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Introduction

Do speculative price movements follow some systematic and hence predictable pattern or class of patterns? Can information about tomorrow's price movements be gained by studying today's price data? Professional traders or speculators would have to answer these questions in the affirmative, for they operate as if this period's price movements can be used to their advantage. But today it is respectable, if not fashionable, for the professional economist and statistician to answer these questions in the negative. In the past few years a number of academic papers have concluded that speculative price movements are random walks.[1]

How should we interpret the claim that speculative prices move randomly? Following Hendrik S. Houthakker, randomness in speculative price data may be defined negatively as the "absence of any systematic pattern."[2] Alternatively, following Harry V. Roberts, the random-walk hypothesis may be taken to mean that speculative price movements "behave very much as if they had been generated by an extremely simple chance model."[3] Whether randomness is defined negatively following Houthakker or positively with Roberts, the implication of the random-walk hypothesis is that the speculators cannot know what they are doing when they study this period's price movements by way of seeking some sign of the next period's movements. I shall argue that the random-walk hypothesis flies in the face of common sense and the facts and, moreover, suggests a

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1. See, for example, Harry V. Roberts, "Stock 'Patterns' and Financial Analysis: Methodological Suggestions," *Journal of Finance,* XIV (1959), 1–10; M. F. M. Osborne, "Brownian Motion in the Stock Market," *Operations Research,* VII (1959), 145–73; Holbrook Working, "New Ideas and Methods for Price Research," *Journal of Farm Economics,* XXXVIII (1956), 1427–36; and Maurice G. Kendall, "The Analysis of Economic Time Series. Part I. Prices," *Journal of the Royal Statistical Society,* Ser. A, CXVI (1953), 11–25.

2. Hendrik S. Houthakker, "Systematic and Random Elements in Short-Term Price Movements," *American Economic Review,* LI (1961), 164.

3. Roberts, *op. cit.,* p. 2.

degree of naïveté on the part of its advocates as to the rules of the game which professional speculators are playing.

How valid is the random-walk hypothesis? No one has disagreed in full, but some economists have found elements of non-randomness in speculative price movements. Houthakker presented evidence that stop orders give rise to a non-random profit.[4] Sidney S. Alexander also has published results[5] that would appear (at least at first glance) to confirm that common-stock prices follow discernible paths. According to Alexander, these trends can be brought into common view by "filtering" out random variability in common-stock prices. The filtering process consists simply of ignoring changes of less than—at a first approximation—5 per cent and betting that larger changes are more likely to continue than to reverse.

Alexander's results will please the adherents of all schools of thought on speculative prices save one. "Fundamentalists," "technicians," and supporters of the random-walk hypothesis will be pleased. But professional speculators—men who adhere to the view that it pays to study the past (e.g., "the tape")—will be confused by and also disdainful of Alexander's findings. Fundamentalists will be pleased because the existence of major non-random moves tends to affirm their contention that fundamental developments in underlying supply and demand factors must bring major price changes. They will not care that moves of less than 5 per cent appear to follow random walks; for they would not regard moves of this order as being fundamental in any sense whatever. Technicians also will be delighted by the existence of major non-random moves and will not be bothered by Alexander's failure to find trends in the cases of moves of less than 5 per cent. Their charts are usually drawn so that traders may ignore minor fluctuations and concentrate on formations and patterns showing major price movements. Also, adherents of the random-walk hypothesis will not be displeased because Alexander's results corroborate their contention that moves occur that are independent of previous price trends—even though such moves evidently do not exceed 5 per cent. But there is nothing in Alexander's results to comfort professional speculators—men who survive and prosper by exploiting price movements that more often than not are considerably less than 5 per cent.

It is a fact that there are professional traders who earn incomes

4. Houthakker, *op. cit.*, pp. 164–72, esp. 164–68.

5. Sidney S. Alexander, "Price Movements in Speculative Markets: Trends or Random Walks," *Industrial Management Review*, II (1961), 7–26.

from speculating on price movements. It is also true that these earnings are high enough frequently enough that licenses to speculate where trades are executed often can be sold for thousands of dollars. The "seats" of floor traders on the New York Stock Exchange are the clearest and purest example of such licenses. The existence of floor traders or, more to the point, of the value that the market has attached to their licenses to speculate where trades are executed is difficult to reconcile with random-walk hypothesis on speculative prices, including the modified version suggested by Alexander's results. These men, in effect, earn their incomes by betting against the applicability of the random-walk hypothesis to price moves of less than 5 per cent.

