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NATURAL FIBRE REINFORCED COMPOSITES: THE GREEN ALTERNATIVES FOR VARIOUS INDUSTRIAL AND ENGINEERING APPLICATIONS

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Abstract *:* As the human civilization rolled on, the needs and necessities of mankind have ever increased. The non-renewable resources at hand are ought to be under pressure of getting exhausted keeping in view the ever increasing population demands. We have tried actively and thoughtfully to recreate fresh resources for various applications to support our lives and necessities. Natural fibre composites are excellent alternatives to sustain our needs through green alternatives. They have the advantage being eco-friendly as well as being sustainable for various necessities. With the rise in environmental concerns and regulations, the natural fibre composites are quite beneficial alternatives paving way for environmental friendly renewable raw materials. This paper evaluates the possible combinations and creations and how successfully they can be put into varied applications. The use of natural fibres like sisal, jute, palm, flax etc in natural fibre composites have come up positively to support various applications ranging from automotive industries to other engineering applications. In addition to being environmental friendly, they have the added advantage of being lightweight, renewable, abundant, cheaper yet relatively good mechanical properties such as tensile and flexural modulus. Natural fibre composites have flexibility in production and pose minimal health hazards and are biodegradable too.

Keywords:NaturalFibreComposites,Environmentalfriendly,Engineeringapplications.

I. INTRODUCTION

Natural fibres made of cellulose or plant matter can be obtained from almost every part of the plant such as the root, stem or shoot, leaf, fruit and bark from many tree species (Figure 1). Fibre can be extracted from a leaf which is fibrous, pliable, strong and green. If the leaf can be wound around a finger without breaking, then it indicates a potential source for making fibre. Natural fibre products have certain distinctive qualities: they share a common language of colour, texture and of belonging to the earth. The appearance, feel, and texture of a bamboo basket are clearly different from that of a plastic bag. Different fibres have varying physical properties of strength, appearance, pliability, colour, texture and fragrance.

Traditional skills and knowledge of working with these materials is an economic activity, often undertaken as an additional activity, to earn a little extra income when there is a break in the agricultural cycle of work. Fibres are obtained by shredding or peeling parts of plants, or pounding them to make threads or by cutting them to make strips. Ancient communities must have used natural fibres to build shelters and thatched roof.

Root	Stem	Branch	Leaf	Fruit/Seed
Khus	Bamboo	Willow	Palmyra	Cotton
	Kora grass		Palm date	Coir
	Jute		Palm coconut	Arecanut
	Hemp		Arecanut palm	
	Water hyacinth		*Sisal*	
	Banana		Banana	
	Kauna reed		Pineapple	
	Cane palm		Screw pine	
	Moonj grass			
	Sarkanda			
	Wagoo reed			
	Sikki grass			
	Cannabis/pulla			
	Wicker			
	Bhindi			
	Nettle			
	Flax			
	Arhar/Pigeon pea			

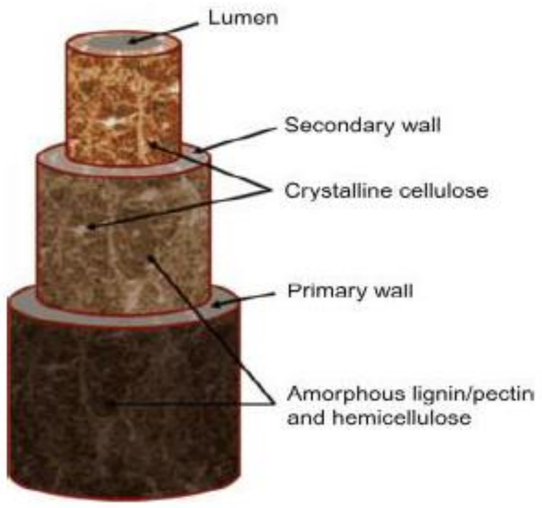
Figure -1 Natural Fibres from different parts of plants.

