A Test of Arbitrage Pricing Theory: Evidence from Malaysia*

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This study uses monthly data (from September 1988 to June 1997) on 213 stocks listed on the Main Board of the Kuala Lumpur Stock Exchange to investigate whether cross-sectional variations in stock returns are sufficiently explained by the Arbitrage Pricing Theory (APT). The study uses two approaches—factor analysis and the macroeconomic factors technique. The results indicate that the APT model is quite robust, and that two unknown factors are significant in the first approach and just one (expected inflation) in the second approach to explaining the cross-sectional variations in stock returns.

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INTRODUCTION

The Kuala Lumpur Stock Exchange (KLSE) has witnessed phenomenal growth over the last thirty years. From a total of 262 stocks valued at RM13.3 billion in 1973, the KLSE could boast of 773 stocks valued at RM554.11 billion by the end of June 2000. Although the KLSE has undergone such dramatic growth, the bourse has not been extensively researched upon, especially when one compares it with the stock exchanges in the United States (US) and Europe. Admittedly, research on the KLSE has increased in recent years. However, this research can still be regarded as at the embryonic stage. The sustained efforts of such notable scholars as Md Ariff, Annuar Md Nassir, Md Shamsher, Yong Othman, Mat Nor Fauzias, Kok Kim Lian and Md Isa Mansor, to name but a few, have resulted in some good research on the KLSE.

In 1998, Md Ariff, Md Shamsher and Annuar Md Nassir suggested several areas of the KLSE worth further investigation. The authors noted that even though the capital asset pricing model (CAPM) and the Arbitrage Pricing Theory (APT) have been widely applied in professional and academic training, the '...ideas have not been tested in the Asia Pacific market places except in a few cases' (Ariff, Shamsher & Nassir 1998: 331). They also draw attention to the fact that 'while the testability of the CAPM has been questioned, nothing stands in the way of testing if the systematic measure of CAPM is a pricing factor...or of testing the relevance of APT to identify the factors associated with pricing securities in the region' (p. 331). In summarizing the need for additional empirical work, the authors observed that 'a useful agenda of research is to examine the relevance of the theory-suggested factors for pricing of securities in this region' (Ariff, Shamsher & Nassir 1998: 331). The present paper is a modest attempt to take up this suggestion. It aims to examine the extent to which the APT explains the cross-sectoral variations in stock returns on the KLSE.

This study should be useful to the policy-makers because it provides some insights into the relationship between stock returns and macroeconomic variables. The governments of many emerging markets have, on many occasions, had to control macroeconomic variables in order to restore stability in the stock market. For example, in the 1980s, the Latin American countries suffered serious falls in their stock prices. A good number of them, such as Argentina and Mexico, had to be rescued by the International Monetary Fund (IMF) upon the understanding that they would keep a tight lid on the money supply and liberalize the interest rate environment. A similar experience was repeated in Asia, beginning in 1997, with the devaluation of the Thai baht on 2 July of that year. The devaluation sparked off what is now regarded as the East Asian Crisis. The governments of the region were very keen to restore stability, especially in the stock markets, which had plunged to unprecedented levels.

An understanding of the relationship between stock returns and macroeconomic variables would be useful to market participants as well. If, for example, inflation is found to be a significant factor, investors could make use of forecasts of inflation figures to design their portfolios. Some studies in the US have found no relationship between stock returns and inflation. If this were true, it would mean that the investors need not expose themselves to the risk of inflation as this would not be compensated.

While numerous studies on these aspects exist for the stock markets in developed countries, there is a paucity of such studies for the emerging markets. This provides a rationale for this study. The organization of the paper may now be explained. The paper is presented in seven sections. The next section discusses the framework of the APT, which is followed by the literature review of the empirical evidence on the APT. Then details are provided of the data and methodology used in this study, which is followed by the presentation and discussion of the findings. The penultimate section compares the findings of this study with those in the literature. The last section concludes the paper.

APT FRAMEWORK

The issue of cross-sectional variation in stock returns has traditionally been investigated under the framework of the CAPM, which was advanced by Sharpe (1964) following the portfolio theory of Markowitz (1952). Under the CAPM, return is hypothesized to depend only, and linearly and positively, on the market (systematic) risk. The model assumes a perfectly competitive capital market, perfectly divisible assets, existence of a risk-free asset, no transaction cost and homogenous investors' expectations about assets' returns. Although the CAPM was found by Black, Jenson and Scholes (1972), and Fama and MacBeth (1973) to be a good model in explaining the return behaviour, the subsequent research suggests the contrary. It is argued that the model is afflicted by several problems generally referred to as 'anomalies' (Fama & French 1992). These include the model's inability to account for the differences in return between the small and large firms (size effect); its inability to account for the differences in return across days of the week (week-end effect) and months of the year (January effect); and the differences in return due to analysts' following (neglected firm effect), among other factors. Further, it is suggested that there is no single measure of the market which could serve as the single determinant of return on stocks (Ross 1976).

Ross (1976) presented an alternative approach, which has come to be known as the Arbitrage Pricing Theory. Under this approach, return is explained not just through a single market factor like the CAPM, but through the multiple factors that influence all stocks uniformly. These multiple factors could be unknown and, if so, the factor analysis technique is applied to test the validity of the model. Alternatively, the said factors, called the macroeconomic factors, could be known and identifiable, and, if so, the two-step regression method could be used directly. The details on the methodology are provided in a subsequent section. It must be noted that the APT is based on assumptions similar to those of the CAPM mentioned in the previous paragraph. Recall that the problem under investigation in this study is 'to what extent does the APT explain the cross-sectional variations in stock returns on the KLSE?'.

The APT model hypothesizes that the rate of return on any security is a linear function of a set of the fundamental factors (F_k) common to all securities :

$$R_j = E(R_j) + \beta_{j1}F_1 + \beta_{j2}F_2 + \ldots + \beta_{jk}F_k + \varepsilon_j \qquad (1)$$

where,

R_j = stochastic rate of return on the jth stock

$E(R_j)$ = expected level of return for stock j

F_k = value of the kth index that impacts the return on stock j (factors)

β_{jk} = sensitivity of stock j's return to the kth index (factor loading)

ε_j = random error term with mean equal to zero and variance equal to $\sigma^2{}_{ei}$.

