Arbitrage Pricing Theory: Empirical Evidence from Turkish Stock Market

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Abstract
Financial Equilibrium models have been widely studied in finance literature especially with respect to asset pricing theories. Validity of CAPM and Preference of APT over CAPM has been interest of academia as well as professionals. This research investigates number of potential factors explaining returns in Turkish markets as suggested by Ross (1980) when presented APT. For this purpose data of Istanbul Stock All exchanges from January 1, 2003 to December 31, 2013 has been used all the listed companies have been considered for this purpose. Our results suggest that in most of portfolios made for purpose of this research has two significant factors explaining returns although most of portfolios were having three orthogonal factors. It was rare that three factors were significantly explaining returns but it was not investigated that what are those factors.
Keywords: Arbitrage Pricing Theory, Factors Analysis, Principal Component Analysis

I. Introduction

The Arbitrage Pricing Theory (APT) and Capital Asset Pricing Model (CAPM) have been created as two models that have measured the potential for assets to generate a return or a loss. The Capital Asset Pricing Model assumes that stock returns are generated by a one-factor model. The factor corresponds to the market portfolio of all risky assets. Measuring the true market portfolio has emerged as main difficulty in the estimation of the CAPM.

Arbitrage Pricing Theory (APT) have been proposed by Ross (1976) as an alternative to the CAPM due to the severe problems in the testing the CAPM. The APT proposes that there are many sources of risk in the real economy and they cannot be eliminated by diversification. The common economic factors such as inflation constitute sources of risk. In the APT, an asset's return has sensitivity called as beta to changes in each factor, however in the CAPM there is only one beta.

In Arbitrage Pricing Theory, a security return is a linear function of several factors. Therefore the risk premium of an asset is related to the risk premium for each factor with the rate of sensitivity coefficients.

According to Chen (1986), changes in fundamental economic variables such as interest rate, inflation, market index are the main reasons for risk factors.

There are two main methods for testing the APT empirically. The first one is exploratory factor analysis. In this method, the asset sensitivities and unknown factors can be estimated simultaneously. However, the exact content and even the number of relevant factors aren't predicted. The other method is using pre-specifying general factors.

II. Literature Review

Yusuf Demur(2009) analyzed macroeconomic factors which affects stock return of banks traded in Istanbul Stock Exchange(İMKB) using the Arbitrage Pricing Theory. In that study monthly returns and sensitivity of stocks to the macroeconomic variables of 13 continuously traded banks in IMKB were investigated. Foreign exchange rate, capacity utilization ratio, Treasury bill rate, IMKB-100 index, money supply, industrial production rate, gross domestic product, gold prices and current accounts balance are considered as main factors in this study.

Javed Iqbal and Aziz Haider (2005) investigate the validity of the Arbitrage Pricing Theory (APT) model on returns from 24 stocks in Karachi Stock Exchange with monthly data from January 1997 to December 2003. Explanatory factor analysis shows that there are two factors. According to pre-specified macroeconomic approach, these two factors are the anticipated and unanticipated inflation and market index and dividend yield.

Sulaiman D. Mohammad, Syed Iqbal Hussain Naqvi and Irfan Lal (2012) examined the variability of Arbitrage price theory (APT) in in Karachi Stock Exchange with the monthly data from Jan 1985 to Dec 2008. Johnson co integration and Error correction model are used to check out the validity of APT in this study.

According to conclusion of this study there is an inverse relationship between quasi money with KSE 100 index return. On the Contrary bullion price and inflation rate are insignificant regarding to KSE 100 index returns

Hussain, A. et al (2009) finds the long run relationship between macroeconomic variables and prices of shares in Karachi stock exchange in Pakistan context. their study considers the monthly data of several macroeconomic variables such as real foreign exchange rate, foreign exchange reserve, industrial production index, whole sale price index, gross fixed capital formation, and broad money M2 , these variables are obtain from 1987 to 2008 period. For the purpose of finding long run relationship among the variables Johansen co-integration test is applied. The results show that after the reforms in 1991 the influence of foreign exchanges rate and foreign exchange reserve effects significantly to stock market. The result also shows that there was positive relationship between GFCF and M2 while WPI is negative relationship with stock price. The result also highlighted that interest rate is insignificant with stock prices in the long run. The VECM analysis illustrated that the coefficients of ecm1 (–1), and ecm2 (–1) were significant with negative signs. The coefficients of both error correction terms showed high speed of adjustment. The results of variance decompositions revealed that out of seven macroeconomic variables inflation showed greater forecast error for KSE 100 Index