Our daily observations suggest that almost everybody is so deeply entangled and occupied with one's own self that the caring and sharing for Mother Nature is dwindling under pressure and scarcity. People are negligent of the environmental bliss i.e. the greenery, flowers, rivers, birds, wild animals, mountains. This negligence and ignorance has led to loss of environmental balance and beauty. It is high time that we become more selfless and nurture the nature and maintain its beauty and bliss. If we keep on ignoring the flora and fauna, the natural resources will keep shrinking and its abundance and beauty will remain restricted to the photographs. Still the process of construction and building the necessities of life has to continue unabated. In this context, some thought can be put into replacing or reducing the use of the traditional metals and alloys by materials more nature friendly and economically viable composites which can provide the adequate strength and suitability

Natural vegetative plant fibre durable polymer composites are very much in demand and matter of interest among the materials for scientists and engineers. The composites provide a combination of advanced mechanical property, dielectric and environmental benefits together with renewability and biodegradability. Due to emerging risks like excessive progressing technologies, rising costs of finite resources, the traditional petroleum-based totally plastic, glass or carbon fiber materials are compensated by way of natural / bio-based fibres. These fibre composites are appropriate as wooden substitutes used in the housing and production sector. The use of such natural / bio-fibers with polymers based on renewable sources will allow many environmental problems to be solved. The various types of natural vegetative plant fibre like jute, coir, sisal, pineapple, bamboo, and banana, rice straw, lufa etc., are used as reinforcement of polymer composites now. In recent years, many investigations have been made which brings out the worth of natural fibres against their synthetic equivalents inclusive of glass and/or carbon fibre-bolstered polymer composites.

Figure- 2 Various examples of natural and synthetic fibres

2. Structure and properties of natural fibres



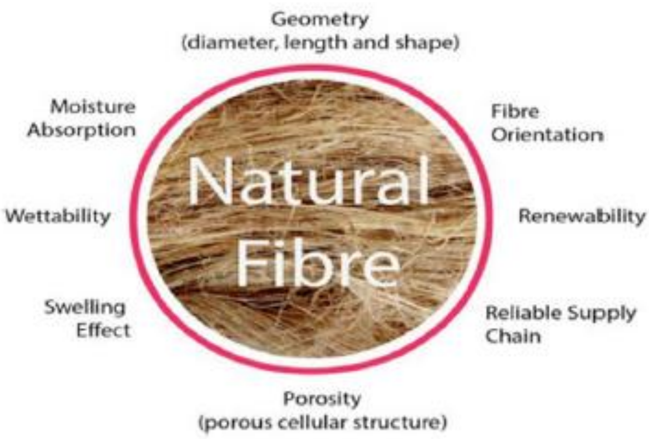


Figure- 3 Structure and the various properties of a natural fibre

The cell structures of natural fibres are layered structures having four different layers each having their unique thickness and chemical composition as well as shown in Figure 3. The cell wall of fibre is composed of the outermost primary wall and the innermost thick middle layer called lumen. In between there are secondary cell walls. A series of cellular microfibrils are helically wound along the middle hollow fibre axis. The structure and the chemical and physical composition are dominantly affected by the age of the plant, species, climate, harvesting time and fibre processing procedures. The microfibrillar angle determines the fibre stiffness and thus spiral oriented microfibrils are more ductile than the parallely oriented ones which are more rigid and inflexible.

There are various categories of natural fibre composite and the basis of classification is summarized in Figure -4. The properties of natural fibres are vividly studied which brings out their possible applications in various engineering domains making best use of the available properties. The advantages, disadvantages and applications of various natural fibres are summarized in the next section as is obtained from various references.

