



## TESTING THE VALIDITY OF ARBITRAGE PRICING THEORY: A STUDY ON DHAKA STOCK EXCHANGE BANGLADESH

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### ABSTRACT

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The purpose of the study was to test the validity of Arbitrage Pricing Theory (APT) in Dhaka Stock Exchange (DSE) of Bangladesh. Secondary data has been used which was composed of observable macroeconomic and stock market variables. Study period was from January 2013 to October 2018, making a total of 70 monthly observations. Study found that interest rate and exchange rate has significant influence but market capitalization and tax rate have insignificant impact on return of DS-30 index. Except exchange rate, other three variables were negatively related with DS-30 index return. 1% increases in exchange rate results 0.993% increase in stock prices while 1% increases in interest rate results 0.486% decrease in stock prices and vice-versa. Strong negative correlation was seen between interest rate and stock index return. APT have failed to fully explain the change of DS-30 index return due to presence of two insignificant explanatory variables. This research has practical implications on stock market participants as investors' optimal strategy largely influenced by precision of asset pricing models. This research has also policy implications for Securities & Exchange Commission, government, and other regulators as findings of the study will assist them to develop more efficient capital market.

**Contribution/Originality:** This study contributes to the existing literature of asset pricing model by judging its reliability in Bangladeshi capital market. This study is one of very few studies which have investigated the validity of Arbitrage Pricing Theory in Dhaka Stock Exchange with the help of index of blue chip companies.

### 1. BACKGROUND OF THE STUDY

The capital market is a channel of direct finance. It enables mobilization of funds for investment purposes from purchaser of capital market securities or investor to issuer of securities or borrowers (Imam, 2001). It is a market where savings are made available to investors as firms get capital through issuing financial assets such as bonds and equities. In other words, through capital market funds are transferred from investors to different economic entities in exchange of transfer of financial instruments (Chowdhury, 2005). Like other markets it has a set of rules to ensure protection of the buyers i.e. investors.

Capital market lies at the heart of the economic development of a country as it circulates the life blood of industrialization, i.e. the capital, in an economy; like a heart circulates blood in a human body. But it requires rigorous, conscious, and continuous human efforts to result in a fully and efficiently functioning organ of an economy. These efforts encompass some fundamentals related to the very nature of the market without establishing which the true benefits of the market cannot be harnessed. Several theories and models have been developed for

estimating prices or values of financial instruments. Arbitrage Pricing Theory (APT) is one of them. Determination of asset prices through well-established models or theories is an indicator of a well-functioning capital market.

## 2. PROBLEM STATEMENT

An investor's appropriate investment decision largely depends on accuracy level of forecasting stock prices or values. In general, market prices of firms' shares in Dhaka Stock Exchange (DSE) fluctuates every now and then and price variation enhances as investors' holding periods lengthen (Mollik & Bepari, 2010). DSE stock return behave abnormally for example stock market price crash of 1996 and 2010. Many investors gained and many faced tremendous losses from the unexpected price abrupt DSE trade stock. As the shares of stocks of different industries' firms are traded in DSE and the economy consists of different industries so certain macro-economic variables should have significant impact on stock prices. Some macro-economic variables are treated as explanatory variable in APT and in an efficient and well developed capital market true asset prices can be forecasted through APT which guides rational investment behavior. Individual and institutional investors' investment decisions influence the degree of abnormal return and price instability.

## 3. THEORETICAL FRAMEWORK OF ARBITRAGE PRICING THEORY (APT)

The APT is a multi-index model which along with market index describes both macroeconomic and industrial factors that changes most of the security prices to a specific direction. Influence of non-market factors are incorporated. Initial equation for APT test is:

$$R_{it} = \alpha + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \dots + \beta_i X_{it} + \varepsilon \quad (\text{Dimson \& Mussavian, 1999})$$

Here,  $R_{it}$  the return of  $i$ th stock at  $t$  period.  $\alpha$  is the intercept,  $\beta_1, \beta_2, \dots, \beta_i$  are relative slopes of  $X_1, X_2, \dots, X_i$  macro variables.  $\varepsilon$  is the error term.