A corollary to the APT states that the risk from each factor is priced as in the following cross-sectional equation:

$$R_j = \gamma_0 + \sum_{j=1}^{N} \gamma_j \beta_j + \varepsilon_j \qquad (2)$$

where,

R_j = rate of return of factor j

γ_j = parameters to be estimated

β_j = beta for factor j, calculated from equation (1).

Equation (1) is estimated for each stock or each portfolio of stocks in the sample, using the time series data. This provides the estimates of the market risks, called betas, which measure the sensitivity of the concerned return to the corresponding market risk factor. This is referred to as the first step or the estimation/first pass step of the two-step regression technique. Equation (2) uses the betas estimated in the first step for each stock/portfolio and then runs the cross-section regression of returns on the beta estimates. This step is referred to as the second step or the testing/second pass step of APT. The CAPM is a special case of APT, where the number of explanatory variables in equations (1) and (2) above is just one, and that is a sole measure of the market risk.

The results of the second regression provide the necessary inputs for testing the validity of the APT. The closer the value of the R-square to unity, the more appropriate the model is. Further, the estimates of the coefficients of equation (2), called gammas in the finance literature, would indicate as to whether the particular risk factor is priced or not. Thus, if only gamma one alone is significant, then only factor one is rewarded by the market in terms of return. If the sign of a gamma is positive, the reward is positive; and it is negative otherwise.

EMPIRICAL EVIDENCE ON APT

Empirical research on the APT has grown since the pioneering work of Ross (1976). Furthermore, both the approaches have been applied. The first, which assumes unknown factors, has been tested by Roll and Ross (1980), Cho, Elton and Gruber (1984), Elton and Gruber (1989, 1990), Lehmann and Modest (1988), and Connor and Korajczyk (1986), among others. The second, which is based on the known macroeconomic factors and the methodology of Fama and MacBeth (1973), has been followed by Litzenberger and Ramaswamy (1979), Sharpe (1982), Chen, Roll and Ross (1986), Burmeister and McElroy (1988, 1989), Warga (1989), Shukla and Trzcinka (1990), Young *et al.* (1991), and Grinold and Kahn (1994), among others. While most of these studies have concentrated on the macroeconomic factors, some have used company-specific variables as well.

Roll and Ross (1980) applied factor analysis to forty-two groups of thirty stocks, using the daily data for the period July 1962 to December 1972. They found that at least three factors were significant. This contradicts the CAPM (single beta CAPM), which hypothesizes just one factor to be significant. Cho, Elton and Gruber (1984) repeated the Roll and Ross methodology and found more factors to be significant than did Roll and Ross. Connor and Korajczyk (1986) provide a test of the APT using the asymmetric principal components technique. They found that with five factors, they could explain the extra return on small firms and in January better than the CAPM based on the value-weighted index.

Lehmann and Modest (1988) formed portfolios of assets that mimic factor realization (returns) which have the minimum residual risk for each factor. They used such a set of portfolios to estimate the sensitivities of each of a large number of securities to each influence (factor). They found that a multi-index model like the APT could explain the discrepancies due to the dividend yield and own variance, and thereby they support the APT over the CAPM. Litzenberger and Ramaswamy (1979) included the dividend yield as an additional variable to test their model and found that its impact was statistically significant. This encouraged the pursuit of models containing more characteristics. Similar results were reported by Sharpe (1982), who used 2,197 stocks on a monthly basis from 1931 to 1979 to test his model. He identified some additional characteristics, beyond the stock's beta (proxy for the market portfolio), which were found to be useful in explaining the variation in cross-sectional returns.

Chen, Roll and Ross (1986) hypothesized and tested a set of economic variables as arguments in the APT framework. They reasoned that the return on stocks should be affected by any influence that affects either the future cash flows from holding a security or the value of these cash flows to the investor. They constructed sets of alternative measures of the unanticipated changes in the select factors, *viz*. inflation, the term structure of interest rates, risk premium, unexpected inflation, and industrial production. They examined these measures or indices to see if these were correlated with the set of indices extracted by the factor analysis used by Roll and Ross and could explain the equilibrium returns.

When they examined the relationship between the macroeconomic variables and the factors over the period to which the factors were formed, they found a strong relationship. Furthermore, when the relationship was tested over a holdout period (a period following the estimation period), it continued to be strong. They found a strong relationship between the stock return and macroeconomic variables. They concluded that they could not claim to have found the correct variables for asset pricing, but that they certainly had made an important start in that direction.

Burmeister and McElroy (1988) continued the Chen, Roll and Ross approach to test the factor models. They assume returns to be generated by the five indices, *viz*. default risk, time premium, deflation, change in expected sales, and the market return not captured by the other four variables (proxy for any unobserved general influences). They found that the first four factors account for about 25% of the variation in the return on the S&P Composite Index and each of the four coefficients was significantly different from zero at the 5% level; and the five variables typically account for 30–50% of the variation in the return of individual firms. Burmeister and McElroy (1989) extended their earlier test. They modified their definition of the observable factor and assumed that there were three unobservable factors rather than just one. They used three portfolios to represent the unobservable factors: the return on the S&P 500 stock index; the return on the twenty-year corporate bonds; and the return on the twenty-year government bonds. Their findings rejected the CAPM in favour of the APT model.

Warga (1989) applied the two-step regression technique employed by Fama and MacBeth (1973) and the experimental design similar to Chen, Roll and Ross (1986). His results corroborate those of Chen, Roll and Ross. Shukla and Trzcinka (1990) used the elements of eigenvectors and the Maximum Likelihood factor loading of the covariance matrix of returns as measures of risk. The results indicate that, for the data assumed to be stationary over twenty years, the first vector is a surprisingly good measure of risk when compared either with a one or five-factor model or a five-vector model. They concluded that, in some circumstances, the principal component analysis may be preferred to factor analysis.

Young *et al.* (1991) examined whether some financial variables happen to be important factors in the APT. Their model is based on four factors, *viz.* inflation, the term structure of interest rates, unexpected inflation, and growth in final sales.

