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The Johannesburg Stock Exchange as an efficient market

ABSTRACT

This note reviews the evidence for and against the assumption that The Johannesburg Stock Exchange is an efficient market. After considering the results of statistical tests and trading rule simulations on share price sequences, and analysing the performance of mutual fund portfolios, it concludes that the evidence supports the assumption. This conclusion has important practical implications for portfolio managers.

1 INTRODUCTION

For more than fifteen years American academics have debated the economic process that underlies the pricing of ordinary shares. The controversy revolves around the so-called 'efficient market hypothesis' (henceforth 'EMH') which states that the market prices of securities at any time 'fully reflect' all available information.

The validity or otherwise of this hypothesis is of great practical significance. For example, it implies that the study of trends and patterns in past price behaviour will not allow one to predict the future performance of a given share. Consequently the activities of chartists, and indeed the whole field of technical analysis, are of no value to investors. It further implies that fundamental analysis — i.e. the acquisition and analysis of company financial statements, directors' reports, earnings and dividend records, and the like — also cannot be expected to allow superior investment performance. Given the importance of these two categories of analysis in the traditional approach to portfolio management, the depth of the controversy becomes evident.

Two studies of shares listed on The Johannesburg Stock Exchange ('JSE') have recently appeared[1,2] in South African journals. Since the authors arrive at conclusions* that are contradictory and not supported by the evidence presented, we anticipate some confusion in the minds of their readers. This situation is not unlike that which existed in the early stages of American research, and it seems desirable that we should learn from that experience.

In this note we shall review the evidence as far as it supports or denies the assumption of efficiency for the JSE; in so doing, we shall also refer to the findings of our own research in this field.

2 THE EFFICIENT MARKET MODEL

The major didactic work on efficient markets is that of Fama,[3] as modified.[4,5] We shall follow closely his outline and terminology.

The definitional statement that, in an efficient market, security prices 'fully reflect' all available information is so general that it has no empirically testable implications. Most research has therefore been based on the assumption that the conditions of market equilibrium can somehow be stated in terms of expected returns. The basic model of market equilibrium is then the 'fair game' expected return model† which states that

$$E(\tilde{x}_{t+1} \mid \phi_t) = 0 \qquad \text{I}$$

or alternatively

$$E(\tilde{z}_{t+1} \mid \phi_t) = 0 \qquad \text{II}$$

where $x_{t+1} = P_{t+1} - E(\tilde{P}_{t+1} \mid \phi_t)$

or $z_{t+1} = r_{t+1} - E(\tilde{r}_{t+1} \mid \phi_t)$

Here E = expected value operator

P_t = price of the security at time t

r_t = one period percentage return $= (P_{t+1} - P_t) / P_t$

ϕ_t = symbol representing whatever set of information is assumed to be 'fully reflected' in the price at time t, and

a tilde indicates a random variable.

The variable x_{t+1} thus denotes the 'excess' market value of the security at time t+1, i.e. the difference between the observed market price and the expected value of the price that was projected at t on the basis of the information set ϕ_t. Equation I defines the expected value of x to be zero in the 'fair game' model.

Two important special cases of this general 'fair game' model can be derived. The first is the submartingale which arises as follows:

If for all t and ϕ_t

$$E(\tilde{P}_{t+1} \mid \phi_t) \geqslant P_t \qquad \text{III}$$

or equivalently

$$E(\tilde{r}_{t+1} \mid \phi_t) \geqslant 0 \qquad \text{IV}$$

then the price sequence $\{P_t\}$ is said to follow a submartingale‡ with respect to the information sequence $\{\phi_t\}$. If equations III and IV hold as equalities the price sequence follows a martingale.‡ The properties of these processes are described in 6 and 7.

The second special case of the general 'fair game' model is the 'random walk'. This case arises when the stochastic process§ that generates the one-period returns r_t has specific properties such that the returns are independent and their distributions repeat themselves through time (see 8 for the theory of random walks). This model implies much more than the general 'fair game' model of equations I and II. Therefore, empirical evidence that conflicts with the random walk model would not necessarily constitute a denial of the EMH.

*See section 3 below.

†A game having zero as the expected winnings per play is called a fair game.

‡In brief, if a price sequence follows a submartingale, the expected value of the next period's price is equal to or greater than the current price. If it follows a martingale the expected price *change* is zero.

§A stochastic process can be conveniently imagined to consist of the performance of a succession of random experiments, each experiment determining the value of one random variable.

The efficient market model described above is concerned with market expectations and therefore it is not possible to test it directly. Empirical work has thus focused on the testable implications of the model. Historically, four major categories of tests have been devised:

(a) Statistical tests on price sequences

(b) Evaluation of trading rules

(c) So-called 'semi-strong' tests of whether prices adjust efficiently to specific information

(d) Portfolio performance tests.