The Fama-French three factor model:

Fama and French (1993); Fama and French (1995) proposed a three factor model to evaluate stock market return;

$$E(R_i) = R_f + \beta_1 [E(R_m) - R_f] + \beta_2 \text{SMB} + \beta_3 \text{HML}$$

Here, HML is the difference in return between portfolios of assets with high book to market and low book to market ratio. SMB is the difference in return between portfolios of assets with small market capitalization and big market capitalization.

## 4. LITERATURE REVIEW AND RESEARCH GAP

Lehmann and Modest (2005) published a study examining the different strategies for constructing basis portfolios that are highly correlated with the factors affecting security rates of return. Study found that performance of portfolios with large number of securities was better than portfolios with small number of securities. They found factor analysis as superior technique to principal components procedures. Ingersoll (1984) is one of the supporters of the APT model, stating in his study that the APT does not incorporate CAPM's dubious assumptions in describing simple linear relationship between security prices and various factors those have impact on rates of return. According to opinion of some researchers, although equally weighted stock market index does not truly represent market portfolio, its movement of returns should be highly associated with the true market portfolio (Kandel & Stambaugh, 1987; Shanken, 1985).

Chen, Roll, and Ross (1986) in their study verified the soundness of the APT in US stock markets. They found several macroeconomic factors such as industrial production, variations in risk premiums, and the shifts in the yield curve have profound influence on stock's return. The relation between risk and return for agricultural assets was examined by Arthur, Carter, and Abizadeh (1988) who concluded that the APT was better at explaining returns for these assets than the CAPM. Handa and Linn (1993) in their study depicted a linear relationship between expected

asset returns and their factor betas; however, they also concluded that when there is more information available, predicted prices were higher while factor betas were relatively lower. On the other hand, less available information underestimated prices and overestimated factor betas.

Sarver and Philippatos (1993) evaluated the nature of spot foreign exchange risk premiums using the APT. They tested whether the differences in the pure returns on currencies depend on systematic risk. They came to the result that single-factor APT model can describe expected exchange returns. Due to non-stationarity problem of security returns, Koutmos and Theodossiou (1993) examined the impact of conditional heteroskedasticity in the APT with observed variables. Study revealed that forming portfolios can't remove the existence of conditional heteroskedasticity which leads to inefficient estimates of factor betas, and if ignored leads to erroneous pricing of factors. Nshom (2007) analyzed 18 stocks listed in London Stock Exchange (LSE) to explore the association between return of stock and currency exchange rates. Study revealed that in case of some firms, return of stock was significantly affected by exchange rate changes. Cauchie, Hoesli, and Isako (2004) conducted a study on the determinants of stock returns using an APT framework in the Swiss stock market which is particular because it includes a large number of firms that are susceptible to foreign economic conditions. They used statistical and macroeconomic implementations of the APT on 19 industrial sector indices. They concluded that statistically determined factors were better at explaining determinants of stock returns than macroeconomic variables.

Altay (2003) analyzed German and Turkish economies and used the factor analysis technique on key economic indicators for identifying significant factors that affect security returns in an APT framework. Altay used the same economic indicators for both countries and found four factors affecting the German market while he found only 3 for the Turkish market. The German market had two factors relating to unexpected economic changes. Ramadan (2012) conducted a research on 12 industrial portfolios which consisted of listed stocks traded in Amman Stock Exchange of Jordan over the period 2001-2011. Regressing six variables on stock return study found that four variables explained 84% changes in stock return. Study also revealed that the impact changes across industries. Zubairi and Farooq (2012) in their research tested both CAPM and APT using stock returns of fertilizer and power industries listed in Karachi Stock Exchange, Pakistan. Study found that macroeconomic variables were not the significant determinant of stock returns and hence APT was not valid. For testing efficiency of APT, (Basu & Chawla, 2012) analyzed 10 portfolios which consists of 50 stocks traded in Indian stock exchange over the period 2003 to 2008. Study found that APT is valid since macroeconomic variables of APT were significantly associated with portfolios' return. Iqbal, Khattak, Khattak, and Ullah (2012) tested the validity of APT in Karachi Stock Exchange of Pakistan using four macroeconomic factors and 26 listed firms' stocks during 2004-2008. Study found that APT was valid since actual return did not significantly deviate from projected return.