They find that the forecasts of beta derived through the financial variables consistently outperform the naive random-walk forecasts.

To probe into the earlier works on APT, Grinold and Khan (1994) conducted their own study. They found as many as nine firm characteristics to be relevant factors. Those characteristics constitute the measures of volatility, momentum, size, liquidity, growth, value, earning, financial leverage, and industry membership. These characteristics are being used by BARRA, an investment management firm, for its portfolio management.

Fama and French (1993) specified a set of portfolios (which may or may not include the market portfolio) which were thought to capture the influences affecting the securities' returns. These portfolios were selected on the basis of some beliefs about the types of securities and/or economic influences that affect the security return. The variables are the differences in the return on each of the following portfolios:

a) small stocks and large stocks
b) high book to market value stocks and low book to market value stocks
c) long-term government bond return and the one-month Treasury bill return, and
d) long-term corporate bonds and long-term government bonds.

Fama and French tested their model over a number of the time-series tests. They concluded that 'at a minimum, our results show that five factors do a good job in explaining a) common variations in bond and stock return and b) the cross-section of average returns'.

The literature also contains some studies on the number of unknown factors in the factor analysis approach of APT. Dhrymes, Friend and Gultekin (1984) found that, as the number of securities included in the factor analysis increases from fifteen to sixty, the number of significant factors increases from three to seven. They further suggest that the factors identified within any subgroup of a sample may not be the same as factors identified in a second subgroup. Blin (1999) employed around two dozen factors in the Advanced Portfolio Technologies' software. Jeyasreedharan (1989) reports four common factors that determine the returns in the KLSE. Trzcinka (1986) suggests that there is no obvious way to choose the number of factors; however, the first five factors are the most distinct. Connor and Korajczyk (1993) provide evidence for one to six factors in the NYSE.

Elton and Gruber (1989) report that by employing a multi-index model (e.g. APT) rather than the one-index model (CAPM), one allows the creation of an index which is more closely related to the desired index. The study suggests that the fewer the stocks in an index-matching portfolio, the less likely the portfolio will be matched on the common factors affecting the portfolio and the index, and the greater will be the superiority of the multi-index model over the single-index model. Elton and Gruber also realized that one of the problems with the APT is the desire to match an index with a portfolio that excludes certain types of stocks.

To conclude this section, the empirical findings reviewed above seem to indicate the superiority of the APT over the CAPM, though there are studies questioning the validity of this assertion. The doubts relate to the problems with the APT. The first problem inherent in the APT arises from the use of the factor analysis technique, which can accommodate only a limited number of securities for the analysis. Although Chen (1981) has described a procedure that allows the APT to be estimated and tested across a large number of securities, his procedure involved forming a small number of portfolios of securities based on an initial factor solution. This has been criticized by Dhrymes, Friend and Gultekin (1984). Another criticism comes from the work of Shanken (1982), who has raised serious issues relating to the testability of the APT.

He argues that the shares of stocks traded in the market-place are actually portfolios of the *n* individual units of production in the economy. These portfolios have been created through mergers and by the adoption of multiple capital budgeting projects by the concerned firms. Consequently, given a factor structure that relates to the returns on the individual units of production, it may not be recognizable on the basis of the portfolios (the stocks traded in the market-place).

DATA AND METHODOLOGY

The month-end KLSE data were obtained from the Pusat Komputer Professional (PKP), a company based in Pahang, Malaysia. The database contains daily closing prices, daily high and low prices, and the volume of transactions. Adjustments were made to take into account the stock splits, right/bonus issues, and dividends. The sample selection criteria applied were that only the companies listed before September 1988 (the Second Board companies were listed on the KLSE afterwards and, thus, excluded from the sample) and whose data for the full sample period were available were included in the study. The sample period chosen was September 1988 to June 1997 (n = 106), the choice being dictated by maximizing the sample size of the companies and the desire to avoid the South East Asian Crisis period (when the stocks' returns turned negative in most cases). All companies that met these criteria were selected. The sample included in this study thus comprises of 213 companies listed on the Main Board of the KLSE.

The rate of return of security *i* is calculated as follows:

$$R_{it} = \ln \frac{P_{it}}{P_{i(t-1)}} \tag{3}$$

where,

R_{it} = the rate of return of the security i at time t

P_{it} = the closing price of security i at time t.

The methodology is presented under two parts, *viz*. factor analysis and macroeconomic factor approaches. The former is largely statistical in nature and it is applied mainly to see if the variations in returns across stocks are amenable to any explanation at all. The latter is an econometric technique, which not only attempts to explain the behaviour of stock return but also identifies the economic factors causing those variations. Since the APT concentrates on the macroeconomic factors only, no micro economic/finance factors have been included among the list of the determinants of stock return.

Factor Analysis Approach[1]

Before testing the APT by the factor analysis approach, it is important to know the number of factors to be used in equation (1) above. Ch'ng (2001) reports that a diversified portfolio in Malaysia must consist of at least twenty-seven stocks in a randomly selected portfolio. The factor analysis was thus applied to the thirty (law of large numbers) random samples of portfolios, each consisting of twenty-seven stocks. For each sample, twenty-six stocks were selected at random and the twenty-seventh stock was selected such that the portfolio return of each sample of twenty-seven stocks had the same value. The Statistical Package for Social Sciences (SPSS) was used to obtain the results, which are reported in Table 1 (opposite). On average, there are six components that give the eigenvalue more than

TABLE 1
Results of factor analysis: number of factors

Samples	No. of Factors	Cumulative Eigenvalue (Above 1)	Samples	No. of Factors	Cumulative Eigenvalue (Above 1)
1	5	65.21	17	7	66.50
2	6	71.70	18	5	61.55
3	7	67.47	19	6	68.33
4	8	70.05	20	6	68.58
5	6	68.58	21	5	67.93
6	6	62.57	22	6	67.44
7	5	65.98	23	6	70.78
8	6	69.97	24	6	64.04
9	7	63.78	25	7	68.51
10	6	66.12	26	6	68.00
11	6	69.81	27	6	64.12
12	6	66.43	28	6	67.10
13	5	57.50	29	5	63.67
14	6	60.81	30	6	66.92
15	6	68.36			
16	5	56.60	Mean	5.97	66.15

unity. Thus, six factors have been applied to test the APT based on the factor analysis approach.