III. Empirical Results

A. Data

Table 1 describes data used in this research. To test Arbitrage Price Theory we have used Bloomberg portal provided by Department of Management, Faculty of Business Administration, Bilkent University, Ankara, Turkey. Sample of 348 listed companies of Istanbul All Index were used for this purpose. Daily Shares Prices were obtained from there for the period of January 1, 2003 to December 31, 2013 giving Maximum Daily Observation of 4016 However, Data of Some companies was not available due to Suspension of trading, temporary delisting or simply to missing data for some of individual securities. Then from the Shares prices Daily Log Returns were calculated for all 348 companies. To make portfolios, 20 securities per group were decided and portfolios were form alphabetically. However, 9 of the securities were not having enough observation to be part of groups so those securities were discarded leaving 18 or 19 securities in some of Group. So Total 17 portfolios were formed out of which 9 portfolios were having 20 securities, 7 portfolios were having 19 securities and only 1 portfolio with 18 securities and 8 Securities with Last Alphabet were left as Group of 8 was insufficient to observe as portfolio.

Table 1: Data Description

Source	Bloomberg Portal, Department of Management, Bilkent University, Ankara, Turkey
Sample	348 Listed Companies of Istanbul All Index
Selection Criterion	17 Portfolios were created on the basis of alphabetical sequence listed on Istanbul All index on October 15, 2014. Daily Share Prices of All listed companies were taken from January 1, 2003 to December 31, 2013
Basic Data Unit	Daily Log Returns were calculated for All available Listed Companies
Maximum Sample Size per Security	4016 Daily returns
Number of Selected Securities	339 (Total 17 Portfolios, 9 Portfolio with 20 Securities, and 7 with 19 Securities and 1 with 18 Securities; 8 Securities with Last Alphabets were Left)

B. Estimating the Factor Model

Our research analysis includes following stages:

- For every portfolio, a sample product moment co-variance matrix is computed from their time series returns of Istanbul Stock Exchange from January 1, 2003 through December 31, 2013
- Initially maximum likelihood factor analysis was performed on the co-variance matrix of every portfolio but it was result in Heywood case which results in boundary solution so second best alternative method of principle component analysis was adapted to estimates the number of factors presented in series of returns from each portfolio.
- The individual assets factors loading estimates from previous steps were used to explain cross sectional variation of individual estimated expected returns. For this purpose ordinary least square cross sectional regression was used.
- Estimates from the cross sectional model were used to measure the size and statistical significance of risk premia associated with the estimated factors

Table 2 is showing the Factor Analysis with Principle Component Method on all 17 portfolios. Factor analysis shows the orthogonal factors presented in returns of all portfolio. We can see that in portfolio 1 there were three orthogonal factors with Eigen Value greater than or equal to 1. These three factors in portfolio 1 are capturing 55% of variation in returns. Similarly, in portfolio 2, again three factors were identified capturing two-third of variation of returns. We can see that orthogonal factors are capturing almost more than 50% of variation of

returns from different portfolios. Even In portfolio 17, captured variation is around four-fifth almost 80% which were captured on average by three orthogonal factors.

Table 2.1 summarize how many orthogonal factors were identified in available portfolios we can see that 11 out of 17 portfolios have three orthogonal factors around 65% whereas 4 portfolios out of 17 (24%) are having even more than three orthogonal factors. Only two portfolios out of 17 around 11% are having only two factors.

