Testing the Arbitrage Pricing Theory on Karachi Stock Exchange

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Abstract

The aims of the study is to test the validity of arbitrage pricing theory (APT) in Pakistani Economy using macroeconomic factors and identifying the most relevant macroeconomic factors that are helpful in explaining variation in the stock returns. Moreover, study also reveals the extent to which identified factors explain variation in stock returns. The study has important implications for Pakistani investors to move from CAPM to APT (A more reliable measure of risk premium) for estimation of risk premium while scaling their required rates of returns. Four macroeconomic variables (Inflation, Exchange Rate, Money Supply (M1) and Oil Prices) are identified using pre-specified macroeconomic variable approach. Exchange rate is taken as Pak Rupee against US Dollar. Convenience sampling technique is used to locate the sample and 26 companies listed on Karachi Stock Exchange (KSE) constitute the sample for this study. Monthly data for all macroeconomic variables and stock prices of the sampled companies is collected over a period of 5 years (2004-2008). Data is scaled by calculating the percentage returns to facilitate the comparison. Regression is run for all 26 companies individually using stock return as dependent variable and all the macroeconomic factors as independent variables. This yielded the sensitivity of stock prices to each macroeconomic variable (beta) for all the companies in sample. Using these beta coefficients, the projected values of stock returns for sample period are calculated. One sample t-test is used to compare the actual and projected stock returns. The results showed no significant difference between two value sets. Thus we concluded that the outcome of Arbitrage Pricing Theory is much similar to actual one and APT is efficient enough to predict the future stock returns, hence its validity is supported. This study has limitations for example the convenience sampling technique may not be the appropriate to generalize the results. However if comparatively large sample is taken from each sector and more macro and micro variable both are taken together, the study can yield better results.
Keywords: *Arbitrage Pricing Theory, Inflation, Exchange Rate, Money Supply, Oil Prices*

Background

Investment decision remained a confusing task till early 1950, investors used to make investment decisions solely on return, they talked about the risk but there was no measure for it. To build a portfolio model however investors had to quantify their risk variable. The basic portfolio model was developed by Harry Markowitz (1952), who developed the measure of expected rate of return and expected risk. He showed that weighted average of historical returns and the variance of these returns represent the expected return and expected risk respectively. He showed a linear relationship between risk and return.

Although the relationship between risk and return was linear but investors were facing a difficulty as to how much extra return (Risk Premium) should be demanded for bearing the risk. Moreover, Markowitz theory proposed limited options of efficient portfolios for investors without considering the risk free asset and with diminishing trade off between risk and return. In William Sharpe (1964) added the risk free asset in Markowitz portfolio theory; this led to the base of Capital Market Theory. With addition of risk free asset the options for the investors were extended and a model to determine the risk premium was developed known as Capital Asset Pricing Model (CAPM). Lintner (1965) and Mossin (1966) derived the similar theories independently. The capital asset pricing model calculates risk premium for a given portfolio by multiplying the market risk premium with beta measure of systematic risk. The assumption underlying the capital asset pricing model that unsystematic risk has totally been eliminated during the portfolio construction allows the consideration of only systematic risk in calculation of risk premium. Market risk premium is calculated by subtracting the rate of return on a risk free asset from the rate of return on a market portfolio while beta measure of systematic risk is calculated by dividing the covariance between a given asset and market portfolio by the variance of market portfolio. Theoretically the beta measures the extent to which the returns from a given portfolio move with the changes in market's portfolio's return.

John Lintner (1969) criticized the CAPM for its assumptions of investor's homogenous expectations, availability of risk free lending and borrowing facility and absence of taxes and transaction costs.

Fischer Black (1972) proposed that there is no risk free asset and hence no riskless borrowing or lending available to investors. So he added a risky asset in place of risk free asset in CAPM and proved that results are significant for risky asset.

One of criticism on Capital Asset Pricing Model was that it is a static model (for a single time period); Robert C. Merton (1973) respond to this criticism by introducing the instantaneous rate of return on a portfolio that has negative correlation with risk free asset.