Depending on the previous studies mentioned above, it can be concluded that some of these studies supported the APT while others don't. All studies used different methods in testing the validity of the models, some used unconditional APT while others used conditional APT, and thus the results are inconclusive. So, here some space of investigating the validity of model on Bangladesh Stock Market is found. Although few research works were done on Capital Asset Pricing Model (CAPM) but no research work was done on validity of APT from the context of Bangladeshi Stock Market. Aim of the present study is to fill this research gap.

## 5. RESEARCH OBJECTIVES:

The main purpose of the study is to test the validity of Arbitrage Pricing Theory (APT) model in Dhaka Stock Exchange (DSE). The specific objectives are as follows:

- a. To know about some descriptive statistics of DS-30 index return and macro-economic variables used in APT model.
- b. To identify the strength and direction of co-movement between DS-30 index return and macro-economic variables used in APT model.

- c. To explore the significance of impact of macro-economic variables on DS-30 index return.

## 6. HYPOTHESES

The hypotheses of the study are as follows:

*H<sub>0</sub>-1: Exchange rate has significant effect on return of DS-30 index.*

*H<sub>0</sub>-2: Interest rate has significant influence on return of DS-30 index.*

*H<sub>0</sub>-3: Market capitalization has significant impact on return of DS-30 index.*

*H<sub>0</sub>-4: Tax rate has significant influence on return of DS-30 index.*

## 7. RESEARCH METHODOLOGY

### 7.1. Data and Sample

The data in this particular study consist of secondary data composed of observable variables that has been obtained from the DSE library, Bangladesh Bureau of Statistics, and Bangladesh Institute of Bank Management. This has covered the period from January 2013 to October 2018, making a total of 70 monthly observations. Data has comprised of interest on commercial bank loans & advances; interest on savings of commercial banks; exchange rate of the U.S dollar, Value of market capitalization, Taxes paid to government by investor and rate of return of DS 30 index.

### 7.2. Model Specification

The analysis has involved performing test of relative pricing model to know how much of the movement in stock returns is picked up by the several explanatory variables. From the full sample of 30 stocks, the firms selected spanned the full spectrum of stocks contained in the sample. The model for APT test is:

$$RRD_t = \alpha + \beta_1 EXP_t + \beta_2 INT_t + \beta_3 CAP_t + \beta_4 TAX_t + \varepsilon_t \quad (\text{Sharpe \& Cooper, 1972})$$

Here,  $RRD_t$  representing Rate of Return on DS 30 companies at time period  $t$  is the *dependent variable*. Returns are articulated in percentage forms for study periods.

*Independent variables:* Exchange Rate ( $EXP_t$ ), Interest Rate ( $INT_t$ ), Market Capitalization ( $CAP_t$ ), and Taxes paid by investors ( $TAX_t$ ) at time period  $t$ .  $\beta_1, \beta_2, \beta_3, \beta_4$  are coefficients of exchange rate, interest rates, market capitalization & taxes respectively while  $\alpha$  is constant and  $\varepsilon_t$  is the error of analysis

- **Stock return** –Return of a stock ( $RRD$ ): It depends on stock prices which is largely influenced by value creation.
- **Exchange Rate**- Ratio of two currencies ( $EXP$ ): An exchange rate estimates the estimation of one cash in units of another money.
- **Interest rate** ( $INT$ ): It is the general market interest rate which indicates the fee paid for obtaining the fund. It is the cost of borrowing for the fund receiving entity.
- **Market capitalization** ( $CAP$ )-Aggregate market stock value: It alludes to the all-out dollar market value of an organization's outstanding shares. It is determined by duplicating an organization's offers remarkable by the present market price of one share.
- **Taxes** - Mandatory charges paid to government ( $TAX$ ): A charge which is an obligatory budgetary charge or some other kind of toll forced upon a citizen (an individual or other lawful element) by a legislative association so as to support different open expenditures.

### 7.3. Data Analysis Technique

Here in the study, data have been analyzed using Ordinary Least Squares (OLS) or linear least squares method. It is a method for estimating the unknown parameters in a linear regression model. For APT test a regression model for establishing an equation is formed. This equation describes the relationship of  $RRD$  with other independent variables such as exchange rates, interest rates, market capitalization and taxes.