Table 2.1: Possible Factors present in Portfolios

Number of Factors	Portfolios
Five Factors	1
Four Factors	3
Three Factors	11
Two Factors	2
One Factor	0
Total Portfolios	17

Table 3.1: Cross-sectional least squares regressions of Mean Sample Returns on factor loadings Estimates (17 groups of 20 individual securities per group, 2003-2013 daily returns)

Percentage of groups with at least this many factor risk premia significant at the 95% level				
Factors	**1**	**2**	**3**	**4**
% of Groups	41.18%	17.65%	5.88%	0.00%
Note: 10 out of 17 (58% portfolio does not have any significant Factor)				
Percentage of groups with at least this many factor risk premia significant at the 90% level				
Factors	**1**	**2**	**3**	**4**
% of Groups	64.71%	23.53%	11.76%	0.00%
Note: 6 out of 17 (35.3% portfolio does not have any significant Factor)				

Table 3 shows results of all the portfolio showing number of factors significant with regression including intercept as risk free returns. We can see out of 17 portfolios only 6 portfolios having significant F statistics showing although number of hidden factors are presented in returns but they are not significant on regular basis (6 out of 17). We can see that In portfolio P1, P11 and P13, out of 3 factors identified in factors analysis only 1 is significant, in portfolio P4, out of 4 factors identified in factors analysis two factors are significant, where as in P17, factors analysis was showing 3 potential factors explaining returns out of which 2 are significant. Only in one portfolio P6 which identified 4 factors from factors analysis, three were significant. Risk Free rate is not significant in 13 out of 17 portfolios showing weakness of efficient market hypothesis in turkey.

Table 3.1 summarizes table 3 in more concise way showing number of factors which are significant at 95% in first panel and factors which are significant at 90% in second panel of table. First Panel of 3.1 is showing 7 out of 17 (41.18%) portfolios were having at least 1 factor significant in explaining returns and 3 portfolios having 2 significant factors and only 1 portfolio having 3 significant factors. However, if we sacrifice margin of errors by 5% and checks the results again we can claim that 11 out of 17 approx. two-third of the portfolios having at least one factors significant in explaining returns and 4 portfolios around one fourth portfolios having two significant factor and 2 having 3 significant factors.

Table 4.1: Cross-sectional least squares regressions of Mean Sample Returns on factor loadings Estimates (17 groups of 20 individual securities per group, 2003-2013 daily returns)

Percentage of groups with at least this many factor risk premia significant at the 95% level				
Factors	**1**	**2**	**3**	**4**
% of Groups	58.82%	23.53%	0.00%	0.00%
Note: 7 out of 17 (41.1% portfolio does not have any significant Factor)				
Percentage of groups with at least this many factor risk premia significant at the 90% level				
Factors	**1**	**2**	**3**	**4**
% of Groups	76.47%	29.41%	0.00%	0.00%
Note: 4 out of 17 (23.5% portfolio does not have any significant Factor)				

Table 4 shows results of all the portfolio showing number of factors significant with regression excluding intercept assuming zero risk free rates. We can see out of 17 portfolios most of portfolios are having at least 1 significant Factor presented in returns but overall significance of regression is presented in only 7 portfolios out of 17. We can see that In portfolio P8, P9, P11 and P14 does not have any significant factors at all and portfolio P1, P4, P13 and P16 are having 2 factors significant., whereas all other factors having only 1 factor

significant.

Table 4.1 summarizes table 4 in more concise way showing number of factors which are significant at 95% in first panel and factors which are significant at 90% in second panel of table. First Panel of 4.1 is showing 10 out of 17 (approx. two-third) portfolios were having at least 1 factor significant in explaining returns and 4 portfolios having 2 significant factors but no portfolio having 3 significant factors. However, if we sacrifice margin of errors by 5% and checks the results again we can claim that 13 out of 17 more than three-fourth of the portfolios having at least one factors significant in explaining returns and 5 portfolios around 30% of portfolios having two significant factor again no portfolio has three of more significant factors.