Introduction

One challenge to efficacy of the CAPM was the set of the results suggesting that it is possible to use knowledge of certain security characteristics to develop profitable trading strategies, even after adjusting for investment risk measured by beta. One of the criticisms on Capital Asset Pricing Model was that there are certain other factors that contribute to the risk of a given asset while CAPM considers only beta measure to calculate the risk premium. Although the CAPM is an elegant and appealing explanation for the way in which investment risk and expected returns are related, a number of empirical anomalies-such as the small firm effect-have caused financial economists to seek other answers. Stephen A. Ross (1976) subsequently devised an alternative asset pricing model that makes fewer assumptions than the CAPM and does not specifically require the designation of a market portfolio. Instead, the APT asserts that expected security returns are related in a linear fashion to a multiple common risk factors and these factors have orthogonal relationship.

$$R_i = R_f + b_{i1}f_1 + b_{i2}f_2 + \ldots\ldots\ldots + b_{ik}f_k + \epsilon_i$$

R_i is random return of asset i, R_f is risk free return on asset I, b_{ik} is the sensitivity of the assets return to the k factor and ϵ_i is random error (represents unsystematic or idiosyncratic factor).

The APT is derived under the usual assumptions of perfectly competitive and friction less capital market, Individuals with homogeneous expectations (rational), random returns are due to the K factors in the market, and number of assets under consideration be much larger than number of factors.

Unfortunately the APT does not offer guidance as to how many factors exist or what their identities might be. Given the common risk factors are not identified the APT is difficult to put in to practice in a theoretically rigorous fashion. Especially the findings of Banz (1981)

showed that portfolio of the stocks with low adjusted bases, and Basu (1977) who documented that stocks with low P/E ratios, out performed high P/E stocks.

Richard J. Dowen and W. Scott Bauman (1986) argued that persistent, positive abnormal re-turns accrue to common stocks that have low price-earnings (P/E) ratios, have small corporate capitalizations and are neglected by institutional investors. Given the persistence of these special effects, it may be useful to incorporate them into a pricing model. More recent work by Fama and French (1992) also demonstrate that those stocks with high book value to market price ratios tend to produce large risk adjusted returns than growth stocks. To bridge this gap Fama and French (1996) proposed the multifactor model which specify the set of variables that are brought to capture the essence of systematic risk exposure that exist in capital market. Fama and French (1996) used the microeconomic approach to employ three risk factors, the broad market index returns, difference in the returns of small and large capitalization stock and return difference between portfolios of value and growth oriented stocks.

This study aims at testing the validity of arbitrage pricing theory (APT) in Pakistani Economy using macroeconomic factors and identifying the most relevant macroeconomic factors that are helpful in explaining variation in the stock returns. Moreover, study also reveals the extent to which identified factors explain variation in stock returns.

This study has important implications for Pakistani investors to move from CAPM to APT: A more reliable measure of risk premium, for estimation of risk premium while scaling their required rates of returns. Despite differing empirical results, researchers term APT as more reliable measure of risk premium as compared to CAPM but investors pay little heed to APT and prefer the use of CAPM in their investment decisions. This is may be due to the fact that APT does not specify the factors that explain the variance in stock returns. Different micro and macroeconomic factors affect asset returns differently; APT needs to be tested for its validity in different economies (John 1996).

The researchers in the past have debated the validity of APT in various economies; this study investigates whether APT is valid in Pakistani economy using macroeconomic factors and what are the most relevant factors that help in explaining the variations in stock returns. Moreover to what extent the identified variables explain variation in stock returns.

Literature Review

Most of the literature on testing of APT revolves around two main topics, one the identification of relevant factors and second the fact that whether APT is testable or not. Shanken(1982) in his research paper " The Arbitrage Pricing Theory: Is it testable?" took the issue with a view that the empirical APT differs from actual APT in that the assertion that implies is held to be valid, independent of other assumption, not only for assets but also for arbitrary portfolios. He argued that empirical tests are performed using actual assets (Stocks etc), not on arbitrary recombination. This means that empirical APT is unrelated to the empirical work.

