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# A Test for Normal Distribution and the Statistical Measures of Distribution for the Malaysian Stock Prices

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*ABSTRACT*

*This paper attempts to explore the nature of price changes for the Malaysian Stocks. A non-parametric test called the Kolmogorov-Smirnov one sample goodness-of-fit was used to determine whether or not the price changes of the Malaysian stocks conform to the normal distribution. This test proved conclusively that the price changes of the Malaysian stocks are non-normal, thus substantiating the results of tests performed on other stock markets in the developed countries. In addition, statistical measures such as mean, standard deviation, skewness and kurtosis were used to further describe the distributional nature of the price changes for these stocks.*

*ABSTRAK*

*Kertas kajian ini cuba mendalami tentang tabii perubahan harga bagi saham-saham Malaysia. Satu ujian "non-parametric" bernama Kolmogorov-Smirnov telah digunakan untuk menentukan sama ada perubahan-perubahan harga bagi saham-saham Malaysia mempunyai taburan normal. Ujian ini membuktikan bahawa sesungguhnya perubahan harga bagi saham-saham Malaysia tidak bertaburan normal, oleh itu menyokong keputusan-keputusan yang didapati bagi ujian-ujian yang dilakukan pada pasaran-pasaran saham di negara-negara yang telah maju. Selain dari itu, ukuran-ukuran statistik seperti purata, sisihan piawai, "skewness", dan kurtosis digunakan untuk menerangkan dengan lebih lanjut lagi tentang tabii taburan perubahan harga bagi saham-saham ini.*

## INTRODUCTION

Most of the studies performed on non-Malaysian stocks [Ang and Pohlman (1978), Fama (1965), Conrad and Juttner (1973), Dryden (1969), and Jennergren and Korsvold (1975)] indicated that the distributions of stock

price changes are non-normal. However, this conclusion is based on the comparison between the actual distribution of the price changes with a normal distribution. None of these studies performed a formal test to prove that indeed the price changes are not distributed normally. Fama (1965) indicated that the distribution of the stock price's changes is not that important as far as the random walk model is concerned. However, he stated that the nature of the distribution for these price changes is important in determining the riskiness of investment in common stocks, and to a reseacher it helps him/her to design a more appropriate statistical test when dealing with stock price changes. For example, if it is found that price changes were non-normal, then all tests which assume normality (with the population of the data used), are not appropriate. In addition, nonnormality with the price changes will have a serious implication to the modern portfolio theory because of its normality assumption regarding the distribution of the stocks' returns. In fact, the risk-return relationship, popularly mentioned in the portfolio theory, is based on the normality assumption. In addition, regression analysis (both simple and multiple), as used in developing the single index model, multi-index model, capital asset pricing model, and arbitrage pricing theory, is not appropriate to be used in the development of these models because of its normality assumption.

The test chosen for this paper is a non-parametric test, which makes no assumption regarding the distribution of the data used. This is important because we have not yet established the nature of distribution of these price changes. If we can establish that price changes of the Malaysian stocks are non-normal, then all future tests which assume normality (with the population of the data) should not be used. In fact, the findings of the tests performed on stock markets in the developed countries suggest that all tests carried out on stock price changes should be those tests which make no assumption regarding the nature of distribution, i.e., non-parametric tests.

Statistical measures such as mean, standard deviation, skewness and kurtosis were used to further describe the distributional nature of price changes for these stocks. These measures were calculated with the help of a well-known statistical package, the SPSS-X.

## METHODOLOGY

The data used in this study were the weekly closing pricess of 30 randomly selected stocks from a pool of stocks listed in the KLSE industrial index and the New Straits Times industrial index. These stocks were traded on the KLSE from January 1977 to May 1985 inclusive. These stock prices were corrected for capital adjustments (splits, stock dividends, and rights). The corrected prices were then transformed into the percentage changes.

## TEST FOR NORMAL DISTRIBUTION

Let $F_o(x)$ be the hypothesized cumulative distribution, F(x) be the observed cumulative distribution, and S(x) be a random sample drawn from F(x), then the Kolmogorov-Smirnov one sample goodness-of-fit test (Daniel 1978) can be used to determine whether the lack of agreement between $F_o(x)$ and S(x) is sufficient to cast doubt on the null hypothesis that $F(x) = F_o(x)$.

Let x be the percentage changes in stock prices, then S(x) = the proportion of sample observations less than or equal to x. The test statistic $D = \text{Sup}\,[S(x) - F_o(x)]$, which is read "D equals the supremum, over all x, of the obsolute value of the difference $S(x) - F_o(x)$." If the two functions are represented graphically, D is the greatest vertical distance between S(x) and F(x).