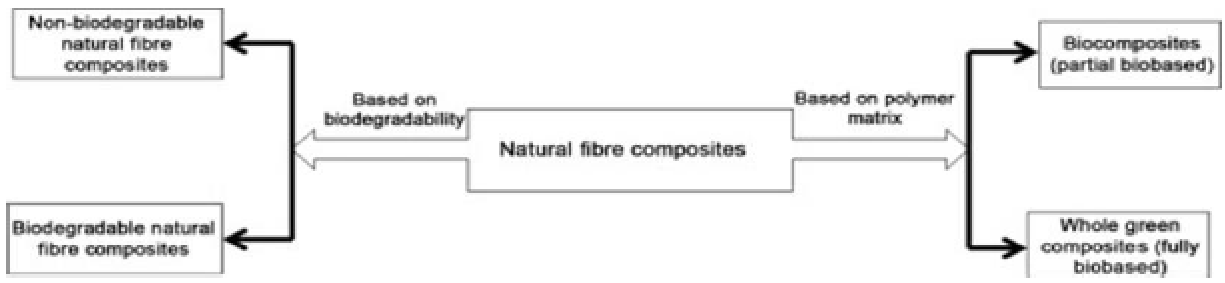


Figure 4 Basis of classification of Natural fibre Composites

3. Comparison table for advantages, disadvantages and applications of various natural fibres
(Data collected from various references enlisted at the end of the paper)

Fiber		Advantages, disadvantages, and applications
Coir	Advantages	• High abrasion resistance • Strong and durable • Good acoustic properties
	Disadvantages	Has less cellulose than fibers like flax or cotton, thus making it less flexible
	Applications	Building panels, flush door shutters, roofing sheets, storage tank, helmets and post boxes, projector cover, voltage stabilizer cover, brushes, and brooms
Kenaf	Advantages	• Fast growing • High fiber yield • Low cost and easily available • Relatively low specific weight and perform well in tension
	Disadvantages	• Absorption of moisture in core portions is relatively high • Handling and processing of long fiber bundles is difficult • Exhibiting brittle fracture • Applying binder to long fiber bundle lengths is difficult • High water requirements for growth
	Applications	Packaging material, mobile cases, bags, insulations, clothing-grade cloth, soilless potting mixes, animal bedding, and material that absorbs oil and liquids
Flax	Advantages	• Relatively strong • Can be used to make clothing
	Disadvantages	• Gives off a large amount of dust in the early stages of the isolation process • Low elasticity
	Applications	Window frame, panels, decking, railing systems, fencing, tennis racket, bicycle frame, fork, seat post, snowboarding, and laptop
Jute	Advantages	• Low cost • Can be widely used in agriculture, textile, woven and nonwoven sector
	Disadvantages	• The crease resistance is very low • Lose of strength when wet
	Applications	Building panels, roofing sheets, door frames, door shutters, transport, packaging, geotextiles, and chipboards
Sisal	Advantages	• High specific strength • Easy availability • Good sound absorption properties
	Disadvantages	Restricted maximum processing temperature
	Applications	In construction industry such as panels, doors, shutting plate, and roofing sheets; also, manufacturing of paper and pulp

Fiber		Advantages, disadvantages, and applications
Ramie	Advantages	• High strength • Excellent microbial resistance • Hygienic properties
	Disadvantages	Difficulty in degumming
	Applications	Used in products as industrial sewing thread, fishing nets, and filter cloths. Also made into fabrics for household furnishings and clothing
Hemp	Advantages	• Very strong and does not require pesticides • Requires little fertilizing and grows faster than other natural fibers • Generally drought and light frost resistant
	Disadvantages	• Separation of the fibers from the bast is very labor-intensive • Growth and cultivation restrictions in many countries
	Applications	Construction products, textiles, cordage, geotextiles, paper and packaging, furniture, electrical, manufacture of bank notes, and manufacture of pipes

4. CURRENT TRENDS AND FUTURE SCOPE

The ability of natural fibre-reinforced composites and their applications is realised in nearly every industry including construction, aerospace, automobile, and electronics. Composite substances are more and more used for dielectric applications, that is, applications that make use of electrically insulating behaviour. This is due to the requirement of the digital industry for dielectric substances in electrical insulation, encapsulation, multilayer ceramic chip and capacitors and for piezoelectric, ferroelectric, and pyroelectric devices. Developing an efficient and light weight dielectric material from sustainable resources, such as brown bamboo, rice straw, coconut, palm composites reinforced with natural fibers, is quite appealing from both economic and environmental perspectives. This has led to worldwide focus and application of natural fibre composites for various applications as is shown in the figure below.