"The Next Move"

The fallacy or delusive quality of the probabilistic view of speculative prices arises from the very peculiar definition of the term "the next move," which is employed by those who claim that the next move is independent of past moves.

The most important and impressive study tending to corroborate the random-walk hypothesis of speculative prices was published by Maurice G. Kendall in 1953.[6] Kendall calculated lagged serial correlations of the first differences of series of observations of speculative prices existing at specified moments in time, e.g., series of Friday closing prices. Graphically, Kendall plotted the difference between the closing prices on the first and second Fridays observed against the difference between the second and third Fridays; and the latter difference against the difference between closing prices on the third and fourth Fridays, etc. Thus Kendall defined, implicitly if not explicitly, the next move as the difference between the prices existing at the ends of two adjacent finite time periods. To date, no one has questioned the usefulness of this definition, even though it is obviously irrelevant. Kendall's definition is a non-operational concept and hence irrelevant because professional traders do not operate only at specified moments in time such as on Fridays at 3:30 E.S.T.

Conceptually, the next move is simply the difference between the current price and the very next one. But to define the next move in this way is also to impose a non-operational time horizon upon speculators. They are not compelled to sell on the trade immediately after they buy or to cover on the trade immediately following their making a short sale. The next move must be defined so that the abstract speculator of statistical research has the same, or nearly

6. Kendall, *op. cit.*

the same, opportunities to speculate which real-world speculators have. In terms of satisfying this requirement about opportunities, either one of two definitions of the next move would appear to be appropriate. First, the next move of a price may be defined as equal to the difference between the *highest* price reached in time period t_1 (e.g., Wednesday) and the closing price of t (Tuesday), provided that the difference between the closing prices of t (Tuesday) and the preceding period t_{-1} (Monday) is positive. But if the previous trend (i.e., the difference between the closing prices of t and t_{-1}) is negative, then the next move is the difference between the *lowest* price reached in t_1 and the closing price of t. It should be realized that the use of the *highest* and *lowest* prices of t_1 in the definition is essential to provide the abstract speculator of statistical research with the same opportunities that real-world speculators have, for the latter have opportunities to sell at the highest price and to cover at the lowest price.

Speculators using the above formulation of the next move will buy whenever price in t closed above the closing price of t_{-1}. They sell sometime during period t_1, hopefully at the highest price in t_1 and in the hope that the highest price in t_1 is above the closing price of t. Conversely, they sell whenever price in t closed below the closing price of t_{-1} and buy (cover) during t_1, hopefully at the lowest price in t_1 and in the hope that the lowest price in t_1 is below the closing price of t. Thus speculators using this definition are betting on the existence of monotonic day-to-day trends.

Alternatively, it would be appropriate to define the next move as follows: the next move is the difference between the *lowest* price reached in t_1 and the closing price of t, provided that the closing price of t is higher than that of t_{-1}. But if the preceding trend is negative, the next move is the difference between the *highest* price reached in t_1 and the closing price of t. Speculators using this definition of the next move are betting against the existence of trends or, if the reader prefers, on the existence of zigzag patterns. They will sell short whenever price in t closed above the closing price of t_{-1} and cover during t_1, hopefully at the lowest price in t_1 and in the hope that the lowest price in t_1 is below the closing price of t. Conversely, they buy whenever price in t closed below the closing price of t_{-1} and sell in t_1, hopefully at the *highest* price of this period and in the hope that the highest price of t_1 is above the closing price of t.

It is useful to iterate that, unlike the Kendall definition, our formulations of the next move are operational concepts for professional speculators. The definition of the next move that is employed by the probabilistic school requires speculators to cash in their bets at a specified moment in time. There is no such rule or limitation on speculative activity, and hence this definition is not operational for professional speculators. Unlike the Kendall definition, our formulations of the next move permit speculators, whether they are betting on or against trends, to cash in their bets at the most opportune moment in time (i.e., at the most advantageous price) between the close of t and the close of t_1. Thus our formulations permit testing for trends in speculative prices under rules that give speculators no more and no less freedom than they actually have.