The null hypothesis, which states that the cumulative probability distribution of the percentage changes in stock price is normal, was tested using the formula

$$Z - (\text{observed}) = D \times [1/n]^{1/2}$$

as suggested by the procedure in the SPSS-X. The null hypothesis is accepted if Z-(observed) is within plus ot minus 1.96 at the 5 percent level of significance, or within plus or minus 2.576 at the one percent level of significance.

## STATISTICAL MEASURES OF THE DISTRIBUTION

Let $r_i$ be the percentage price change for a stock at time period i, $P_i$ as the probability of $r_i$ and E(r) as the expected mean for $r_i$ (where $E(R) = \sum_{i=1}^{n} P_i r_i$), then we can discuss these terms in terms of four different statistical moments (Francis 1986). The first moment, $M_1 = \sum_{i=1}^{n} P_i[r_i - E(r)]$, is always equivalent to zero. The expected mean, E(r), is equivalent to $\sum_{i=1}^{n} P_i r_i$. The second moment, $M_2 = \sum_{i=1}^{n} P_i[r_i - E(r)]^2$, which is another name for variance, measures the distribution's dispersion or wideness. Its square root, $\sigma$, is the standard deviation, which measures the variability of price changes.

The third moment, $M_3 = \sum_{i=1}^{n} P_i\,[r_i - E(r)]^3$, measures the lopsidedness of the distribution. It is normalized by dividing it by the standard deviation cubed. This put the third moments of different distribution in terms of a relative measure of lopsidedness which is called "skewness", $sk(r) = M_3/\sigma^3$. Figure 1 shows three probability distributions with different type of skewness.

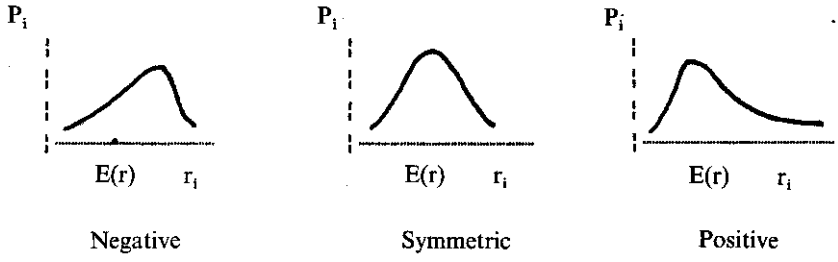


FIGURE 1. Three Probability Distributions with Different Type of Skewness

The Fourth moment, $M_4 = \sum_{i=1}^{n} P_i [r_i - E(r)]^4$, measures the peakedness of a probability distribution. The fourth moment is also called kurtosis. Figure 2 shows three probability distributions with different types of kurtosis. In the SPSS-X procedure, $Kur(r) = [M_4/\sigma^4] - 3$.

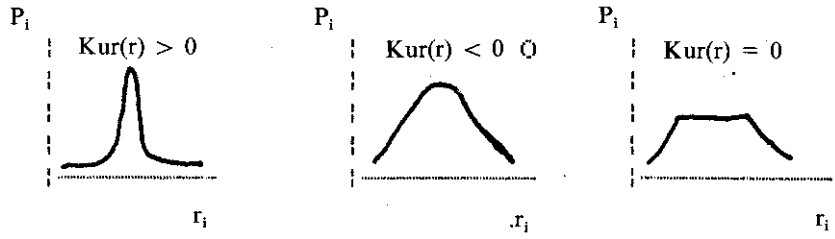


FIGURE 2. (a) Leptokurtic (b) Normal or Mesokurtic (c) Platykurtic

A well-known statistical package, SPSS-X, was used to provide some statistical measures which describe the distribution of the price changes. These measures are mean, median, mode, standard deviation, skewness, kurtosis and range (minimum and maximum values). Means and standard deviations are recomputed as annualized values in order to make a meaningful comparison with the results of a study done in the US.