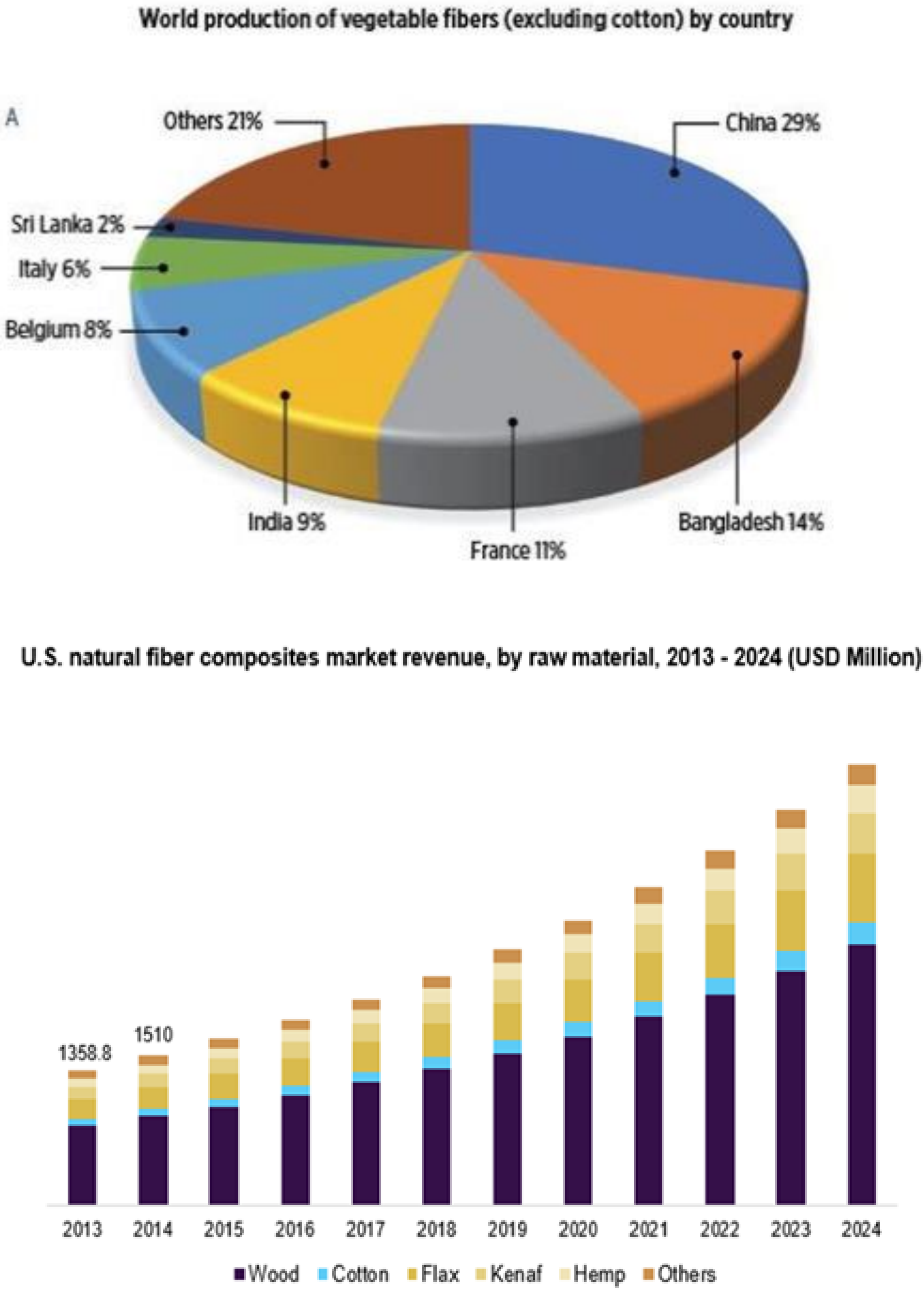


Figure- 5 The Global Scenario

5. Conclusion

As is studied, natural fibre-based composites possess an edge over synthetic fibre based composites due to properties such as low cost, light weight, biodegradability, high thermal and acoustic insulation, high specific strength and stiffness. The synthetic fibres are not an advantageous choice due to high cost, high energy consumption during manufacturing, poor recycling and non-renewable attributes. Thus it can be confirmed that natural fibres fit in our requirement as they will are accompanied with energy recovery, no addition to carbon emissions and lower global warming effects.

6. References

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3.1Population and Sample

KSE-100 index is an index of 100 companies selected from 580 companies on the basis of sector leading and market capitalization. It represents almost 80% weight of the total market capitalization of KSE. It reflects different sector company's performance and productivity. It is the performance indicator or benchmark of all listed companies of KSE. So it can be regarded as universe of the study.Non-financial firms listed at KSE-100 Index (74 companies according to the page of KSE visited on 20.5.2015) are treated as universe of the study and the study have selected sample from these companies.

The study comprised of non-financial companies listed at KSE-100 Index and 30 actively traded companies are selected on the bases of market capitalization.And 2015 is taken as base year for KSE-100 index.

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For this study secondary data has been collected. From the website of KSE the monthly stock prices for the sample firms are obtained from Jan 2010 to Dec 2014. And from the website of SBP the data for the macroeconomic variables are collected for the period of five years. The time series monthly data is collected on stock prices for sample firmsand relative macroeconomic variables for the period of 5 years. The data collection period is ranging from January 2010 to Dec 2014. Monthly prices of KSE - 100 Index is taken from yahoo finance.

3.3 Theoretical framework

Variables of the study contains dependent and independent variable. The study used pre-specified method for the selection ofvariables. The study used the Stock returns are as dependent variable. From the share price of the firm the Stock returns are calculated. Rate of a stock salable at stock market is known as stock price.

Systematic risk is the only independent variable for the CAPM and inflation, interest rate, oil prices and exchange rate are the independent variables for APT model.

Consumer Price Index (CPI) is used as a proxy in this study for inflation rate. CPI is a wide basic measure to computeusualvariation in prices of goods and services throughout a particular time period. It is assumed that arise in inflation is inversely associated to security prices because Inflation is at lastturned into nominal interest rate andchange in nominal interest rates caused change in discount rate so discount rate increase due to increase in inflation rate and increase in discount rateleads todecreasethe cash flow's present value (Jecheche, 2010). The purchasing power of money decreased due to inflation, and due to which the investors demand high rate of return, and the prices decreased with increase in required rate of return (Iqbal et al, 2010).

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I. RESEARCH METHODOLOGY

The methodology section outline the plan and method that how the study is conducted. This includes Universe of the study, sample of the study,Data and Sources of Data, study's variables and analytical framework. The detailsare as follows;