Chen at al. (1986) proposed that impact of macroeconomic factors on equity returns can be found and the results can be compared to check the validity of these tests. He regressed all identified macroeconomic factors on stock returns of individual companies to identify sensitivity of stock returns to the factors. He then used these sensitivities (betas) to project the returns for the companies for next 12 months. He compared the predicted returns with actual returns and found no significant difference. He termed those factors valid for predictions of equity returns.

Ross (1986), in response to Shanken (1982) critique, stated that both CAPM and APT are linked to separation theory- two fund separation and k fund separation respectively. If asset returns are generated by a factor model and no asset is in large aggregate supply, the CAPM implies the APT, but the converse is not true. He further stated that testing the APT on subset is typically valid. In the degenerated cases for which the testability is biased, the bias is towards rejection, so there is little danger of spurious acceptance of the APT.

Reisman (1988) demonstrated that APT is a simple consequence of a mathematical theorem if asset returns have an approximate factor structure. He mathematically derived the theory by just changing the variables with different micro and macroeconomic factors.

Ali Ataullah (2001) took macroeconomic variables as common pervasive risk factors and tested it empirically on Karachi Stock Exchange. He used pre specified macroeconomic factors approach for identifying the factor for pricing the securities and applied Iterative

Non Linear Seemingly Unrelated Regression (ITNLSUR). He specified the 9 macroeconomic variables like unexpected inflation, money supply, term structure, exchange rate, and oil prices etc. as common pricing factors. The data for these macroeconomic variables and for seventy securities listed in the stock market was taken for the period of April 1993 to December 1998. Unanticipated shocks in these factors are determined by the researcher. The results showed that four macroeconomic factors, unexpected inflation, exchange rate, trade balance and oil prices were carrying the risk premium in the Pakistani Stock Market. These are source of systematic risk in the market because they were determining the returns.

Iqbal et al (2005) studied the relationship of Arbitrage Pricing Theory and Karachi Stock Market as an emerging market. They used the monthly data for the period of January 1997 to December 2003. The data consisted of 24 actively traded stock returns of Karachi Stock Exchange comprising the 80% weight of aggregate market capitalization of KSE-100 index companies. In order to analyze the stability, they divided the data into two parts; the first data period was from January 1997 to December 1999 and the second is from January 2000 to December 2003. They included 16 macroeconomic variables and by using the exploratory factor analysis approach and pre-specified macroeconomic factors approach, they got 9 factors on the basis of variances explained by the factors. In exploratory factor analysis, they applied OLS regression and in pre specified approach, they used regression. Results of the two approaches were nearly same because in both methods two factors were pricing the returns, but the number of pricing factors was low. So there was instability of the explanatory power of APT.

Mauri Paavola (2006) tested the APT on Russian Equity Market by taking the 20 largest equity stocks of Russian Equity Market and calculated the returns. For the independent variables selection factor analysis approach is used which showed only five macroeconomic factors which were accounting for 80% of the variance. These variables were Money Supply, Inflation, Oil Prices, Industrial Production and Exchange Rates. Data taken was from the period of 1999-2006. After that a multiple regression was run on this sample. The results revealed that the macro economic variables were not determining the excess returns and the overall result was insignificant.

Tursoy et al (2008) tested the APT using the macroeconomic variables on the Istanbul Stock Market. They took the data for the period of February 2001 to September 2005 on monthly basis. They constructed 11 portfolios against 13 macroeconomic variables. The macroeconomic variables included were money supply (M2), industrial production, crude oil price, consumer price index (CPI), import, export, gold price, exchange rate, interest rate, gross domestic product (GDP), foreign reserve, unemployment rate and market pressure index (MPI) .Using the ordinary least square technique, they observed some differences among the portfolios they constructed. They concluded that macroeconomic variables have no significant results on the stock returns on the Istanbul Stock Market. But in different portfolios some macroeconomic variables were having positive affect while in other industry portfolio it was having adverse impact.