- a) Data were dissected to information utilizing E-Views 10. Some specific tests were performed as followings:
- 1) Descriptive measurements.
  - 2) Correlations between factors.
  - 3) Estimation of regression coefficients.
  - 4) Diagnostic tests: Normality, heteroskedasticity, serial auto correlation, model stability, and multicollinearity.
- b) Hypothesis test was performed through multiple linear regression.

## 8. RESULTS AND DISCUSSIONS

### 8.1. Descriptive Statistics of Variables

It is necessary to comment on some preliminary features of the data for analyzing the result of the study. Table 1 shows descriptive statistics for the Return of DS30 and other independent variables.

**Table-1.** Descriptive statistics of dependent variable and independent variables.

Statistics	RRD	EXP	INT	CAP	TAX
Mean	3.249404	1.897652	0.808625	3.753781	5.075939
Median	3.245375	1.894316	0.814229	3.778838	5.076294
Maximum	3.358549	1.922985	0.938520	3.834866	5.311029
Minimum	3.108089	1.888741	0.684845	3.443106	4.436799
Std. Dev.	0.059084	0.009821	0.089872	0.103793	0.137199
Skewness	-0.129869	1.371836	0.082612	-2.399796	-
Kurtosis	2.486674	3.632694	1.488254	7.121232	8.240003
Probability	0.634397	0.000018	0.041589	0.000000	0.000000
Sum Sq. Dev.	0.226910	0.006269	0.525002	0.700242	1.223524
Observations	70	70	70	70	70

**Note:** Here all variables are in the percentage form. Data have been compiled by the researchers and calculated in EViews10.

From the table, we can see that average return of DS30 is 3.25%. The mean of TAX is the largest (5.08) and the lowest one is INT (.81) over the period. In term of standard deviation, highest value is TAX with 0.137 followed by CAP, INT, RRD and EXP with 0.104, 0.0899, 0.059 and 0.0098 respectively. All of the variables except EXP and INT have negative skewness and positive kurtosis values.

### 8.2. Correlation between Macroeconomic variables and DS-30 Index

**Table-2.** Correlation among variables.

Variables	RRD	EXP	INT	CAP	TAX
RRD	1	0.65223686	-0.8295003	-0.4721129	0.45743023
EXP	0.65223686	1	-0.6582619	-0.8305811	0.41359074
INT	-0.8295003	-0.6582619	1	0.45274716	-0.5795148
CAP	-0.4721129	-0.8305811	0.45274716	1	-0.5046696
TAX	0.45743073	0.41359074	-0.5795148	-0.5046696	1

From Table 2 it is seen that relationship between RRD and INT is strong and negative as the value of correlation coefficient is -0.829. Moderate and positive correlation is seen between RRD and EXP (0.65). Negative and weak correlation is seen between RRD and CAP (-0.472) while TAX is positively related with RRD.

### 8.3. Impact of Macroeconomic Variables on Return of DS-30 Index

Regression model paves the way of constituting the mentioned equation. The independent variable which has high coefficient value at low probability has impact RRD more.

From the Table 3, it is clear that constant value is 1.932. Coefficient values of EXP, INT, CAP and TAX are 0.993, -0.486, -0.015 and -0.023 respectively. The probabilities are less than 5% for EXP and INT which means that

null hypothesis is rejected and these two macroeconomic variables has significant impact on return of DS-30 index. The other two variables CAP and TAX are insignificant as probabilities are greater than 5% and thus null hypothesis is accepted. From the regression model the actual equation established such as-

$$RRD_t = 1.93 + 0.993 EXP_t + (-0.486) INT_t + (-0.015) CAP_t + (-0.023) TAX_t$$

From the empirical study it is obvious that exchange rate significantly and positively affects stock return of DS30 companies. 1% increases in exchange rate results in 0.993% increase in stock prices at 5% significant level in the safe range having 0.097% standard error. Another variable that has significant impact is INT but it is negatively related with return of DS-30 index. 1% increases in interest rate results in 0.486% decrease in stock prices at 5% significant level having standard error 0.075%. The other two variables TAX and CAP have negative impact on stock prices but have insignificant impact. This supports the findings of Dimitrova (2005). 1% increase in market capitalization results in 0.015% decrease in Return of DS30 having standard error 0.187%. It is noted that 1% increase in TAX causes 0.023% decrease in stock price and vice versa. So, it is relatively more worthy in considering exchange rate and interest rate effect for investing in stock market although market capitalization and tax rate has insignificant effect. So, APT is not fully valid for determining stock prices of DS-30 companies of Dhaka Stock Exchange.