## FINDINGS

Tables 1 shows the results of the Kolmogorov-Smirnov test performed on the 30 industrial selected for this study. All the 30 stocks show a significant departure from the normal distribution. This finding is consistent with the findings on the Asian and Australian stocks (Ang & Pohlman 1978), American stocks (Fama 1965), German stocks (Conrad & Juttner 1973),

TABLE 1. Results of the Kolmogorov-Smirnov test

| Stock | Value of D | Number of observation | Z-(observed) | Two-tailed P-prob. |
|---|---|---|---|---|
| 1. Alcom | 0.84134 | 436 | 17.568 | 0.000 |
| 2. Boustead | 0.84134 | 437 | 17.588 | 0.000 |
| 3. Chem. Co | 0.84134 | 436 | 17.568 | 0.000 |
| 4. Cold Storage | 0.84134 | 437 | 17.588 | 0.000 |
| 5. Cycle and Carriage | 0.84134 | 436 | 17.568 | 0.000 |
| 6. Esso | 0.84134 | 434 | 17.527 | 0.000 |
| 7. Fed. Cable and W | 0.84134 | 437 | 17.588 | 0.000 |
| 8. F & N | 0.84134 | 437 | 17.588 | 0.000 |
| 9. General Lumber | 0.84134 | 437 | 17.588 | 0.000 |
| 10. Genting | 0.84134 | 429 | 17.426 | 0.000 |
| 11. Haw Par | 0.84134 | 435 | 17.548 | 0.000 |
| 12. Inchape | 0.84134 | 431 | 17.467 | 0.000 |
| 13. Jack Chia | 0.84134 | 434 | 17.527 | 0.000 |
| 14. Malayan Cement | 0.84134 | 432 | 17.487 | 0.000 |
| 15. Malayan Tobacco | 0.84134 | 431 | 17.467 | 0.000 |
| 16. Malayawata | 0.84134 | 433 | 17.507 | 0.000 |
| 17. Matshusita | 0.84134 | 437 | 17.588 | 0.000 |
| 18. New Straits Times | 0.84134 | 437 | 17.588 | 0.000 |
| 19. Pan M Cement | 0.84134 | 430 | 17.446 | 0.000 |
| 20. Paper Product | 0.84134 | 432 | 17.487 | 0.000 |
| 21. Perlis Plantation | 0.84134 | 437 | 17.588 | 0.000 |
| 22. Rothmans M | 0.84134 | 431 | 17.467 | 0.000 |
| 23. Sanyo | 0.84134 | 436 | 17.568 | 0.000 |
| 24. Shell | 0.84134 | 437 | 17.588 | 0.000 |
| 25. Sime Darby | 0.84134 | 435 | 17.548 | 0.000 |
| 26. Strait S'ship | 0.84134 | 432 | 17.487 | 0.000 |
| 27. Strait Trading | 0.84134 | 436 | 17.568 | 0.000 |
| 28. Tan Chong | 0.84134 | 430 | 17.446 | 0.000 |
| 29. UMW | 0.84134 | 436 | 17.568 | 0.000 |
| 30. Yeo H Seng | 0.84134 | 437 | 17.588 | 0.000 |

United Kingdom stocks (Dryden 1969), and the Norweigian and Swedish stocks (Jennergren & Korsvold 1975).

Table 2 shows the distributional nature of the weekly price changes for the thirty Malaysian stocks selected for this study. The means of the weekly price changes vary from 0.058 percent for Malayawata to 0.670 percent for Esso, with an average of 0.340 percent. The medians with the exception of Esso (median equals 1), are all zero. Three of the stocks have a mode of 1, seven stocks have a mode of −1, and the rest have zero mode. It should be noted here that for a distribution to be normal, the values for mean, median, and mode should be the same. This means that none of the stocks exhibits a normal distribution.

The values of standard deviation vary from 3.122 percent for Esso to 6.842 percent for General Lumber, with an average of 4.832 percent. All, with the exception of 4 stocks, have positive skewness. The average skewness is 0.504. A normal distribution has a zero skewness; that is, these stocks deviate from normal distributions. All stocks have kurtosis greater than zero, i.e., all are platykurtic. A normal distribution has a kurtosis of zero. On the average, the price changes range from −24 percent to +27 percent. The largest minimum value is −38 percent for Malayawata and Yeo Hiap Seng, and the largest maximum value is 46 percent for Cycle and Carriage.

Table 3 shows the annualized means and standard deviations of the price changes for the thirty Malaysian stocks. The annualized means vary from 0.70 for Malayawata to 8.04 percent for Esso, with an average of 4.08. The annualized standard deviations vary from 22.51 percent for Esso to 49.34 percent for General Lumber, with an average of 34.84 percent.

Table 4 shows the basic series investment total annual returns for United States for the period 1926–1978. As we can see, the annualized average return for common stocks is 11.2 percent, and the standard deviation is 22.2 percent. This means that, on the average, the Malaysian stocks have higher return than the US stocks, and a higher standard deviation. It should be noted here that the price changes for Malaysian stocks do not really reflect the actual returns. We have to add dividend yield to the percentage change in order to get the actual return. It should be noted that most Malaysian stocks have low dividend yields (less than 4 percent annually). If we add dividend yield, the average return for Malaysian stocks will still be higher than the average return for US stocks during that time period.