This study uses a variant of the Fama and McBeth (1973) procedure to verify the APT. The Fama–MacBeth approach is preferred as it avoids the error-in-variables problem as indicated by Blume (1970), as well as the degrees of freedom issue contained in the alternative method of Chen (1983). Blume suggests that the betas of individual stocks are highly unstable, while those of the portfolios of stocks are fairly stable over time. Chen's procedure of bifurcating the data into odd and even months, and using the one set to estimate the first regression and the second set for that of the second equation, reduces the degrees of freedom. The Fama–MacBeth method, which minimizes both these problems, tests the CAPM/APT model for portfolios (not for individual stocks) and uses the overlapping sample periods. Under this method, the portfolios are formed on the basis of the beta values, the lowest beta stocks combined into portfolio 1, the second lowest beta stocks portfolio 2,…, and the highest beta stocks being the last portfolio. This minimizes the error-in-variables problem. The overlapping sample period is used to maximize the degrees of freedom without compromising on the quality of the estimates. This study uses a modified version of this method as applied by Shafie (1994), where the portfolios are formed on the basis of the sector groupings while the other parts of the method remain the same as in Fama and MacBeth.

In Malaysia, various companies are categorized under nine sectors, thus giving nine portfolios, one for each sector. In the first step of the factor analysis approach, various stocks in a sector were combined on an equal weighting basis, using 1988 as the base period, to give the sector portfolios and the return/risk on them. The nine sectors consist of construction, consumer products, finance, hotel, mining, plantation, industrial products, property and trading. The returns from each of the nine indices were calculated and denoted as $RI1, RI2, \ldots, RI9$. The second step involved running the factor analysis and saving the factor scores. This study, as rationalized below, uses six factors for the estimation. The third step divides the sample into two overlapping periods, with the estimating period spanning the first ninety-nine months, and the testing period covering the months 62–106. The first period is then divided into forty moving windows of size sixty, with the first window covering months 1–60, the second covering months 2–61, until the fortieth window, which covers months 40–99. For each of these windows, the following time series regression was run nine times, one each for the nine sectoral portfolios:

$$RI_j = \beta_{j0} + \beta_{j1}F_1 + \beta_{j2}F_2 + \beta_{j3}F_3 + \beta_{j4}F_4 + \beta_{j5}F_5 + \beta_{j6}F_6 + \varepsilon_j \qquad (4)$$

where RI_j denotes the returns on the sectoral indices and F_js the factor scores obtained from the factor analysis. For the first-pass results, 360 (9 x 40) multiple regressions were run, giving 2,160 (9 x 40 x 6) parameter estimates for the use in the second-pass regressions. The β_js are the risk estimates obtained for the six unknown factors. The F_is are the six factor scores saved in a factor analysis of the returns of all the sample stocks.

The fourth step makes use of the sub-period II data for the second-pass regressions. However, before going to the second-pass regressions, the sub-period was divided into forty moving windows of size six (in the spirit of Shafie (1994)), with the first window covering months 62–67, the second covering months 63–68, until the fortieth window, which covers months 101–106. For each window, the mean returns for the sectoral indices were computed. Using the first window, the nine sectoral returns were regressed against the beta estimates obtained in the first window of period I. In the same fashion, the nine sectoral returns for the second window of period II were regressed against the beta estimates obtained in the second window of period I. This procedure was repeated until the fortieth cross-sectional regression, which used the returns for the fortieth window in period II as the dependent variable and the estimates of beta for the fortieth window in period I as the independent variables in equation (2). The results are reported in Table 2 (opposite).

It should be noted that the cross-sectional regressions give forty estimates of each of the parameters. Thus, to test the significance of each of them, the fifth step conducted the *t*-test using the following formula:

TABLE 2
Factor analysis results: second pass regressions

Window	Gamma 1	Gamma 2	Gamma 3	Gamma 4	Gamma 5	Gamma 6	R^2
1	-0.1305	0.2216	-0.4091	0.2705	0.2023	0.0056	0.9897
2	-0.0760	0.2869	-0.2214	0.0844	-0.0713	0.0434	0.9967
3	-0.0207	0.5910	0.1339	0.6316	-0.0594	-0.0766	0.9971
4	0.0812	0.3370	0.8083	0.1407	-0.0399	-0.0892	0.9880
5	0.0772	0.3421	0.4557	0.2726	-0.0480	-0.0615	0.9848
6	0.2876	0.2184	0.3281	-0.0377	-0.0172	-0.0870	0.9897
7	-0.0607	0.1807	0.5600	-0.2966	-0.0469	-0.0157	0.9835
8	-0.0799	-0.2946	0.4361	0.7966	0.0771	-0.1504	0.9837
9	-0.2130	-0.2550	0.5642	0.0028	-0.0085	-0.0383	0.9876
10	-0.2561	-0.9693	0.1322	-0.0715	0.0178	-0.0353	0.9911
11	-0.4513	-0.7377	0.4872	0.1599	0.0253	0.0347	0.9811
12	-0.3595	-0.2976	0.6802	0.5145	0.1426	0.0063	0.9908
13	-0.0133	-0.2858	0.6992	-0.2279	0.0128	0.0148	0.9929
14	-0.0533	-0.2825	0.6711	-0.0957	-0.0258	0.0193	0.9756
15	-0.0306	0.2824	0.6561	-0.3762	0.0600	0.0219	0.9859
16	0.0466	-0.2379	0.2554	-0.5715	0.0914	0.0948	0.9734
17	0.1212	0.6595	0.5491	-0.3184	-0.0156	-0.0814	0.9944
18	0.1038	0.7611	-0.3197	0.1505	-0.0025	-0.1025	0.9930
19	0.0439	0.2846	-0.1061	-0.1497	0.0279	0.0117	0.9794
20	-0.0599	0.5641	-0.3837	-0.0180	-0.0201	-0.0133	0.9846
21	0.0415	0.6317	-2.2230	-0.7065	-0.0093	0.0862	0.9971
22	0.3115	0.5205	-0.3402	-0.2850	-0.0193	0.1620	0.9975
23	0.1600	0.5958	0.5921	-0.2737	0.0031	0.1863	0.9932
24	-0.0818	1.0338	0.4588	-0.2706	-0.1331	0.0867	0.9830
25	0.0696	0.4782	0.1769	0.3887	0.0053	0.0871	0.9805
26	-0.1869	0.4938	0.0084	0.2485	-0.0218	0.0296	0.9848
27	-0.6939	0.2220	-0.0399	0.1535	-0.0242	0.0350	0.9847
28	-0.2932	0.3360	0.5949	-0.0141	0.0063	0.0392	0.9824
29	-0.5192	0.2454	0.4901	-0.3858	0.0358	0.0298	0.9812
30	-0.3824	0.1835	0.5610	0.7289	0.0105	0.0190	0.9839
31	-0.0562	0.0558	0.9736	-0.3661	0.0113	0.0141	0.9941
32	-0.8637	-0.3917	0.4504	0.0538	0.0190	0.0127	0.9923
33	-0.0220	0.3506	0.4650	0.0137	-0.0209	-0.0066	0.9849
34	-0.0024	-0.3182	0.2090	0.0872	0.0394	-0.0126	0.9871
35	-0.1747	0.1964	0.3164	0.2638	0.0283	-0.0218	0.9965
36	-0.0159	-0.2003	0.2312	-0.5951	-0.0120	-0.0241	0.9988
37	-0.4337	-0.1972	0.1729	-0.1260	0.0087	-0.0172	0.9988
38	0.4654	-0.1214	-0.0151	0.5403	0.0073	-0.0298	0.9927
39	-0.3323	-0.5029	0.0495	-0.5645	0.0116	-0.0013	0.9903
40	-0.2455	-0.7838	-0.0463	0.0674	-0.0042	-0.0169	0.9860
MEAN	-0.1075	0.1049	0.2266	-0.0045	0.0061	0.0040	0.9883
Standard Deviation	0.2610	0.4526	0.527349	0.3621	0.0556	0.0665	
N	40	40	40	40	40	40	
T-Test	-2.6042	1.4661	2.7172	-0.0791	0.6928	0.3776	

$$t = \frac{\hat{\gamma}_i}{\frac{\sigma_{\hat{\gamma}_i}}{\sqrt{n}}} \qquad (5)$$

where t denotes the value of the t-statistic in the t-test, $\hat{\gamma}_i$ is the mean (gammas) for the forty windows (equation 2), $\sigma_{\hat{\gamma}_i}$ the standard deviation for the mean gammas, and n the number of observations.

To justify the value of $R^2 = 0.9883$ for the average of forty windows in Table 2 (p. 85), in the sixth step, the factor analysis was re-run on the nine sectors for the six factors irrespective of the value of the eigenvalues using all the 106 months data for all the nine sectors. The results are reported in Table 3 (opposite).

The results indicate that the first factor explains 56.429% of the eigenvalue, the second 29.511%,..., and the last factor 1.238%, with all the six factors accounting for a cumulative total of about 98%, which approximates the R^2 value of 0.9883.

Macroeconomic Factors Approach

Unlike the factor analytic approach, the macroeconomic factors approach uses the known macroeconomic variables as the arguments in the first regression. This study draws inspiration from the approach of Chen, Roll and Ross (1986), which used five factors. However, the present study uses four factors because the data for the risk premia were not available. The variables used and the justification for them follows.

INDUSTRIAL PRODUCTION

The growth rate of industrial production has been used in many studies as an explanatory variable in the APT equation. For example, Shafie (1994) has incorporated industrial production in his study and found that this variable is significantly important in explaining the return on the KLSE stocks. Other researchers such as Pesek (1999), Chaze (1999) and Nasseh (2000) also stress that industrial production is one of the important variables in all economic activities. Several studies, including the ones on Malaysia, have found that industrial production and Gross Domestic Product (GDP) are highly correlated. Due to the non-availability of the monthly data, GDP could not be included in the study. Industrial production serves as a proxy for GDP. This choice of the variable is also good because the share of industrial production in GDP is high and growing, even in emerging markets like Malaysia, and the volatility in itself is a crucial factor in stock price behaviour. An examination of data would indicate that stock prices follow fairly well the ups and downs in industrial production.

The higher the level of industrial production, the larger the profit the companies are likely to reap. During boom periods, industrial production tends to grow to keep pace with the increasing demand for it. During slumps, industrial production tends to decline in tandem with the falling demand. Thus, one would expect profits to be high during the booms and to be low during the recessions. When profits are high, dividends would also be high, so that stock returns would also be high. Thus, a positive relationship is expected between the stock returns and the percentage change in industrial production.

INFLATION

The effect of inflation on stock returns has been investigated by many authors. Such empirical studies derive inspiration from the pioneering work of Irving Fisher, who argued that there is a one-to-one

TABLE 3
Results of factor analysis: eigenvalues

Component	Total	Variance (%)	Cumulative %
1	5.083	56.479	56.479
2	2.656	29.511	85.990
3	0.488	5.421	91.411
4	0.297	3.300	94.711
5	0.184	2.050	96.761
6	0.111	1.238	97.999

relationship between stock returns (nominal) and expected inflation. The effect of inflation on the common stock return has been studied by Jaffe and Mandelkar (1976), and Nelson (1976), who use US data (1953–71 in the former study and 1953–74 in the latter) to test the relation between stock returns and inflation. Both results show that Fisher's hypothesis of a positive relationship between stock returns and inflation is rejected. They both conclude that stock returns do not serve as a hedge against inflation, a finding that contradicts the efficient market hypothesis.

A similar result was reported by Bodie (1976), who used data for the US for the period January 1953 to December 1972. In contrast to these studies, Firth (1979) found a positive relationship between stock prices and inflation, supporting the view that stocks act as a hedge against inflation. Gultekin (1983) investigated the relation between the common stock returns and inflation, using data for the twenty-six countries for the post-war period. Using time series regression, Gultekin found that the 'regression coefficients are predominantly negative' and that 'the stock return – inflation relation is not stable over time' (p. 64). He concludes that 'the relation between the common stock return and inflation in other countries is as puzzling as the findings in the US' (p. 64).

