/C

Table 5. (Continued)

Article	Model performance measures	Best model
Oomen, R. (2001)	SSE, RFA, sum of squared errors of forecasted cumulative realized volatility, forecast error standard deviation	ARFIMA
Oomen, R. (2002)	Residual test statistics, log-likelihood ratio test, AIC	ARFIMA
Pandey, A.(2003)	Bias, MSE, Relative Bias and MAE, t-statistics, R-squared, etc	Extreme-value estimators
Park and Lee (2003)	MAPE	PBR
Patev and Kanaryan (2004)	Number of violations, Kupiec's Likelihood Ratio, and upper and lower bounds	EWMA-ged model
Pereira, R (2004)	ME, RMSE, MAPE, MME	The best forecasting model depends on the evaluation measure used
Perez-Cruz, F.et al. (2003)	R^2, Squared returns	SVMs
Peters, J-P (2001)	MSE, MedSE, MAE, AMAPE, TIC, R^2	GJR and APARCH models
Raaij, G. and Raunig, B. (2002).	F-tests, LR-tests, JB-tests, W-tests etc	GARCH
Rookley C. (1998)	Percent improved over BandH, Final wealth from initial dollar investment	N/C
Sanso, A. et al. (2003)	Ljung-Box statistic, Engle's Lagrange multiplier test, Inclan and Tiao (1994) –IT	K2 test better than IT-test
	test, κ2 test (Monte Carlo experiments for evaluate the k2 test)	
Sarno, L. et al. (2005)	MAE, RMSE, R^2	N/P

Shaikh, A. (1998)	Stock rate of return	Theoretical approach
Sharpe, S. (2002)	R^2, earnings quality: estimate of the mismeasurement in current-period earnings.	N/C
Sibbertsen, P. (2004)	GPH-estimator and tapered GPH-estimator (TGPH), sample variance and Wavelet Estimation	Long memory
Skaradzinski, D. (2003)	ANOVA testing and Waller groupings	N/P
Spann and Skiera (2003)	MAPE	BOM (Box Office Mojo)
Stentoft, L. (2005)	Q^2 statistic, AIC, SIC and Hannan Quinn, hibata (with the log-likelihood value), mean bias, MAE, MSE, relative bias, relative MAE, relative MSE	EGARCH (best in short term options and worst in long term)
Article	Model performance measures	Best model
Tauchen, G. (2001)	N/C	N/C
Taylor, J. (2003)	RMSE, R^2	Smooth transition expo-nential smoothing method
Taylor, S. (2001)	Log- likelihood	Long memory models
Tolvi, J. (2002)	SE, d, p.	N/P
Tse, Y.K. (1991)	MEAN, STV, Normal erros, Non-normal erros	EWMA
Turiel A. et al. (2005)	N/C	N/P
Virtanen and Yli-Olli (1987)	Residual mean square, MAE, MSE, RMSE, MPE, MAPE	Composite econometric ARIMA
Wallmeier, M. (2005)	STD, MSE RMSE, MAE MEAN, median, minimum and maximum of the distribution of forecasts	Analysts' Earnings Forecasts and M5
Watanabe and Yamaguchi (2005)	MAE, MAPE, RMSE, RMSPE	ARFIMA
Wolf, M. (2000)	Estimated coverage probabilities of nominal confidence intervals	Subsampling method
Wong et al. (2003)	Test- statistics	MA
Worthington and Valadkhani (2004)	R^2, Schwartz specification criterion (SC), Watson (DW), Ljung-Box (Q) and Breusch-Godfrey Lagrange multiplier (LM) test statistics	N/P
Yao, J. et al. (2005)	R^2, Durbin–Watson statistics for residual serial correlation, Ljung–Box Q test, ARC H test, Goldfeld–Quandt test, MAE, MSE, ordinary least square (OLS) model	Multivariant model
Yu and So (2003)	Squared returns, AIC, SBC, α, mean rank,	GARCH with normal

	sample coverage	and t error models produce more
		accurate VaR estimates. FIGARCH with t error model performs the best in estimating one percent VaR
Yu, Jun (2002)	RMSE, MAE, LINEX loss function, Theil-U etc	SV model
Zhang, D. et al. (2005)	CUSUM type test, U-statistics, AIC, BIC etc	N/C
Zontos, Skiadas and Valvis (2000)	N/P	MA

CONCLUSIONS

This survey has compiled and addressed the current development of conventional techniques used to forecast stock market prices as reported in academic articles. Valuable information and conclusions are provided related to conventional technique robustness and forecasting accuracy.

Reported results suggest that the GARCH family: stochastic volatility and long memory models in many cases outperform other traditional techniques like BandH, RW, AR and ARIMA, without excluding paradigms where the opposite occurs.

As seen from many successful results, the traditional strong form version of the efficient market hypothesis is doubtful. Nonetheless, when market inefficient are clearly discovered, and when examples of the successful conventional models and the accompanying trading strategies have been developed, investors will have a better understating of the relationships between available information and future stock returns.

It hass been observed that most papers were drawn up by researchers in academia. This does not imply that financial organizations have not explored the above techniques in the private sector. One interesting thought is that if one succeeds in developing a technology that can correctly predict future stock returns, this finding, will most likely not be published. On the contrary, if something is published, the technology might not be used to generate profits. In fact, the benefit of these technologies may have already been used in some financial companies without them having benn recorded in the academic journals.