Review of previous literatures led us to hypothesize as follows:

Hypothesis: Arbitrage pricing theory is valid using macroeconomic factors in Pakistani context.

Using pre-specified technique of factor identification, we identified five factors to be used in APT model to explain variations in stock returns. These factors are inflation, exchange rate, narrow money, and oil prices.

Theoretical Framework

All the identified factors have a proven affect on stock returns. For example inflation reduces the purchasing power of money and investors build inflation into their required rates of return, increased required rate of return brings prices down. Money supply has an indirect effect, increase in money supply causes interest rates to go down, thus investors move their investments from interest bearing securities to stocks, and pressure on buying side pushes the stock prices up. Costs of inputs bring the profits of organizations down, which causes decline in demand for stock hence pushing their prices down.

Changes in exchange rates can affect the stock prices in both ways. Depreciation in home currency make importing firms pays more for imports, this reduces their profitability, and return on equity, which is ultimately reflected by drop in share prices and vice versa. Exchange rate may have a positive effect on stocks of exporting firms. If home currency

depreciates, firms earn more profit on their exports, their ROE increases and demand for their share goes up and so the prices do and vice versa.

Methodology

There exist a relationship between the stock returns and systematic variables. Change to these variables brings change in the level of sensitivity of the stock returns, so stock prices are usually considered to be affected by these systematic variables, which are like external forces to the stock prices.

Literature on testing the arbitrage pricing theory indicates two types of approaches to identify the relevant factors that explain the variation in stock prices. One is exploratory factor analysis and the other one is Pre- specified macroeconomic variables approach. Pre specified macroeconomic variable approach allows a researcher to use his knowledge of the effects of macroeconomic variables on stock prices and use this knowledge to identify most relevant factors to include in the study. This study uses Pre- specified macroeconomic variable approach to specify or define the macroeconomic variables prevailing in the market. These variables are chosen according to their effect in the Pakistani economy.

Population and Sample

All private companies listed on Karachi Stock Exchange (KSE) constitute the population of this study. Study uses the convenience sampling technique for choice of sample. A total of twenty six companies among the KSE-100 index were selected as sample for this study.

Data Collection

Monthly stock prices for sampled companies are collected from Karachi Stock Exchange website for five years: from 2004 to 2008. As stock prices differ in denomination, to facilitate the comparison we scaled the data by calculating the percentage change in prices (returns) using natural log of ending price divided by beginning price. Data on Exchange Rate, Inflation (CPI), Oil Prices and Money Supply (Narrow Money) is taken from the State Bank of Pakistan website for the period of 2004-2008. Exchange rate is taken as Pak Rupee against US Dollar. As these variables differ in denomination, we scaled the data by calculating the percentage change for ease in comparisons.

Analysis Tools

As Arbitrage Pricing Theory (APT) assumes the sensitivity of stock prices to different micro and macro variables, initially a correlation and regression analysis is needed to find the

sensitivity of these variables. Thus at first stage we used regression to calculate the sensitivity (Beta) of stock returns to the identified macroeconomic factors. Then one sample t-test is used to check difference between actual stock returns and the predicted values for these stocks.

Data Analysis

Co-relational Analysis

In order to proceed toward a causal check, there must be an association among the variables. A correlation analysis is carried out to see this association. Table 2 shows the results of correlation analysis.

Table 1
Co-relational Analysis

	STOCK RETURN	*CPI*	*OIL PRICES*	*M1*	*X.RATE*
STOCK RETURN	1				
CPI	-0.092332571	1			
OIL PRICES	0.114693157	0.243429	1		
M1	0.007525925	-0.2066	-0.1528865	1	
X. RATE	-0.130700047	0.624453	-0.0671434	0.047803	1

Table 1 shows the coefficient of correlation among the variables. Stock Returns and Inflation has negative coefficient of correlation. Oil prices and money supply are positively associated with the stock returns. Exchange rates are negatively correlated with the stock returns.