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Exchange rate is a rate at which one currency exchanged with another currency. Nominal effective exchange rate (Pak Rupee/U.S.D) is taken in this study.This is assumed that decrease in the home currency is inverselyassociated to share prices (Jecheche,2010). Pan et al. (2007) studied exchange rate and its dynamic relationship with share prices in seven East Asian Countries and concludethat relationshipof exchange rate and share prices varies across economies of different countries. So there may be both possibility of either exchange rate directly or inverselyrelated with stock prices.Oil prices are positively related with share prices if oil prices increase stock prices also increase (Iqbal et al, 1012).Ataullah (2001) suggested that oil prices cause positive change in the movement of stock prices. The oil price has no significant effect on stock prices (Dash & Rishika, 2011).Six month T-bills rate is used as proxy of interest rate. As investors arevery sensitive about profit and where the signals turn into red they definitely sell the shares. And this sensitivity of the investors towards profit effects the relationship of the stock prices and interest rate, so the more volatility will be there in the market if the behaviors of the investors are more sensitive. Plethora (2002)has tested interest rate sensitivity to stock market returns, and concluded an inverse relationship between interest rate and stock returns. Nguyen (2010) studies Thailand market and found thatInterest rate has aninverse relationship with stock prices.

KSE-100 index is used as proxy of market risk. KSE-100 index contains top 100 firms which are selected on the bases of their market capitalization. Beta is the measure of systematic risk and has alinear relationship with return (Horn, 1993). High risk is associated with high return (Basu, 1977, Reiganum, 1981 and Gibbons, 1982). Fama and MacBeth (1973) suggested the existence of a significant linear positive relation between realized return and systematic risk as measured by β. But on the other side some empirical results showed that high risk is not associated with high return (Michailidis et al. 2006, Hanif, 2009). Mollah and Jamil (2003) suggested thatrisk-return relationship is notlinear perhaps due to high volatility.

3.4Statistical tools and econometric models

This section elaborates the proper statistical/econometric/financial models which are being used to forward the study from data towards inferences. The detail of methodology is given as follows.

3.4.1 Descriptive Statistics

Descriptive Statics has been used to find the maximum, minimum, standard deviation, mean and normally distribution of the data of all the variables of the study. Normal distribution of data shows the sensitivity of the variables towards the periodic changes and speculation. When the data is not normally distributed it means that the data is sensitive towards periodic changes and speculations which create the chances of arbitrage and the investors have the chance to earn above the normal profit. But the assumption of the APT is that there should not be arbitrage in the market and the investors can earn only normal profit. Jarque bera test is used to test the normality of data.

3.4.2 Fama-Mcbeth two pass regression

After the test statistics the methodology is following the next step in order to test the asset pricing models. When testing asset pricing models related to risk premium on asset to their betas, the primary question of interest is whether the beta risk of particular factor is priced. Fama and McBeth(1973)develop a two pass methodology in which the beta of each asset with respect to a factor is estimated in a first pass time series regression and estimated betas are then used in second pass cross sectional regression to estimate the risk premium of the factor. According to Blum (1968) testing two-parameter models immediately presents an unavoidable errors-in-the variables problem.It is important to note that portfolios (rather than individual assets) are used for the reason of making the analysis statistically feasible.Fama McBeth regression is used to attenuate the problem of errors-in-variables (EIV) for two parameter models (Campbell, Lo and MacKinlay, 1997).If the errors are in the β (beta)of individual security are not perfectly positively correlated, the β of portfolios can be much more precise estimates of the true β (Blum, 1968).

The study follow Fama and McBeth two pass regressionto test these asset pricing models.The Durbin Watson is used to check serial correlation and measures the linear association between adjacent residuals from a regression model. If there is no serial correlation, the DW statistic will be around 2. The DW statistic will fall if there is positive serial correlation (in worst case, it will be near zero). If there is a negative correlation, thestatistic will lie somewhere between 2 and 4. Usually the limit for non-serial correlation is considered to be DW is from 1.8 to 2.2. A very strong positive serial correlation is considered at DW lower than 1.5 (Richardson and smith, 1993).

According to Richardson and smith(1993) to make the model more effective and efficient the selection criteria for the shares in the period are: Shares with no missing values in the period, Shares with adjusted $R^2 < 0$ or F significant (p-value)

>0.05of the first pass regression of the excess returns on the market risk premium are excluded. And Shares are grouped by alphabetic order into group of 30 individual securities (Roll and Ross, 1980).