Local studies have not explicitly used inflation as an explanatory variable affecting returns. In view of the earlier works suggesting a positive relationship between stock returns and inflation, this study incorporates two measures of inflation, the first being the expected inflation, and the second the unexpected inflation. The Consumer Price Index (CPI) was used to compute the inflation rate. To obtain a measure of the expected inflation, the naive model has been used. Under the naive model, the best estimator of inflation is its value in the immediate past period. The unexpected inflation data were then obtained as the difference between the current and previous inflation rates.

TERM STRUCTURE OF INTEREST RATE (BUSINESS CYCLE RISK)

The effect of business cycles on an asset's return is well known. The issue is how to measure this variable. Usually, the difference between the long-term and short-term interest rates is used for the purpose. Chen, Roll and Ross (1986) defined this variable as the difference between the returns on the long-term and short-term government bonds. This study follows this procedure, but with some modification owing to the data problem. While Chen, Roll and Ross used long-term and short-term government bonds, this study uses the twelve-month and one-month fixed deposit rates. Long-term bonds in Malaysia are not issued on a monthly basis (they are issued at very irregular intervals) and, thus, this precludes the use of the interest rate on them.[2]

RISK PREMIA

Since Markowitz (1952), it is well known that the returns are influenced by the degree of the risk of default in the underlying securities. Chen, Roll and Ross used the difference between the yields on the high-grade bonds and low-grade bonds as a measure of this risk. This study does not include this variable for an unavoidable reason. In Malaysia, corporate bonds are often accompanied with warrants. A company with low future prospects could offer a very attractive warrant, but very low rate on the bond. Conversely, a company with good prospects could offer a high bond rate but poor-quality warrant. In the absence of warrants, the higher the prospects of a company, the lower the bond rate. But the use of warrants in Malaysia makes the relationship unpredictable. Admittedly, this variable could be represented by the difference in the yields on government bonds and company bonds. But, again, the study is unable to use this, for government bonds are not issued on a monthly basis.

OTHER VARIABLES

One of the other factors that may affect the share price is the exchange rate. Foreign investors' decisions are surely affected by the movements in the exchange rate. The role of foreign investors has been very significant especially during the nineties. Fauzias and Natarajan (1999) tried to find the factors that caused the currency crisis. They found that the movements in the KLSE composite index are not highly correlated with the changes in the exchange rate. Lai, Chin and Low (1999) investigated the institutional investors and found that the movement of the exchange rate is only ranked seven (out of ten factors) in terms of the importance of the factors listed. On the same test, the unemployment rate was ranked eight. The said rate was not included in this study largely because, during the period of this study (1988–97), this rate was rather low and stable. In fact, there was an acute shortage of labour in Malaysia during the period, so much so that many sectors had to rely on migrant labour.

The company-specific variables, as suggested by Fama and French (1992), have not been included in this study because the APT looks into the market factors only and the micro factors are handled through another approach, generally referred to as the multi-index models.

ESTIMATION OF APT VIA MACROECONOMIC FACTORS

The approach to the estimation of the APT under this system is similar to the factor analysis approach explained above. The only difference is that, instead of the unknown factors, the macroeconomic variables: the industrial production, unanticipated inflation, expected inflation, and the business cycle variable, have been used in the regressions. Thus, equation (4) of the factor analysis was replaced by the following equation in this approach:

$$RI_j = \beta_{j0} + \beta_{j1} BCYCLE + \beta_{j2} INDPROD + \beta_{j3} UI + \beta_{j4} EI + \varepsilon \qquad (6)$$

where,

RI_j	= return on sector j index
$BCYCLE$	= business cycle variable
$INDPROD$	= percentage change in industrial production
UI	= unanticipated inflation rate
EI	= expected inflation rate
ε	= error term

RESULTS AND ANALYSIS

Since the study uses two approaches to test the APT, the results are presented under two separate headings. Since the first pass regression results are needed simply as inputs for the second pass regressions, they have not been included here to save space. The second pass regression results are given in detail, both by each regression, one for each of the forty periods, as well as for the mean values of the parameters. The same are reported in Table 2 (p. 85) for the first approach. The mean value results in Table 2 suggest that only two parameters (gamma 1 and 3) are significant at the 1% level. The first is negatively signed, while the second is signed positively. A look at the coefficient of determination suggests that most of them are very high, averaging 98.83%. Table 3 (p. 87) gives the factor analysis results for rationalizing this value.

The results reported in Table 3 give the contribution of each of the six factors to the value of *R*-square. For getting these results, the SPSS software was given the command to extract six factors and report the eigenvalues. In Table 3, there are two components that give eigenvalues more than one, and these two components explain about 86% of the sample's variance. When the components are added until six, about 98% of the variance is explained.

The unknown nature of the factors in the factor analysis approach is the limitation of the method. The components in the factor analysis can be either individual variables or a combination of many variables. It should be noted here that the present study's finding of just two significant factors differs from the findings of many others. For example, Blin (1999) found twenty-four significant factors, while Connor and Korajczyk (1986) found six factors, and Dhrymes, Friend and Gultekin (1984) report that the number of factors increase from three to seven as the number of securities increase from fifteen to sixty.

TABLE 4
Correlation matrix for multicollinearity test

	BCYCLE	INDPROD	UI
INDPROD	0.74		
UI	0.01	0.01	
EI	0.02	0.02	0.73

Before the results of the macroeconomic factor analysis are analysed, it is imperative to talk about the possibility of multicollinearity. This is important because in the presence of multi-collinearity, the results may show no evidence of significant relationship which may otherwise exist. Table 4 shows the simple correlation results obtained from the variables used for estimation of the APT model via this approach.

From Table 4, it is noted that there are two pairs of variables (business cycle and industrial production, and unanticipated inflation and expected inflation) that appear to be significantly correlated at the 1% level. However, both the correlation coefficients are below 0.8 and, thus, the multicollinearity problem does not appear to be serious enough to warrant dropping of one of the variables from each pair of variables. The forty cross-sectional regressions' results on equation (6) above are summarized in Table 5 (p. 90).