Regression Analysis

At first stage, regression is run for all 26 companies individually using stock return as dependent variable and all the macroeconomic factors as independent variables. This yielded the sensitivity of stock prices to each macroeconomic variable (beta) for all the companies in sample. Table 1 shows the values for these betas.

Stock Returns = α + $\beta1$ (Inflation) + $\beta2$ (Oil Prices) + $\beta3$ (Money Supply) + $\beta4$ (Exchange Rate) + $\acute{\epsilon}$

Where, β_1, β_2, β_3 and β_4 represent Sensitivity of Stock returns to inflation, Oil Prices, Money Supply and Exchange Respectively.

Table 2

Regression Coefficients for 26 Companies

	Company Name	β_1	β_2	β_3	β_4	A
1	Ali Asghar Textile Mills Limited	-2.5348	0.58411	0.997331	0.174108	-0.03034
2	Attock Cement Pakistan Limited	-0.84302	0.124839	-0.4003	-2.70769	0.029154
3	Adam Sugar Mills Limited	1.116556	0.067311	0.667855	0.145045	-0.01163
4	Artistic Denim Mills Limited	-1.18379	-0.10899	-0.25306	-1.86896	0.016679
5	Agriautos Industries Limited	-2.51659	0.273369	-0.32549	-1.43463	0.032747
6	Ahmad Hassan Textile Mills	-0.54405	0.051213	-0.12953	0.440515	0.003491
7	Al-Noor Sugar Mills Limited	-0.37181	0.30331	-0.69726	0.919821	0.030383
8	Al-Qadir Textile Mills Limited	0.277005	-0.15528	-1.04094	1.084132	0.023598
9	Altern Energy Limited	0.7652842	0.28271669	0.4119011	0.971878	0.013903
10	Ansari Sugar Mills Limited	0.0005893	0.32073058	0.0314220	1.566248	0.557094
11	Apollo Textile Mills Limited	4.679001	0.238102	0.326163	-4.3821	-0.00195
12	Aruj Garment Accessories Limited	-4.48948	0.263405	0.364803	2.090016	0.055065
13	Atlas Battery Limited	-1.77847	0.206886	-0.26604	0.073566	0.017306
14	Atlas Honda Limited	-1.70464	0.239344	-0.26551	0.264637	0.023403
15	Attock Refinery Limited	3.638573	0.47961	-0.47334	-4.17835	-0.00455
16	Bawany Sugar Mills Limited	2.776256	0.111955	1.917855	-2.49245	-0.03461
17	Bolan Castings Limited	-1.94413	0.23351	0.094872	0.220897	0.008798
18	Berger Paints Pakistan Limited	-8.2532	0.255776	0.003403	1.154915	0.060629
19	Balochistan Glass Limited	-2.63957	0.151281	0.508494	-1.09954	-0.00355
20	Biafo Industries Limited	1.170945	-0.10673	1.190171	-1.42834	0.00565
21	Brothers Textile Mills Limited	-5.48386	0.343306	1.019541	0.228198	0.006629
22	Century Paper & Board Mills Limited	-1.89233	0.113603	-0.21441	-1.1304	0.008551
23	Cherat Cement Company Limited	0.135794	0.192863	-0.52359	-3.28325	-0.00141
24	Clover Pakistan Limited	-0.09364	0.136735	0.579613	-0.30575	-0.00224
25	Colgate - Palmolive Pakistan	-2.84553	0.134375	-0.23877	0.241968	0.054465
26	Clariant Pakistan Limited	-2.73118	0.078349	-0.69172	-0.53396	0.039357

Values of betas in table 1 reveal the fact that, not all macroeconomic factors affect the stock prices of all the firms in same way. For example inflation has negative coefficient for the 17 out of 26 companies while for 9 companies it has positive coefficient. Oil prices have positive coefficient with stock prices for 23 companies while a negative for 3 companies. Money supply has negative coefficient for 13 companies and positive for remaining. Exchange rate has negative coefficient with stock returns for 12 companies whereas it has positive coefficient for 13 companies. However, on average inflation has a negative impact on stock prices. Oil prices and exchange rates have positive impact on stock prices.