Table-3. Coefficient table of regression analysis.

Variable	Coefficient	Std. Error	t-Statistic	Prob.(p-value)	Decision on H <sub>0</sub>
C	1.932142	2.245506	0.860448	0.3929	
EXP	0.992655	0.097534	10.17746	0.0003***	H <sub>0</sub> -1 accepted
INT	-0.486033	0.074792	-6.498472	0.0004**	H <sub>0</sub> -2 accepted
CAP	-0.015400	0.082530	-0.186598	0.8526	H <sub>0</sub> -3 rejected
TAX	-0.022779	0.041635	-0.547117	0.5863	H <sub>0</sub> -4 rejected

#### 8.4. Model Fitness and Diagnosis Tests

Tests for model fitness are quite positive in the empirical analysis. The Table 4 shows the fitness of the overall model.

Table-4. Fitness of regression model.

R-squared	0.709438
Adjusted R-squared	0.690385***
S.E of regression	0.032876*
F-stat	37.234449**
No of observations	66

Note: (\*\*\*) , (\*\*) and (\*) indicates strongly, moderate and poor results.

Here R-squared is 0.709 meaning that about 71% of independent variables explain change of dependent variable RRD. Summary results of model diagnostic tests are given below:

Table-5. Overall results of diagnosis tests.

Name of Tests	Specific Model	Remarks
Normality Test	Jarque-Bera	Yes
Model specification test	Ramsey-Reset Test	Support
Heteroskedasticity	Breusch-Pagan-Godfrey(BPG) test.	No
Serial auto correlation	Durbin-Watson test/ Breusch- Godfrey Serial Correlation	No
Testing for multicollinearity	Variance Inflation Factors (VIFs)	No

From Table 5 it is seen that the data used in the study are normally distributed. It is found that from Jarque-Bera normality test. The estimated equation is stable and specified having 73% probabilities (Ramsey Reset test). The equation is free from Heteroskedasticity and serial auto correlation. So, the model has passed all of the standard tests.

## 9. CONCLUSION

In this study, four explanatory variables namely interest rate, exchange rate, market capitalization, and tax rate were used in APT model to assess the significance of impact of these variables on return of DS-30 index. It is found that two explanatory variables namely interest rate and exchange rate has significant influence but market capitalization and tax rate have insignificant impact on return of DS-30 index. It is also found that rise of interest rate adversely affects the return of DS-30 index. So, monetary policy has immense importance in this regard. Explanatory variables used in APT model have failed to fully explain the change of return of DS-30 index due to presence of two insignificant variables. Further studies can be undertaken to assess the validity of APT model by incorporating other macroeconomic variables such as inflation rate, per capital income, foreign direct investment etc.

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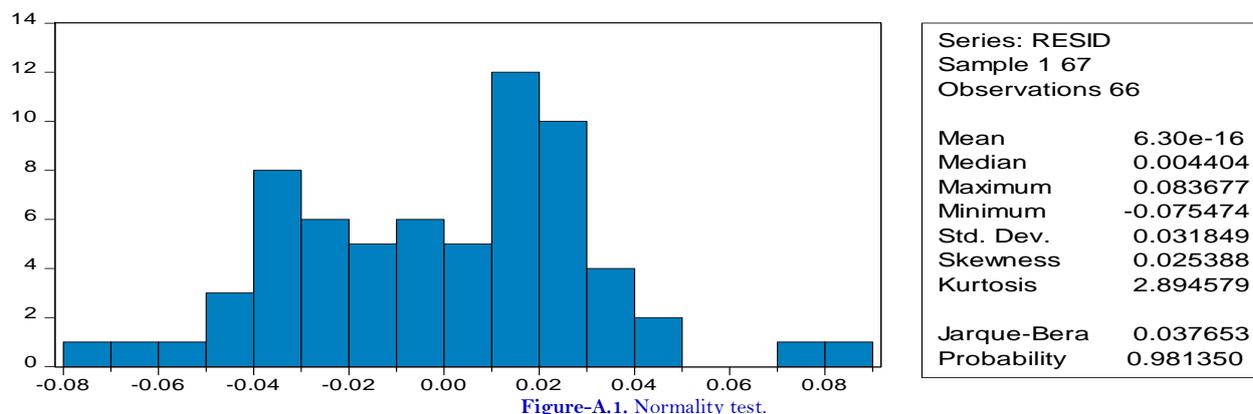
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## APPENDIX