3.4.2.1 Model for CAPM

In first pass the linear regression is used to estimate beta which is the systematic risk.

$$R_i - R_f = \left(R_m - R_f\right)\beta \qquad (3.1)$$

Where $R_i$isMonthly return of thesecurity, R_f isMonthly risk free rate, R_m isMonthly return of market and βis systematic risk (market risk).

The excess returns R_i - R_f of each security is estimated from a time series share prices of KSE-100 index listed shares for each period under consideration. And for the same periodthe market Premium R_m - $R_f$also estimated. After that regress the excess returns R_i - R_f on the market premium R_m - $R_f$to find the beta coefficient (systematic risk).

Then a cross sectional regression or second pass regression is used on average excess returns of the shares and estimated betas.

$$\hat{R}_i = \gamma_0 + \gamma_1\beta_1 + \epsilon \qquad (3.2)$$

Where $ƛ_0$= intercept, $\hat{R}_I$is average excess returns of security i,$\beta_I$isestimated be coefficient of security I and Є is error term.

3.4.2.2 Model for APT

In first pass the betas coefficients are computed by using regression.

$$R_i - R_f = \beta_i f_1 + \beta_{i2} f_2 + \beta_{i3} f_3 + \beta_{i4} f_4 + \epsilon \qquad (3.3)$$

Where Ri is the monthly return of stock i,R_f is risk free rate, β_i is the sensitivity of stock i with factors and ϵ is the error term.

Then a cross sectional regression or second pass regression is used on average excess returns of the shares on the factor scores.

$$\hat{R} = \gamma_0 + \gamma_1\beta_1 + \gamma_2\beta_2 + \gamma_3\beta_3 + \gamma_4\beta_4 + \epsilon_i \qquad (3.4)$$

Where$\hat{R}$ is average monthly excess return of stock I, ƛ = risk premium, β_1 to β_4 are the factors scores and ε_i is the error term.

3.4.3 Comparison of the Models

The next step of the study is to compare these competing models to evaluate that which one of these models is more supported by data.This study follows the methods used by Chen (1983), the Davidson and Mackinnon equation (1981) and the posterior odds ratio (Zellner, 1979) for comparison of these Models.

3.4.3.1 Davidson and MacKinnon Equation

CAPM is considered the particular or strictly case of APT. These two models are non-nested because by imposing a set of linear restrictions on the parameters the APT cannot be reduced to CAPM. In other words the models do not have any common variable. Davidson and MacKinnon (1981) suggested the method to compare non-nested models. The study used the Davidson and MacKinnon equation (1981) to compare CAPM and APT.

This equation is as follows;

$$R_i = \alpha R_{APT} + (1-\alpha)R_{CAPM} + e_i \qquad (3.5)$$

Where$R_{i=}$ the average monthly excess returns of the stock i, $R_{APT=}$ expected excess returns estimated by APT, $R_{CAPM=}$ expected excess returns estimated by CAPM and α measure the effectiveness of the models. The APT is the accurate model to forecast the returns of the stocks as compare to CAPMif α is close to 1.

3.4.3.2 Posterior Odds Ratio

A standard assumption in theoretical and empirical research in finance is that relevant variables (e.g stock returns) have multivariate normal distributions (Richardson and smith, 1993). Given the assumptionthat the residuals of the cross-sectional regression of the CAPM and the APT satisfy the IID (Independently and identically distribution) multivariate normal assumption (Campbell, Lo and MacKinlay, 1997), it is possible to calculate the posterior odds ratio between the two models.In general the posterior odds ratio is a more formal technique as compare to DM equation and has sounder theoretical grounds (Aggelidis and Maditinos, 2006).

The second comparison is done using posterior odd radio. The formula for posterior odds is given by Zellner (1979) in favor of model 0 over model 1.