The comparison of riskiness will be more meaningful if we use the coefficient of variation, which is the standard deviation divided by mean. The coefficient of deviation measures the degree of change in the standard deviation as a result of a unit change in the mean, i.e., $\sigma/\bar{x}$. The Malaysian

TABLE 2. Distributional nature of the weekly percentage price changes for Malaysian stocks, 1977–1985

| Stock | Mean | Median | Mode | Standard Deviation | Skewness | Kurtosis | Range Min | Range Max |
|---|---|---|---|---|---|---|---|---|
| 1. Alcom | .170 | 0 | 0 | 5.313 | 1.150 | 6.190 | −19 | 28 |
| 2. Boustead | .168 | 0 | −1 | 5.379 | −1.066 | 9.018 | −36 | 20 |
| 3. Chem. Co. | .089 | 0 | 0 | 3.277 | .640 | 5.805 | −12 | 19 |
| 4. Cold Storage | .090 | 0 | 0 | 4.273 | .011 | 4.660 | −21 | 19 |
| 5. Cycle & C | .423 | 0 | 0 | 6.078 | .932 | 16.896 | −33 | 46 |
| 6. Esso | .670 | 1 | 1 | 3.122 | .127 | .930 | −9 | 8 |
| 7. Fed. C & W | .423 | 0 | 0 | 6.470 | .374 | 3.727 | −25 | 37 |
| 8. F&N | .134 | 0 | 0 | 3.687 | −.979 | 6.173 | −17 | 10 |
| 9. General Lumb. | .447 | 0 | 0 | 6.842 | .515 | 4.071 | −30 | 32 |
| 10. Genting | .646 | 0 | 0 | 4.900 | .562 | 3.655 | −17 | 25 |
| 11. Haw Par | .313 | 0 | 1 | 5.693 | .541 | 6.132 | −26 | 33 |
| 12. Inchape | .140 | 0 | −1 | 4.677 | .643 | 6.730 | −22 | 25 |
| 13. Jack Chia | .433 | 0 | 0 | 5.189 | 1.013 | 9.406 | −24 | 32 |
| 14. M Cement | .403 | 0 | 0 | 3.836 | .554 | 6.895 | −24 | 20 |
| 15. M T'bacco | .380 | 0 | 0 | 3.464 | .914 | 10.437 | −18 | 24 |
| 16. Malayawata | .058 | 0 | −1 | 5.489 | .900 | 16.814 | −38 | 44 |
| 17. Matshusita | .494 | 0 | 0 | 4.431 | .789 | 19.954 | −27 | 33 |
| 18. New S Times | .549 | 0 | 0 | 3.160 | .617 | 5.561 | −16 | 15 |
| 19. Pan M Cement | .585 | 0 | 0 | 5.879 | .724 | 5.797 | −28 | 31 |
| 20. Paper Products | .326 | 0 | −1 | 5.806 | .790 | 5.453 | −28 | 32 |
| 21. Perlis P'tion | .356 | 0 | 0 | 5.120 | .056 | 3.757 | −24 | 24 |
| 22. Rothmans M | .425 | 0 | 0 | 4.462 | −.238 | 8.634 | −28 | 26 |
| 23. Sanyo | .237 | 0 | 0 | 4.517 | 1.867 | 16.227 | −26 | 30 |
| 24. Shell | .420 | 0 | 0 | 5.031 | 1.725 | 18.226 | −31 | 41 |
| 25. Sime Darby | .145 | 0 | 0 | 4.733 | .372 | 11.843 | −26 | 33 |
| 26. Straits S'ship | .082 | 0 | 0 | 4.524 | 1.096 | 6.673 | −21 | 25 |
| 27. Straits T'ding | .401 | 0 | −1 | 4.364 | .187 | 3.685 | −19 | 19 |
| 28. Tan Chong | .652 | 0 | 1 | 5.101 | .408 | 6.249 | −25 | 29 |
| 29. UMW | .253 | 0 | −1 | 5.452 | .797 | 2.962 | −18 | 26 |
| 30. Yeo H Seng | .293 | 0 | −1 | 4.683 | −.901 | 12.861 | −38 | 22 |
| Average | .340 | * | * | 4.832 | .504 | 8.181 | −24 | 27 |

*Notes:* 1) * Not meaningful.
2) For a normal distribution, mean = median = mode.