Using these beta coefficients, we then calculated the projected values of stock returns for sample period. A comparison of these projected returns with the actual returns for the sample period is then carried out to test the validity of Arbitrage Pricing Theory using t-test

a technique suggested by Chen at al. (1986). He suggested that if actual returns and projected returns are same then the variables taken are significantly affecting the stock returns.

T-test analysis

T-test compares the two variables to analyze the difference between them. We wanted to check the similarity between actual returns and predicted returns. We opted for t-test because if it revealed no significant results then our purpose would be solved. Table 3 and 4 show the results of t-test.

Table 3

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Actual Returns	1560	.0022	.13397	.00339
Predicted Returns	1560	.0021	.04433	.00112

Table 3 shows sample statistics, number of observations in both variables are 1560. Mean for actual returns is 0.002 and for predicted returns is 0.021. This is an indication that two sets of values are nearly the same as there averages have only difference of 0.0001. Here we have some support to our hypothesis as the actual returns are nearly the same as the ones which are reached through use of Arbitrage Pricing Model. But we cannot rely on the averages because the standard deviation for actual return is 0.13397 and for that predicted returns is 0.04433, a difference of 0.08960. This difference somehow weakens our position to reject the null hypothesis, so we move to the results of t-test.

Table 4

One-Sample Test

	T	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Actual Returns	.662	1559	.508	.00225	-.0044	.0089
Predicted Returns	1.886	1559	.059	.00212	.0000	.0043

Table 4 reveals the outcomes of one sample t-test. T value in the second column for actual returns is 0.0662 and for predicted returns is 1.886. The results of t-test are significant if the

t value is greater than 2. This would mean that there is a significant difference between the two sets of values. But here the t value is less than 2, which means the two sets of values (Actual and Predicted Returns) show no significant results. Thus our hypothesis that "Arbitrage Pricing Theory (APT) is valid in Pakistani economy" is supported. This is further supported from the values in column 4 in table 4. For significant difference to exist between two sets of values, the p value has to be less than 0 .05 at 95% confidence level. This value is however greater than 0.05 which indicates that there exists no significant difference between the two series of values. In other words the two series of values are same.

Conclusion and Recommendations

This study examined the efficiency of Arbitrage Pricing Theory (APT) in Pakistani equity market. This study has explored four macroeconomic variables as systematic influences on stock returns in Pakistan. The literature on testing the Arbitrage Pricing Theory (APT) revolves around three main topics. First, the methods to identify the relevant factors that impact the stock prices the most, second, the methodology to be used in testing APT and third, the validity of APT in different economies. This paper used pre-specified macroeconomic method to identify the relevant factors and proposed a methodology bit different to Chen at al. (1986). This methodology to test APT has got three stages. At first stage regression is run for all the companies' returns individually using identified macroeconomic factors as independent variables and the stock returns as dependant variables. The regression analysis yields the regression coefficients (Beta) for all the macroeconomic factors. At second stage these betas are used to calculate the projected values of stock returns for sample period. Third stage compared the actual returns with projected returns to check the similarity between these two set of values.

Results of t-test showed no significant difference between predicted stock returns and actual returns. Thus we concluded that the outcome of Arbitrage Pricing Theory is much similar to actual one and APT is efficient enough to predict the future stock returns, hence its validity is supported.

This study has some limitations for example the convenience sampling technique may not be appropriate to generalize results. However if comparatively large sample is taken from each sector and more macro and micro variable both are taken together, the study can yield better results.

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