An analysis of the results in Table 5 reveals that the *R*-squared values are quite high, most of the time

TABLE 5
Macroeconomic factors' analysis results: second-pass regressions

Window	Gamma 1 (BCYCLE)	Gamma 2 (INDPROD)	Gamma 3 (UI)	Gamma 4 (EI)	R^2
1	0.3814	0.0250	3.7868	0.0034	0.5479
2	0.5794	0.1412	1.2976	0.0255	0.7053
3	0.3228	0.2003	0.9468	0.0131	0.9295
4	0.1526	0.0594	1.7704	0.0067	0.9026
5	0.1426	0.0475	1.4059	0.0057	0.8905
6	0.0182	0.0170	0.3141	0.0153	0.2112
7	0.7162	0.0464	1.5162	0.0568	0.8471
8	0.2889	0.0763	0.6197	0.0240	0.8242
9	0.2775	0.0084	1.1089	0.0425	0.5773
10	0.2743	0.0176	0.5260	0.0313	0.5695
11	0.2742	0.0905	0.6976	0.0046	0.9244
12	0.2310	0.0395	1.0760	0.0707	0.7754
13	0.6403	0.0127	0.7983	0.0018	0.9515
14	0.7389	0.0255	0.6552	0.0002	0.9463
15	0.2763	0.0706	0.4519	0.0143	0.8039
16	0.5477	0.0588	0.2051	0.0013	0.7602
17	0.3007	0.1318	0.0944	0.0355	0.7905
18	0.8075	0.0025	1.5424	0.0381	0.6926
19	0.0028	0.0240	0.0395	0.0272	0.9029
20	0.0725	0.0199	0.3315	0.0201	0.8602
21	0.1621	0.0092	0.6120	0.0098	0.9698
22	0.0683	0.0191	0.0808	0.0058	0.9718
23	0.0545	0.0154	0.0467	0.0016	0.6343
24	0.0827	0.0276	0.3230	0.0065	0.4339
25	0.0382	0.0031	0.0436	0.0058	0.4964
26	0.5216	0.0062	0.0835	0.0216	0.7251
27	0.0143	0.0390	0.0531	0.0046	0.7283
28	0.0970	0.0280	0.2615	0.0060	0.6964
29	0.3711	0.0354	0.0172	0.0160	0.7902
30	0.3911	0.0104	0.2286	0.0198	0.4403
31	0.5723	0.0112	0.2686	0.0339	0.2177
32	0.6033	0.0188	0.6924	0.0270	0.5757
33	0.1277	0.0207	0.4359	0.0010	0.5653
34	0.1518	0.0052	0.0367	0.0040	0.1951
35	0.0139	0.0216	0.2540	0.0023	0.6801
36	0.0884	0.0119	0.3231	0.0035	0.3028
37	0.2674	0.0086	0.0420	0.0091	0.1696
38	0.3940	0.0072	0.2377	0.0078	0.2313
39	0.2519	0.0115	0.4501	0.0033	0.2566
40	0.1556	0.0042	0.8087	0.0045	0.8858
MEAN	**0.0047**	**0.0060**	**0.1324**	**0.0086**	**0.6595**
Standard Deviation	0.3624	0.0543	0.9154	0.0208	
N	40	40	40	40	
T-test	0.0813	0.7032	0.9146	2.6234	

above 0.6 with a mean value of 0.66. It would be observed that out of the forty cross-sectional regressions, more than half of them have *R*-squared values exceeding 60%. Thus, the model appears quite robust, and it can be concluded that the macroeconomic variables used in the study capture well the market factors determining the return on stocks in Malaysia. However, the *R*-squared values are not the only test of the APT. There is a *t*-test for the significance of the regression coefficients. The formula shown in equation (5) above was used to compute the *t*-values for each of the mean values of the parameters. The results are included in Table 5 (opposite). From the results, it is evident that only one of the parameters (gamma 4: the coefficient of the beta of expected inflation) is significant at the 5% level. The results on the individual parameters of the forty regressions in Table 5, whose *t*-values are not included here for simplicity, may now be analysed.

For the business cycle variable, in only one out of the forty windows, the gamma was found to be significantly less than zero. In fact, nineteen out of forty windows have recorded negative but insignificant gamma estimates for the business cycle. Only two estimates are found to be significantly greater than zero. It will be noticed that the *t*-ratio for the mean value of the business cycle variable is very small and insignificant. Thus, it can be concluded that within the framework of the APT model, the business cycle risk appears to have no independent effect on the cross-sectional variations in return.

For industrial production, the estimates of gamma also show a preponderance of insignificant results. For example, seven out of the forty windows produced significantly negative estimates. This contrasts with twelve coefficients found to be negatively signed but insignificant. By the same token, nineteen of the forty estimates of gamma for industrial production are positively signed but insignificant. Only in two out of the forty windows, the coefficent is significantly greater than zero. The overall mean estimate for the gamma for industrial production is found to be small (0.006) and insignificant, with a *t*-ratio of 0.7032. Thus, the risk arising from the changes in industrial production appears to have no independent effect on the variations in cross-section of returns.

A similar picture is obtained for unexpected inflation. For this variable, only seven out of the forty windows produced gamma estimates that are significantly less than zero. At the same time, thirteen of the forty windows produced negative but insignificant estimates of gamma, and eighteen of these windows gave positive but insignificant estimates. Only two of these estimates are significantly greater than zero. The overall mean for the estimates of gamma for unanticipated inflation is found to be small and negative (-0.1324), having a small *t*-ratio of -0.9146, which is below the 5% critical value. Thus, the risk arising from the unanticipated inflation is found not to have an independent effect in explaining the cross-section variations of returns.

The picture is somewhat different for the change in the expected inflation variable. None of the estimates of gamma for this variable is significantly less than zero. Twelve of the estimates are negatively signed but insignificant, while twenty-four of them are positively signed and again insignificant. Four of them are significantly greater than zero. The mean estimate of gamma for the expected inflation is found to be positive with a *t*-ratio of 2.62, which is higher than the 5% critical level. Thus, the expected inflation is found to have a significant independent influence on the variations in cross-sections of returns.