The formula has the following form;

$$R = [ESS_0/ESS_1]^{N/2} N^{K_0 - K_1/2} \qquad (3.6)$$

WhereESS_0iserror sum of squares of APT, ESS_1iserror sum of squares of CAPM, Nisnumber of observations, $K_0$is number of independent variables of the APT and K_1 isnumber of independent variables of the CAPM.As according to the ratio when;

R> 1 means CAPM is more strongly supported by data under consideration than APT.

R < 1 means APT is more strongly supported by data under consideration than CAPM.

IV. RESULTS AND DISCUSSION

4.1 Results of Descriptive Statics of Study Variables

Table 4.1: Descriptive Statics

Variable	Minimum	Maximum	Mean	Std. Deviation	Jarque-Bera test	Sig
KSE-100 Index	-0.11	0.14	0.020	0.047	5.558	0.062
Inflation	-0.01	0.02	0.007	0.008	1.345	0.510
Exchange rate	-0.07	0.04	0.003	0.013	1.517	0.467
Oil Prices	-0.24	0.11	0.041	0.060	2.474	0.290
Interest rate	-0.13	0.05	0.047	0.029	1.745	0.418

Table 4.1 displayed mean, standard deviation, maximum minimum and jarque-bera test and its p value of the macroeconomic variables of the study. The descriptive statistics indicated that the mean values of variables (index, INF, EX, OilP and INT) were 0.020, 0.007, 0.003, 0.041 and 0.047 respectively. The maximum values of the variables between the study periods were 0.14, 0.02, 0.04, 0.41, 0.11 and 0.05 for the KSE- 100 Index, inflation, exchange rate, oil prices and interest rate.

The standard deviations for each variable indicated that data were widely spread around their respective means.

Column 6 in table 4.1 shows jarque bera test which is used to checkthe normality of data. The hypotheses of the normal distribution are given;

H_0 : The data is normally distributed.

H_1 :The data is not normally distributed.

Table 4.1 shows that at 5 % level of confidence, the null hypothesis of normality cannot be rejected. KSE-100 index and macroeconomic variables inflation, exchange rate, oil prices and interest rate are normally distributed.

The descriptive statistics from Table 4.1 showed that the values were normally distributed about their mean and variance. This indicated that aggregate stock prices on the KSE and the macroeconomic factors, inflation rate, oil prices, exchange rate, and interest rate are all not too much sensitive to periodic changes and speculation. To interpret, this study found that an individual investor could not earn higher rate of profit from the KSE. Additionally, individual investors and corporations could not earn higher profits and interest rates from the economy and foreign companies could not earn considerably higher returns in terms of exchange rate. The investor could only earn a normal profit from KSE.

FiguresandTables

Placefiguresandtablesatthetopandbottomofcolumns.Avoidplacingtheminthemiddleofcolumns.Largefiguresandtablesmayspanacrossbothcolumns.Figurecaptionsshouldbebelowthefigures;tablecaptionsshouldappearabovethetables.Insertfiguresandtablesaftertheyarecitedinthetext.Usetheabbreviation**"Fig.1"** in the text, and "**Figure 1**" atthebeginningofasentence.

Use10**pointTimesNewRoman**forfigurelabels.Usewordsratherthansymbolsorabbreviationswhenwritingfigure-axislabelstoavoidconfusingthereader.Asanexample,writethequantity "Magnetization",or "Magnetization,M",notjust "M".

Table 1 Table Type Styles

Table Head	**TableColumnHead**		
	Tablecolumnsubhead	**Subhead**	**Subhead**
copy	Moretablecopy[a]		

V. ACKNOWLEDGMENT

Thepreferredspellingoftheword "acknowledgment" inAmericaiswithoutan "e" afterthe "g".Avoidthestiltedexpression, "Oneofus(R.B.G.)thanks..." Instead,try"R.B.G.thanks".Putapplicablesponsoracknowledgmentshere;DONOTplacethemonthefirstpageofyourpaperorasafootnote.

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