As far as we are aware, semi-strong tests of type (c) have not yet been performed for shares listed on the JSE. However, all of the others have been, and the findings are reviewed below.

3 STATISTICAL TESTS ON PRICE SEQUENCES

Early work in the field focused on statistical tests of the independence or otherwise of successive share price changes. These tests involved the estimation according to exact formulae of various statistics for a sample of empirical data, and then comparison of the results with what would be expected under the assumption of independence. If the two sets of results conform closely, the statistician would conclude that the price changes were independent. In a now classic study, Fama[9] analysed a five-year record of the daily price changes of the thirty industrial stocks that comprise the Dow Jones Industrial Average of the New York Stock Exchange ('NYSE'). One of his main conclusions was that the independence assumption was 'an adequate description of reality'.

Fama's research served as model for three studies of JSE shares. Two of these[1, 2] involved tests on industrial shares only, while the third[10] included tests on shares in mining companies. Both serial correlation and runs tests have been used. In all cases there was some evidence that the price changes were not completely independent. In our study we found that although the apparent deviations from independence were small, they were consistent with a situation in which a time trend or bunching of observations occurred.[10] This finding was significantly different from that of Fama for the NYSE.

The implications of the findings must now be considered. Should one conclude, as does Hadassin,[2] that the JSE 'has been proved to be an inefficient market' and thus 'chartists . . . should be able to make greater gains than those of the market'? Or should one observe conversely, as do Graves and Money,[1] that the auto-correlations are so small as to be 'useless' and therefore 'any form of technical analysis based only on past prices is worthless'? In our view neither conclusion is justified by the evidence presented so far.

Statistical tests of this nature can and have been criticised on quite fundamental grounds. We shall mention four of these. The first two pertain to the conclusions of 2, while the third and fourth pertain to both 1 and 2:

(a) Since such tests are concerned with the independence or otherwise of price changes, they are in fact tests of the random walk model rather than of the EMH. Rejection of the former does not necessarily invalidate the latter.[3]

(b) Non-stationarity of the model, as for example under the sub-martingale of equation III, poses a problem because the usual statistic for correlation assumes a constant mean. Therefore, if no correction for non-stationarity is made, a test for un-correlatedness based on the sample correlation coefficient will be biased toward rejection.[4]

(c) There is evidence[10] that the distributions of price changes for shares listed on the JSE exhibit even more pronounced leptokurtic* properties† than do the NYSE shares reported on by Fama.[9] The empirical distributions seem to conform to a class of non-Gaussian stable distributions‡ which have, inter alia, the property that the variance does not exist except in the special Gaussian case. Since the common statistical tools are based on the assumption of finite variance, they need to be interpreted with caution.[9, 10]

(d) Finally, and perhaps most importantly, the simple linear relationships which underlie the serial correlation model are too unsophisticated to identify the complex non-linear 'patterns' sought by chartists in share price records.[12] To investigate such relationships we must turn to the stricter tests of sections 4 and 5 below.

Given these criticisms, we must conclude that, whereas the small correlation coefficients are consistent with the EMH, they do not prove its validity. Conversely, the observed deviations from independence do not justify rejection of the hypothesis. We shall, therefore, avoid generalised conclusions until we have reviewed the evidence from the other two categories of tests.

4 EVALUATION OF TRADING RULES

Trading rule ('TR') tests have played an important role in the evolution of efficient market theory; in fact, it has been contended that the EMH is directly testable only via such procedures.[13] These tests involve computing the returns that a stock market trader might have achieved had he based his purchase and sales decisions on a mechanical trading rule. The returns generated in this manner have invariably been smaller than those resulting from a simple buy and hold ('B&H') strategy. It can be shown that this would be a major consequence of market efficiency.[3, 5]

Consider, for example, a trading rule which operates as follows: A buying signal is generated if the price of a particular share is greater than some moving average of price by at least x% *and* the volume of shares traded is greater than a moving average of volume by at least y%. A selling signal is generated if the price of the share is less than the price moving average by at least x% *and* the volume of shares traded is greater than the volume moving average.

*The term leptokurtic is used to indicate that there is a relatively high concentration of observations around the modal value and in the extreme tails when compared to the Gaussian distribution.

†In addition there are important differences between the distributions of gold mining shares and those of other shares.

‡We did not investigate the possibility that the empirical distribution might conform more closely to the Student distribution (see 11).

Let us measure the performance P of this TR as the geometric mean of the wealth ratios of the individual transactions. If the above TR were applied* to the historical price record of, say, OK Bazaars, one finds that P = 0,705. Measured according to the same criterion, a naive B&H strategy would generate a performance P = 1,69. Since the B&H strategy has outperformed the TR strategy, the results are consistent with the EMH.