Evidence That Speculative Prices Follow Trends

The existence of trends in speculative prices was tested for by computing three lagged serial correlations from *daily*[7] price data on the *New York Times* Industrial Stock average for November, 1961, and also from daily price data on the more familiar Dow-Jones average for the June 1, 1961, through July 31, 1961, period.[8] These data are presented in Tables 1 and 2.

On October 31, 1961, the *Times* stock average closed at 673.80. On November 30, 1961, it closed at 680.91. Thus there was little, if any, over-all trend in this period. Similarly, there was little overall trend in the summer period. On June 1, the Dow-Jones average closed at 611.05 and on July 31 it closed at 597.93. Both series are therefore taken from periods without over-all trend. Since (presumably) it is easier to speculate successfully in periods marked by over-all trend than in periods without steady up or down price movements, testing for serial correlation in periods without over-all trend eliminates a possible bias in the results.

Also it should be noted that the tests made using the summer data involve 41 observations, whereas the tests made from the fall data involve only 23 observations. If the results of the two series of tests differed markedly, it would make sense to attach more significance to the results pertaining to the summer period than to those pertaining to the fall period. But, insofar as the results are consonant, no special importance should be placed on the results for the summer period. Finally, it should be noted that all of November was characterized by relative day-to-day price stability, whereas the first half

7. The choice of daily price data to test for serial correlation is arbitrary. However, it should be realized that a day is not an unreasonable approximation of a speculator's time horizon; certainly it appears a better approximation than an hour or a week.

8. Choices of indexes and time periods were made haphazardly, not by design—random or other.

of the summer period was marked by fairly wide price swings from day to day. On the common-sense hypothesis that the task of predicting tomorrow's price movements is more difficult in periods of wide daily price swings than in periods of relative price stability, it appears reasonable to expect somewhat less serial correlation in the summer period than in the fall period. The results are as follows:

1. Using Kendall's definition of the next move, the serial correlation is 0.42 for the November period and 0.31 for the summer period.

2. Using the definition of the next move that would be employed by speculators betting on the existence of zigzag patterns (i.e., against trends), the serial correlation is —0.55 for the November period and —0.61 for the summer period.

3. Using the formulation that would be employed by professional

TABLE 1

"THE NEXT MOVE" CALCULATED FROM "NEW YORK TIMES" INDUSTRIALS (25 COMMON STOCKS) DAILY PRICES FOR NOVEMBER, 1961

Date Nov.	High	Low	Close	"The Next Move" Under Kendall's Definition	For Speculators' Betting On Trend	For Speculators' Betting Against Trend
1......	678.54	670.59	674.85	1.05*	....	....
2......	681.11	671.81	677.80	2.95	6.26	3.04
3......	682.11	672.73	678.79	0.99	4.31	5.07
6......	687.20	675.40	683.52	4.73	8.41	6.06
8......	696.96	683.39	692.35	8.83	13.44	0.12
9......	696.70	686.80	691.26	−1.09	4.35	5.55
10......	696.84	687.47	694.27	2.96	− 3.79	−5.58
13......	702.64	690.90	698.34	4.12	8.37	3.37
14......	705.88	693.60	702.55	4.21	7.54	4.74
15......	709.46	700.00	703.14	0.59	6.91	2.55
16......	706.17	694.59	701.01	−1.23	3.03	8.55
17......	704.31	693.57	698.39	−3.52	− 8.34	−2.60
20......	704.20	693.84	698.80	0.41	− 4.55	−5.81
21......	702.80	689.86	693.58	−5.22	4.00	8.94
22......	696.27	687.54	691.76	−1.82	− 6.04	−2.69
24......	697.13	688.01	693.32	1.56	− 3.75	−5.37
27......	698.86	689.01	693.38	0.06	5.54	4.31
28......	695.82	684.80	689.45	−3.93	2.44	8.58
29......	692.29	683.04	687.02	−2.43*	− 6.39	−2.84
30......	687.34	677.70	680.91	−6.11*	− 9.98	−0.32

* The first number in this column, 1.05, is *not* a number in the series termed "The Next Move under Kendall's Definition." But this number is the first number in the previous trend series. Conversely, the last number in this column, −6.11, is not a number in the previous trend series but is the last number in the series termed "The Next Move under Kendall's Definition." The last number in the previous trend series is the next to last number in this column, −2.43.