The review finds that conventional forecasting techniques are challenging techniques that should continue to be promising tools for future research.

This survey has not taken into consideration non conventional forecasting techniques like soft computing; where subject of the paper part II by the same authors are.

APPENDIX

AAD: Absolute average deviation
AIC: Akaike information criterion

AMAPE:	Adjusted Mean Absolute Percentage Error
ANST–GARCH:	Asymmetric Nonlinea Smooth Transition GARCH
APARCH:	Asymmetric Power ARCH model
APT:	Arbitrage Pricing Theory
AR:	Autoregressive model
ARIMA:	Autoregressive intergrated moving average model
ARMA:	Autoregressive moving average model
BIC:	Bayesian information criterion
BandH:	Buy and Hold srategy
CAPM:	Capital Asset Pricing Model
CARs:	Cumulative abnormal returns
Chi-square test:	= (observed frequency – expected frequency)^2/expected frequency
CORR:	Correlation
D(%):	Proportion of correctly predicted directions, i.e., of the volatility movements
Def:	Default-risk spread.
EBNN:	Elman Backprobagation Neural Network
EGARCH (1, 1):	Nelson (1991)
EMM:	e$cient, method of moments
ES:	Exponential smoothing model
ESTAR:	Exponential Smooth Transition Autoregressive
EWMA:	Exponentially-weighted moving average
Fed Model:	It was used in the Fed's Humphry-Hawkins report to Congress in July 1997 and quickly picked up by private security analysts, who gave it the name "Fed Model"
FF:	Three-factor model of Fama and French (1993)
FI- GARCH, AR**FI**MA:	Fractionally Integrated… (Long memory models)
FIC:	Fisher information criterion
GARCH:	Generalized autoregressive conditional heteroskedasticity model
GARCH-M:	GARCH-in-Mean model
GH-method:	Glosten and Harris (1988) method
GJR-GARCH (1, 1):	Glosten, Jagannathan and Runkle (1993)
GKN-method:	George et al. (1991) method
GPH-estimator:	Log-periodogram regression was introduced by Geweke/Porter-Hudak (1983) for explore long-range dependence
HAR:	Heterogeneous interval autoregressive model
HIS:	Historical Volatility Model
HIT:	Direct measure
IMF:	International Monetary Fund policies independently distributed (i.i.d.)
IV:	Implied Volatility
IPOs:	Initial Public Offerings
J-B tests:	Jarque-Bera normality tests of an n-series

LDA:	Linear discriminate analysis
LDST:	Logistic Double Smooth Transition model
LINEX:	Loss function identically long-range dependence, difference-stationarity and deterministic trends
LR-tests:	Joint likelihood ratio test
LSTAR:	Logistic Smooth Transition Autoregressive
M1:	Current earnings as forecasts for next year
M2:	Overall mean of current earnings as forecasts
M3:	Forecasts corresponding to regression of analysts' forecasts on current earnings
M4:	Earnings forecasts corresponding to required rate of return
M5:	Combination of M1 and M4 with equal weights
MAD:	Mean absolute deviation
MAE:	Mean absolute error
MAPE:	Mean absolute prediction error
MEAN:	Prediction mean error
MedSPE:	Median SPE
MF model:	Multi-fractal
MFI:	Money Flow Index
MIDAS:	mixed data sampling approach
MMAR model:	Multifractal Model of Asset Returns (stochastic process)
MME:	Mean mixed error statistics
MRS-GARCH:	Markov Regime-Switching GARCH
MSPE:	Mean square prediction error
Multiplicative Error Model:	Is suited to model the conditional behavior of positively valued variables choosing a convenient GARCH-type structure to model persistence with an exponential error assumption
N/A:	Not available
N/C:	No comparison
N/P:	Not provided
PIC:	Posterior information criterion
PM-GARCH:	Power in-Mean-GARCH
QDA:	Quadraiic discriminant analysis
RFA:	Ratio of forecasted and actual average realized volatility
RMSE:	Root mean squared error
RSI:	Relative Strength Index
RSI:	Relative Strength Index
RW:	Random Walk
STD:	Standard daviation
SE:	sum of error
SEMIFAR	model is a fractional stationary or non-stationary autoregressive model with a nonparametric trend
SEMIFAR	models extend the definition of fractional ARIMA models with arbitrary d= m + δ by including an arbitrary

	deterministic trend function g satisfying certain smoothness assumptions
SEMIFAR models:	These models include a nonparametric trend function as well as a fractional differencing parameter
SETAR:	Shelf-Exciting Threshold Autoregressive model
SGED- GARCH:	skewed fat-tailed generalized error Distribution GARCH
SIC:	Schwarz's information criterion
SMM:	Simulated method of moments (SMM) (model)
SSE:	Sum of squared error
STAR:	Smooth Transition Autoregressive model
STECM:	Switching Transition Error Correction Model
SV model:	Stochastic volatility model
SVM:	Support vector machine
SW-EGARCH:	Switching Exponential GARCH
TERM:	One-year momentum in stock returns, and the differences between returns on long-term and short-term government bonds
TGARCH:	Threshold GARCH
TIC:	Theil Inequality Coefficient
VAR model:	Vector Autoregression Model
VaR:	Value at Risk
VECM:	Vector error correction model
WMA:	Weighted moving average
WML:	Winners-minus-losers
W-test:	Wj denotes a joint test of a restriction in the system under the possibility of heteroskedasticity
?:	Not reported

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