TABLE 3. Annualized stock price changes and standard deviations for Malaysian stocks

| Stock | Mean (%) | Standard Deviation (%) |
|---|---|---|
| 1. Alcom | 8.84 | 38.31 |
| 2. Boustead | 8.74 | 38.79 |
| 3. Chem. Co. | 4.63 | 23.63 |
| 4. Cold Storage | 4.68 | 30.81 |
| 5. Cycle and Carriage | 22.00 | 43.83 |
| 6. Esso | 34.84 | 22.51 |
| 7. Fed. Cable and W | 22.00 | 44.66 |
| 8. F & N | 6.97 | 26.59 |
| 9. General Lumber | 23.24 | 49.34 |
| 10. Genting | 33.59 | 35.33 |
| 11. Haw Par | 16.28 | 41.05 |
| 12. Inchape | 7.28 | 33.73 |
| 13. Jack Chia | 22.52 | 37.42 |
| 14. Malayan Cement | 20.96 | 27.66 |
| 15. Malayan Tobacco | 19.76 | 24.98 |
| 16. Malayawata | 3.02 | 39.58 |
| 17. Matshusita | 25.69 | 31.95 |
| 18. New Straits Times | 28.55 | 22.79 |
| 19. Pan M Cement | 30.42 | 42.39 |
| 20. Paper Product | 16.95 | 41.87 |
| 21. Perlis Plantation | 18.51 | 36.92 |
| 22. Rothmans M | 22.10 | 32.18 |
| 23. Sanyo | 12.32 | 32.57 |
| 24. Shell | 21.84 | 36.28 |
| 25. Sime Darby | 7.54 | 34.13 |
| 26. Straits S'ship | 4.26 | 32.62 |
| 27. Straits Trading | 20.85 | 31.47 |
| 28. Tan Chong | 33.90 | 36.78 |
| 29. UMW | 13.16 | 39.31 |
| 30. Yeo H Seng | 15.24 | 33.77 |
| Average | 17.68 | 34.84 |

TABLE 4. Basic series US investment total annual returns, 1926–1978

| Series | Mean (%) | Standard Deviation (%) |
|---|---|---|
| Common Stock | 11.20 | 22.20 |
| Long-term corp bond | 4.1 | 5.6 |
| Long-term gov't bond | 3.4 | 5.7 |
| U.S Treasury Bill | 2.5 | 2.2 |
| Inflation | 2.6 | 4.8 |

*Source:* Ibbotson, R.G., & Sinquefield, R.A. 1979. *Stocks, Bonds, Bills and Inflation: Historical Returns 1926–1978*. Charlottesville, Va.: The Financial Analysts Research Foundation, p. 12, exhibit 3.

stocks have a coefficient of variation of approximately 2, which is similar to the US stocks which also have a coefficient of variation of approximately 2. This means that the Malaysian stocks, on the average, are approximately as volatile as the US stocks.

## CONCLUSIONS

This paper tests the nature of distribution for the Malaysian stocks prices using a non-parametric test called Kolmogorov-Smirnov. This test proved conclusively that the price changes of the Malaysian stocks are non-normal. This finding is consistent with the findings of other studies performed on stocks markets in the developed countries. This implies that future tests employing price changes should, in facts, be carried out using non-parametric tests. In addition, this results (as well as the findings of other stock markets) has a very important implication to the field of the modern portfolio theory, especially with those which deal with the risk-return relationship. It means that the risk (as measured by the standard deviation, in the case of Markowitz theory), as previously calculated based on the assumption of stock's returns having a normal distribution, is not the "true" risk. In addition, models such as single index, multi-index, capital asset pricing, and arbitrage pricing, should be readjusted or reevaluated because they are developed using the regression analysis, which assumes normality with the population of the sample size under consideration.

This paper also reported the nature of distribution for Malaysian share prices. The statistical measures to describe these distributions were presented. Coefficient of variation was used to compare the relative volatility of returns between US and Malaysian stocks. Overall, Malaysian stock have positive mean, exhibit leptokurtosis, and have positive skewness. In a nutshell, Malaysian stocks do not exhibit a normal distribution. In addition, the coefficient of variation indicated that Malaysian stocks are as volatile as the US stocks in terms of annual returns.

In the past, emphasis had been on mean and standard deviation. Little had been said about skewness of a stock's return. Future research should explore more about the performance of the stocks with positive skewness, since stocks with positive skewness have greater chance of outperforming other stocks. The researcher can start with a portfolio of positively skewed stocks identified in this paper, and compare its performance with the rest.

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