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Appendices

Table 2: Factor Analysis; Principle Component Method – Portfolio wise

		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Cumulative Variation Captured	# of Securities
	Eigen Value	8.927	1.0938	1.0078				
P1	Proportion	0.4464	0.0547	0.0504			0.5515	20
	Eigen Value	9.042	1.199	1.124				
P2	Proportion	0.476	0.063	0.0592			0.5982	19
	Eigen Value	6.952	1.186	1.085				
P3	Proportion	0.365	0.062	0.057			0.484	19
	Eigen Value	5.892	1.119	1.067	1.0108			
P4	Proportion	0.294	0.056	0.053	0.05		0.453	20
	Eigen Value	6.95	1.2	1.07				
P5	Proportion	0.365	0.063	0.056			0.484	19
	Eigen Value	6.571	1.195	1.14	1.007			
P6	Proportion	0.328	0.0598	0.057	0.0504		0.4952	20
	Eigen Value	6.11	1.149	1.032				
P7	Proportion	0.306	0.0575	0.0516			0.4151	20
	Eigen Value	6.281	1.195	1.078	1.052			
P8	Proportion	0.3305	0.062	0.056	0.0554		0.5039	19
	Eigen Value	8.534	1.626	1.029				
P9	Proportion	0.426	0.081	0.051			0.558	20
	Eigen Value	7.748	1.1563	0.9852	0.9812			
P10	Proportion	0.387	0.058	0.049	0.049		0.543	20
	Eigen Value	7.212	1.06	1.003				
P11	Proportion	0.4007	0.0589	0.0556			0.5152	18
	Eigen Value	7.516	1.584	1.1667	1.085	1.068		
P12	Proportion	0.375	0.079	0.058	0.054	0.053	0.619	20
	Eigen Value	9.346	1.145	1.046				
P13	Proportion	0.491	0.0603	0.0551			0.6064	19
	Eigen Value	11.943	1.73	1.119				
P14	Proportion	0.628	0.0911	0.058			0.7771	19
	Eigen Value	9.213	1.278	1.023				
P15	Proportion	0.4607	0.0639	0.0512			0.5758	20
	Eigen Value	9.0568	1.213	0.978				
P16	Proportion	0.476	0.063	0.0515			0.5905	19
	Eigen Value	12.795	1.936	1.163				
P17	Proportion	0.6398	0.096	0.0582			0.794	20

Table 3: Regression of Factors Loading Estimates with Expected Returns of Securities

$$R_p = \gamma_0 + \gamma_1 b_{p1} + \cdots + \gamma_5 b_{p5} \ (\gamma_0 \ estimated)$$

		Intercept	Factor1	Factor2	Factor3	Factor4	Factor5	Adjusted R Square	F Stats of Portfolio Regression	Significant Factors **(0.05)	Significant Factors * (0.1)
P1	Coefficient	0.000148	-7.00E-05	0.000609	-0.00023			0.290052	3.587506	1	1
	T Stats	0.594359	-0.214	2.328375	-1.0222						
P2	Coefficient	0.000178	-8.70E-06	-0.00019	-0.00017			-0.02118	0.875566	0	0
	T Stats	1.201862	-0.04553	-1.17216	-1.11507						
P3	Coefficient	-0.00021	4.85E-04	3.21E-05	4.83E-05			-0.02978	0.826471	0	0
	T Stats	-1.13604	1.574536	0.188149	0.268177						
P4	Coefficient	0.000477	-6.70E-04	-0.00041	-0.00028	-0.00053		0.293818	2.976313	2	2
	T Stats	1.539574	-1.194	-2.04727	-1.17529	-2.97977					
P5	Coefficient	8.86E-05	-7.60E-05	1.35E-06	-0.00036			-0.00234	0.986021	0	0
	T Stats	0.298022	-0.15372	0.006852	-1.70443						
P6	Coefficient	-0.00083	1.46E-03	-5.5E-05	-0.00111	0.000975		0.550831	6.825089	3	3
	T Stats	-2.77321	2.8331	-0.16359	-3.36415	2.728256					
P7	Coefficient	-5.8E-05	2.96E-04	-0.00015	-0.00011			0.023417	1.151865	0	0
	T Stats	-0.39817	1.132924	-1.00753	-0.71852						
P8	Coefficient	-0.00071	1.33E-03	0.00079	0.000185	0.00068		0.118704	1.606118	1	3
	T Stats	-1.98534	2.195633	1.877944	0.475979	1.722555					
P9	Coefficient	2.07E-05	-5.60E-05	0.000355	0.00037			0.048429	1.322329	0	0
	T Stats	0.05023	-0.08956	1.504094	1.169446						
P10	Coefficient	0.000218	-3.10E-04	-0.0007				0.071459	1.731109	0	1
	T Stats	0.45309	-0.40913	-1.83357							
P11	Coefficient	-0.00089	1.39E-03	6.79E-05	-7.4E-05			0.385362	4.552856	1	1
	T Stats	-3.58082	3.551722	0.272653	-0.28494						
P12	Coefficient	8.05E-05	-7.20E-05	-0.0002	0.00026	-0.00019	0.000645	0.030839	1.120915	0	1
	T Stats	0.190938	-0.10578	-0.68838	0.721617	-0.52801	1.831455				
P13	Coefficient	-0.00069	9.69E-04	-0.00038	0.00118			0.518244	7.45443	1	1
	T Stats	-1.49951	1.506821	-0.89165	3.740252						
P14	Coefficient	-0.0006	6.84E-04	0.000656	0.000664			0.07969	1.519544	0	1
	T Stats	-0.87552	0.795056	1.758739	1.437103						
P15	Coefficient	-0.00028	5.11E-04	-0.00014	0.000259			0.108348	1.769587	0	1
	T Stats	-1.33015	1.669272	-0.84304	1.378734						
P16	Coefficient	-7.8E-05	3.06E-04	-0.00015				0.310685	5.056442	0	0
	T Stats	-0.49962	1.356472	-1.33609							
P17	Coefficient	-0.00138	1.69E-03	4.24E-05	0.001081			0.411386	5.426413	2	2
	T Stats	-3.06859	3.020805	0.181946	3.510453						