### 1. Jarque-Bera Normality Test:

$H_0$ : Variables are normally distributed.

$H_1$ : Variables are not normally distributed.



From Figure A-1, it is revealed that p value of obtaining such a value from chi square is 0.9814(>0.05). Normality assumption of this study is not rejected.

### 2. Detection of heteroskedasticity:

$H_0$ : The error variance is homoscedastic.

$H_1$ : The error variance is not homoscedastic.

Table-A-1. Heteroskedasticity Test (Breusch-Pagan-Godfrey (BPG) Test).

F-statistic	1.029456	Prob. F(4.61)	0.3994
Obs *R-squared	4.173610	Prob. Chi-Square(4)	0.3830
Scaled explained SS	3.377274	Prob. Chi-Square(4)	0.4968

From Table A-1, it is seen that the observed chi-square value 0.4968 has high p value of 0.40 which suggesting that it is failed to reject null hypothesis. So, the model does not suffer from heteroskedasticity.

### 3. Model specification test (Ramsey-Reset Test):

$H_0$ : No specification error

$H_1$ : Having specification error

**Table-A-2.** Ramsey-Reset Test (Omitted variables: Squares of fitted values).

	Value	df	Probability
t-statistic	0.462769	60	0.6452
F-statistic	0.214155	(1,60)	0.6542
Likelihood ratio	0.235151	1	0.6277

Table A-2, showed that the P value of Ramsey's Reset Test F-statistics value is quite high ( $0.65 > 0.05$ ). So, we must accept null hypothesis and say that the equation is not mis-specified.

### 4. Detection of serial auto correlation:

$H_0$ : There is no positive auto correlation

$H_1$ : There is positive auto correlation

**Table-A-3.** Breusch- Godfrey Serial Correlation LM test.

F-statistic	40.72243	Prob. F(2,59)	0.083
Obs *R-squared	38.27382	Prob. Chi-Square(2)	0.0012

**Table-A-4.** Durbin watson test.

R-squared	0.579906	Mean dependent var	6.30E-16
Adjusted R-squared	0.537185	S.D. dependent var	0.031849
S.E. of regression	0.021667	Akaike info criterion	-4.726075
Sum squared resid	0.027697	Schwarz criterion	-4.493839
Log likelihood	162.9605	Hannan-Quinn criter.	-4.634308
F-statistic	13.57414	Durbin-Watson stat	1.881036
Prob (F-statistic)	0.000000		

Table A-4, showed that the estimated value of Durbin-Watson value is 1.88 which is near 2.0. It means that we may accept null hypothesis. So, there is no serial correlation in the study. For further testing, Breusch-Pagan LM test also has been used which is shown in Table A-3. Here, we see that p value .083 is above the level of significance (.05). So, null hypothesis is accepted.

### 5. Multicollinearity Test:

$H_0$ : There is significant correlation among independent variables.

$H_1$ : There is no significant correlation among independent variables.

Table-A-5. Results of multicollinearity test.

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	5.042298	307900.5	NA
EXP	0.951302	209191.9	5.517513
INT	0.005594	226.0663	2.717109
CAP	0.006811	5865.005	4.412733
TAX	0.001734	2729.313	1.962352

Table A-5 showed that no variable has centered VIF more than 10. So, we can say that variables do not suffer from strong relation within themselves or multicollinearity.

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