COMPARISON OF FINDINGS

The key point to note in the results of this study is the evidence (perhaps a weak one) in support of the APT. The model is found to have a high explanatory power, though only two factors in the factor analysis and just one variable in the macroeconomic factors have turned out to be significant.

A number of previous studies have found support for this theory just as several have produced evidence against it. Take the case of Oldfield and Rogalski (1981), which opines that the APT gives a more compact method for deriving a linear *ex ante* security return model than the CAPM. They stress that in the arbitrage theory of Ross (1976), the return generating equation is the basis for the *ex ante* return relationship. Briefly, an approximate linear expected return equation is derived directly from the return generating equation and, thus, the two separate models are not required. In addition, the *ex ante* return equation is defined in terms of an arbitrary number of special factor portfolio returns rather than a single market portfolio return. In this sense, Oldfield and Rogalski (1981) are of the opinion that the APT has richer implications and a simpler structure than the CAPM. In short, they suggest that the APT is 'a correct specification of *ex post* and *ex ante* security returns'. They also opine that the treasury bill rate provides a source for identifying statistical factors that influence common stock returns (p. 349).

There are other studies that have reported support for the APT. Fogler, John and Tipton (1981) hypothesize that the *ex post* return on an asset would be systematically related to the return on a stock market index, as well as that on a US Government bond index and a corporate bond index. The purpose of Fogler, John and Tipton's study was to assign economic meaning to the stock market factors and to determine the extent to which these factors were related to the prices of capital in the bond market. They feel that their analysis has achieved these goals. Further, the returns on bond market variables were found to relate to the stock market factors derived from all 100 stocks, although those bonds with default risk show a very weak relationship. Thus, although Fogler, John and Tipton use a different set of variables in their model, they report results that indicate a support for the APT.

There are findings that run contrary to the APT. The study of Dhrymes, Friend and Gultekin (1984) questions the validity of the current methodology employed to test the APT. They demonstrate that there is a general non-equivalence of factor analysing small groups of securities and factor analysing a group of securities sufficiently large for the APT model to hold. As a result, they found that as one increases the number of securities in the groups to which the APT/factor analytic procedures are applied, the number of 'factors' with larger security groups cannot readily be explained away by a distinction between 'priced' and 'non-priced' risk factors. Further, they stress that the key implications of the APT, as developed by Ross (1976) and subsequently tested by Roll and Ross (1980), and many others, are that (a) only the covariance measures of risk (beta coefficients on different factors) are relevant to the relative pricing of risky assets; and (b) the constant term in the linear relationship of expected returns and its determinants is either the risk-free rate or the zero-beta rate.

The Dhrymes, Friend and Gultekin (1984) paper presents a comprehensive set of tests of both of these implications of the APT, and reports results that lead to substantially different conclusions from those drawn by Roll and Ross (1980). Dhrymes, Friend and Gultekin find a very limited relationship between the expected returns and the covariance measures of risk (factor loadings). Clearly, the results presented in this study are at variance with those of Dhrymes, Friend and Gultekin in at least one important respect: the APT has a significant explanatory power. One possible reason for the differences between the results reported here and those of Dhrymes, Friend and Gultekin may be attributed to the differences in the level of computer sophistication during the period of Dhrymes, Friend and Gultekin's study and that of this study. It is no doubt that advances in computer programming have been dramatic, and perhaps unparalleled by progress in any other sector. At the time of the earlier study, there was a severe limitation on the number of stocks that could be handled by the factor analysis. Although there still is a constraint, it is by no means as severe now as at that time. Dhrymes, Friend and Gultekin (1984), in fact, note the severity of the constraint imposed by the computer technology when they stress:

> *A major part of the problem results from the necessity to break down the universe being analysed through the APT model; this is forced upon the investigator by the fact that the computer software does not permit factor analysis involving covariance or correlation matrices of high order.*

The results presented in this study are, therefore, some indication of support for the APT. This conclusion should, however, be taken against the background of the limitations of this study.

SUMMARY AND CONCLUSIONS

The study uses both the factor analysis and the macroeconomic factors approaches to test the APT. The former approach employs six unknown factors; and the latter, four known variables: business cycle measure, industrial production, unexpected inflation, and expected inflation. The results show that two factors are significant in the factor analysis approach and just one (expected inflation) in the other approach.

An implication of the findings is that investors should pay close attention to the macroeconomic variables, such as inflation, as these have at least a joint effect on the returns they get from their investments. This has an important lesson for investors of varying levels of risk aversion. For investors who are ready to take on risk arising from the macroeconomic events, they should consider paying particular attention to the stocks that are sensitive to changes in the condition of the macroeconomy. Stocks, such as those in the finance and related sectors, tend to be very sensitive to the health of the economy and, thus, this category of stocks should be given more emphasis when it is expected that the macroeconomic situation is heading for better times. For more risk-averse investors, the message is that they should concentrate on stocks that are less sensitive to changes in the health of the economy. Perhaps stocks in the food and other basic goods sector are less prone to cyclical changes in the economy and, hence, those would be good candidates for the portfolios of risk-averse investors and in periods of, or heading for, economic downturn.

Needless to say, the findings of the paper are subject to the limitations of the testing procedure for the APT and the sample, both period and stocks. A more rigorous study would cover the post-crisis period as well as the stocks of the second board (small and medium size) companies on the KLSE. Such a study, if undertaken, would gauge the effects of the Asian crisis and the company size on the return–risk relationship. This provides a fruitful breeding ground for research in this interesting, and yet highly unexplored area of finance.

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ENDNOTES

1. Although this technique is called the 'factor analysis approach', it does involve a great deal of regression. It is so named because data for the variables used in the first-pass regression are generated with the help of factor analysis.

2. Some researchers have suggested ways to deal with the problem of missing data. For example, the missing data could be replaced by the mean values or by the lagged value of the variable. This study does not take this option because of the preponderance of missing data for the long-term government bonds.

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