Note: Only 23.5% (4 out of 17) Intercept are Significant at 95% and 90% Level

Table 4: Regression of Factors Loading Estimates with Expected Returns of Securities Without Intercept

$$R_p = \gamma_1 b_{p1} + \cdots + \gamma_5 b_{p5} \ (assumed \ \gamma_0 = 0)$$

		Factor1	Factor2	Factor3	Factor4	Factor5	Adjusted R Square	F Stats of Portfolio Regression	Significant Factors (α = 0.05)	Significant Factors (α = 0.1)
P1	T Stats	3.5111219	3.5111219	-0.886488			0.3795918	5.6109446	2	2
P2	T Stats	2.6918665	-0.60361	-0.584737			0.2147067	2.9677948	1	1
P3	T Stats	2.0438847	0.0505595	0.0586139			0.0456811	1.3944898	1	1
P4	T Stats	2.8628687	-1.307125	0.0480155	-2.448656		0.3419582	3.9759303	2	2
P5	T Stats	0.8660437	0.007566	-1.730454			0.0258509	1.2481464	0	1
P6	T Stats	0.503205	-0.932975	-3.076786	1.8081523		0.3012061	3.4651039	1	2
P7	T Stats	3.2789488	-1.153471	-0.739132			0.2998933	4.2093656	1	1
P8	T Stats	1.0121827	0.7986473	-0.305617	0.9222588		-0.089025	0.6515863	0	0
P9	T Stats	-0.253014	1.5642165	1.3108362			0.0461775	1.4096914	0	0
P10	T Stats	0.2120419	-1.840032				0.0578657	1.7153488	0	1
P11	T Stats	0.2410698	-0.118476	-0.779052			-0.150914	0.2263566	0	0
P12	T Stats	0.4657478	-0.685723	0.9682612	-0.511916	2.1162198	0.044028	1.272998	1	1
P13	T Stats	0.1603594	-2.728992	3.3681611			0.4205187	6.2725014	2	2
P14	T Stats	-0.541092	1.5460631	1.1499796			0.0377428	1.3351326	0	0
P15	T Stats	1.8987254	-1.259249	0.8994455			0.1150888	1.9999932	0	1
P16	T Stats	6.2142479	-2.229390				0.6440773	21.792911	2	2
P17	T Stats	-0.068114	-0.810601	2.0135145			0.0662384	1.5719413	1	1

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