TABLE 2

"THE NEXT MOVE" CALCULATED FROM DOW-JONES INDUSTRIALS (30 COMMON STOCKS) DAILY PRICES FOR JUNE 1–JULY 31, 1962

Date	High	Low	Close	"The Next Move": Under Kendall's Definition	"The Next Move": For Speculator Betting: On Trend	"The Next Move": For Speculator Betting: Against Trend
June						
1	616.54	603.58	611.05	− 2.31*	....	....
4	608.82	591.37	593.68	−17.37	−19.68	2.23
5	603.37	584.12	594.96	1.28	− 9.56	9.69
6	611.82	595.50	603.91	8.95	16.86	0.54
7	608.14	599.27	602.20	− 1.71	4.23	− 4.64
8	607.30	598.64	601.61	−00.59	− 3.56	5.10
11	603.20	592.66	595.17	− 6.44	− 8.95	1.59
12	593.83	580.11	580.94	−14.23	−15.06	− 1.34
13	586.42	572.20	574.04	− 6.90	− 8.74	5.48
14	579.14	560.28	563.00	−11.04	−13.76	5.10
15	579.90	556.09	578.18	15.18	− 6.91	16.90
18	583.08	567.05	574.21	− 3.97	4.90	−11.13
19	575.21	566.59	571.61	− 2.60	− 7.62	1.00
20	574.59	561.28	563.08	− 8.53	−10.33	2.98
21	561.87	549.15	550.49	−12.59	−13.93	− 1.21
22	551.99	537.56	539.19	−11.30	−12.93	1.50
25	541.24	524.55	536.77	− 2.42	−14.64	2.05
26	548.61	533.46	535.76	− 1.01	− 3.31	11.84
27	539.28	528.73	536.98	1.22	− 7.03	3.52
28	559.32	541.49	557.35	20.37	22.34	4.51
29	569.06	555.22	561.28	3.93	11.71	− 2.13
July						
2	576.63	557.31	573.75	12.47	15.35	− 3.97
3	582.99	570.53	579.48	5.73	9.24	− 3.22
5	586.30	577.39	583.87	4.39	6.82	− 2.09
6	582.58	571.28	576.17	− 7.70	− 1.29	−12.59
9	582.28	569.65	580.82	4.65	− 6.52	6.11
10	599.02	583.50	586.01	5.19	18.20	2.68
11	590.94	580.36	589.06	3.05	4.93	− 5.65
12	596.59	586.68	590.27	1.21	7.53	− 2.38
13	592.99	583.87	590.19	− 0.08	2.72	− 6.40
16	591.23	582.41	588.10	− 2.09	− 7.78	1.04
17	588.77	576.59	577.85	−10.25	−11.51	0.66
18	577.39	568.02	571.24	− 6.61	− 9.83	− 0.46
19	578.68	568.98	573.16	1.92	− 2.26	7.44
20	579.86	570.78	577.18	4.02	6.70	− 2.38
23	582.24	574.50	577.47	0.29	5.06	− 2.68
24	579.31	572.02	574.12	− 3.35	1.84	− 5.45
25	576.55	568.10	574.67	0.55	− 6.02	2.43
26	582.87	574.08	579.61	4.94	8.20	− 0.59
27	586.80	577.14	585.00	5.39	7.19	− 2.47
30	593.03	583.87	591.44	6.44*	8.03	− 1.13
31	601.15	591.78	597.93	6.49*	9.71	0.34

* See the footnote in Table 1.

traders betting on the existence of monotonic trends, the serial correlation is 0.77 for the November period and 0.69 for the summer period.

The results cannot be tested for significance with standard statistical techniques, since serial correlation is present and, in fact, predicted by hypothesis. Doubtless it would be desirable to test for trend in the way suggested by this paper, using different time periods and different price series, such as individual stock prices, for example, before accepting the suggestion of these results that speculative prices follow trends.

Economic Implications

One of the implications of my results is that speculators have opportunity to make capital gains. A corollary implication is that it is an error to infer, as many have done, from the lack of lagged serial correlation between first differences of closing prices that speculators have little or no opportunity to win. Instead, it would appear that this lack of serial correlation between first differences of closing prices simply means that speculators who are supposed to smooth out price movements over time are doing their job well.