We caution the reader at this stage about the interpretation of results from TR tests. For example, Praetz[14] has recently asserted that the comparison is biased against the TR due to differences in the expected returns from the two strategies. Furthermore, the question of short-term interest on available cash when not invested needs to be considered, and finally, the key aspect of consistency of superior performance must be demonstrated. These questions are beyond the scope of this note, and the interested reader is referred to our detailed analysis in (15). There we applied four trading rules to twenty-four JSE shares, and found that the TR consistently underperformed the B&H strategy. In addition, we specifically investigated whether certain of the large correlation coefficients observed in the earlier statistical tests of (10) could be utilised to earn superior returns. Again the B&H return was found to be consistently greater than the TR return. Although these results do not, of course, prove the validity of the EMH, they must be seen as support for it.

5 PORTFOLIO PERFORMANCE TESTS

The final category of tests has focused on the performance of professionally managed portfolios and, specifically, on the performance of mutual funds. If such portfolios achieve consistently superior performance relative to that of the market as a whole, some element of inefficiency in the pricing process would be indicated. Tests elsewhere have been consistent in finding that no fund achieved such superior performance.

Initial measurement on South African mutual funds have been reported[16,17] but were unsatisfactory in at least two respects. In the first place, the South African mutual fund industry was still in its infancy at the time of this early research (1971) and so only limited amounts of data were available for analysis. Secondly, more rigorous criteria of performance are available than were then used. For example, Kerbel[16] found that the ex post risk-return co-ordinates of South African mutual funds do not cluster around a line joining the risk free rate and the ex post return on the market portfolio. He views such clustering as a requirement for portfolio efficiency (in the Markowitz sense), and he thus concludes that the 'funds cannot be said to have been generally well managed'. However, Jensen[18] has shown that portfolio efficiency cannot be defined without taking into account the *ex ante* expected returns on the market portfolio. Accordingly, portfolio efficiency is not a suitable measure of *ex post* portfolio performance, and the conclusion of poor management is thus not justified.

We have carried out a more rigorous analysis[20] of the performance of South African mutual funds using the greater volume of data that is now available. We modelled our procedures closely on those established by Jensen[18,19] and thus used as our measure of performance the parameter α in the equation

$$(R_j - R_F) = \alpha + \beta (R_m - R_F) + u \qquad v$$

Here R_j = return on the security
R_F = estimated risk-free rate
R_m = return on the 'market portfolio'
β = 'systematic risk' of the security
u = error term with expected value of zero

There are various problems associated with the use of equation v. For example, it requires that the parameter β be both stable and stationary. Du Plessis[17] has reported limited tests on South African mutual fund betas and concluded that they appear to be remarkably stationary. However, in our view, this conclusion was not justified since he considered only two funds and for one of these the beta increased by 25% over two consecutive two-year periods. Our measurements[20] of beta have provided some evidence of stability but little justification for the assumption of stationarity. Nevertheless, the model of equation v can still be used to make meaningful statements about portfolio performance since, under these circumstances, it will emphasise any evidence of the portfolio manager's forecasting ability.[19]

In our analysis[20] we measured the performance of the eleven South African mutual funds under various assumptions. In one of these assumption sets we ignored

(a) dividend declarations, and

(b) the bias which is introduced by the model's implicit assumption that the funds are always fully invested in equities† (a situation prohibited by the Unit Trusts Control Act)

Under these circumstances we found that during the period 30 June 1973 to 30 September 1976, the South African mutual funds earned on the average 1,6% per annum (compounded continuously) less than they should have earned given their level of systematic risk.

In addition to these average results, we found no evidence that any individual fund was able consistently to outperform any other or significantly to outperform the market.‡

These findings are in good agreement with those reported by Jensen for the American mutual fund movement. They are also consistent with the EMH.

6 SUMMARY AND CONCLUSIONS

In this note we have reviewed the evidence for and against the assumption that the JSE is an efficient capital market. In the case of the statistical tests on price change sequences we found some evidence of deviations from strict independence. However, in view of the limited relevance of such tests and the small degree of dependence observed, we choose to interpret them as being, generally speaking, consistent with the EMH.

*Over the period from 22nd February 1971 to 22nd February 1976 and with x = 5%, y = 100%.

†Consideration of these issues is beyond the scope of the present note. The interested reader is referred to 20 for a fuller discussion.

‡We comment in passing that these findings do not necessarily imply criticism of the mutual fund managers. In an efficient market, no portfolio manager will be able to achieve consistently superior performance, yet he will have to incur costs to comply with statutory reporting requirements, and so on.

In the two other and stronger form tests the results were unequivocable: neither trading rules nor (risk-adjusted) mutual fund managers were able to outperform the market. These findings are in agreement with the results of similar studies on the American stock markets, and are consistent with the EMH. Of course, 'consistent with' does not constitute proof of hypothesis validity. However, taking all the evidence together, we must conclude that there is persuasive support for the view that the JSE is an efficient capital market. That being so, the practical implications stated in the second paragraph of this note are relevant.

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(Copies of references 10, 15 and 20 may be obtained on request from the present authors.)

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