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# TOWARD A FULLY AUTOMATED STOCK EXCHANCE

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by Fischer Black



Is the judgment of the exchange specialist the one human element in the present system that can't be replaced by a computer? In the first of two articles examining the role of the specialist, the author analyzes what we mean by an "efficient" market and suggests changes in the specialist's mode of operation that will enable him to serve investors — particularly large institutional investors—more efficiently.

UTOMATION of the stock exchanges and over-the-counter markets is moving ahead rapidly. Steps are being taken to reduce the use of stock certificates, and the clearing process is being converted to computer by both the exchanges and individual member firms. A portion of the trading in large blocks is now done with the help of systems that provide information on their availability, and systems that actually bring buyers and sellers together. Market makers and brokers in the over-the-counter market now have available an automated communications system. And plans are under study for using computers to eliminate trading floors, handle odd-lot trading automatically, and help the specialist with the management of his "book" of limit orders.

There has been little serious discussion, however, of the use of computer technology to reduce or eliminate the need for specialists, market makers, and block positioners. The role of the market maker is seen as vital to the operation of an efficient trading market by the exchanges themselves, by regulators, and by most economists. (An economist might refer to a market maker as a "speculator.")

There has been even less discussion of the use of computer technology to reduce or eliminate the need for brokers who are not specialists (such as floor brokers) and for institutional traders in the execution of orders. Currently, these brokers and traders play a role that is just as important as the role of specialists, market makers, and block positioners.

It appears that the market for a single stock is most efficient if all orders for the stock come in to a single point, so that all potential buyers can be exposed to all sell orders, and all potential sellers can be exposed to all buy orders. This article is the first of two exploring the extent to which the trading process at that single point can be handled by a computer, without the participation of brokers of any kind, and without the active participation of the buyers and sellers.

It is clearly possible to use a computer as a communications device between all the participants in the present system of trading. But we want to know instead whether it is possible to have an automated exchange providing markets as good as, or better than, the markets provided by current methods, and acting as the only intermediary between the ultimate buyers and sellers. Can a system be designed that will allow the user to place his order and then leave it to be executed by the system either immediately or over a period of time?

Note that we are not talking about the role of brokers in underwriting, or in generating and selling information about companies and stocks. We are talking only about the participation of brokers and traders in the trading process itself.

Let us begin by looking at the properties that we expect to find in an efficiently operated market.

## Liquidity

Liquidity seems to have several meanings. In general, an asset is said to be liquid if it can be sold

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in a short time, at a price not too much below the price the seller would get if he took plenty of time to sell the asset. A specialist or market maker is said to provide liquidity because he stands ready at all times to buy small amounts of his stock at his bid price. A block positioning firm is said to provide liquidity because it will make bids for immediate purchase of large blocks of stock.

The exchanges have been criticized for not providing enough liquidity in the sense of being able to handle large blocks of stock directly at the specialist's post. Institutions go instead to a broker who specializes in large blocks and contacts other institutions directly. If he can arrange a trade, it is then taken to the floor of the exchange. (Or the trade may be handled by a broker who is not a member of any major exchange.) It does appear that an efficiently organized exchange should be able to handle the immediate purchase or sale of large blocks of stock at least as well as a block positioning firm.

Some institutions believe, on the other hand, that a liquid market means the ability to buy or sell large blocks of stock in short periods of time without moving the price of the stock very much. This is simply unrealistic. Generally speaking, an institution will not want to buy or sell a large block quickly unless it has information that it thinks changes the value of the stock substantially, that has not been discounted in the market, and that will reach others in a relatively short time. Thus anyone trading with such an institution will do well to protect himself by agreeing to buy only at a substantial discount from the current market price, or to sell only at a substantial premium above the market price. Unless, of course, there is another institution just as anxious to buy as the first institution is to sell, or just as anxious to sell as the first institution is to buy.

If an institution wants to sell just to raise cash, and not because it believes that a particular stock is greatly overpriced, then it can demonstrate this to potential trading partners by offering to sell any of a variety of stocks in its portfolio, or by selling smaller amounts of each of a variety of stocks, or by selling a single stock slowly over a longer period of time. These tactics should cause the price of the stock or stocks sold to be affected very little. Since these alternative trading tactics are obviously available to it, the institution should not be surprised if it is unable to sell large amounts of a single stock quickly without affecting the price.

If an individual with large holdings of stock wants to raise cash, he can do many of the same

things an institution can do, and in addition he can borrow against his portfolio to gain time to sell at favorable prices. If he has a diversified portfolio, he can sell small amounts of a number of stocks without affecting their prices. If he has a large amount of a single stock, he can sell it over a long period of time, or he can arrange to have it sold in a secondary distribution by brokers who will tell their customers, in effect, that the stock is fairly priced. Thus an individual does not need to sell a large amount of a single stock in a short period of time unless he believes that the value of the stock is much lower than its current market price. And if he believes that, he should not be surprised to find that the price drops substantially when he sells.

Thus the market for a stock is liquid if the following conditions hold:

- (1) There are always bid and asked prices for the investor who wants to buy or sell small amounts of stock immediately.
- (2) The difference between the bid and asked prices (the spread) is always small.
- (3) An investor who is buying or selling a large amount of stock, in the absence of special information, can expect to do so over a long period of time at a price not very different, on average, from the current market price. predating execution algos
- (4) An investor can buy or sell a large block of stock immediately, but at a premium or discount that depends on the size of the block. The larger the block, the larger the premium or discount.

In other words, a liquid market is a continuous market, in the sense that almost any amount of stock can be bought or sold immediately; and an efficient market, in the sense that small amounts of stock can always be bought or sold very near the current market price, and in the sense that large amounts can be bought or sold over long periods of time at prices that, on average, are very near the current market price.

When an investor buys over a long period of time, he does not expect the price of the stock to stay fixed for the entire period. Some stocks that he buys will go up while he is buying, and others will go down. On average, however, if he starts buying a number of stocks at prices that he regards as fair, he expects their prices to go up about the same amount as the prices of other stocks.

On the other hand, an investor who buys large amounts of stocks that he believes to be substantially undervalued should not be surprised if he pays prices substantially higher than their current market prices, no matter what trading method he uses. If he buys in large blocks immediately, he should expect to pay a premium. If he buys slowly over a long period of time, he should expect his special information to be largely discounted by the market before the time he finishes buying, so that over the period the average price he pays will be higher than the current market price.

The ability to handle large amounts of stock in short periods of time without changing the price of the stock is not a characteristic of a liquid market.

#### Price Continuity

It follows from the above description of a liquid market that the price of a stock will display "continuity" over time only if the trading in the stock is characterized by a large volume of trading, where each individual trade is relatively small.

If the volume of trading in a stock is very low, then we would expect to find large changes in price between successive trades, because a large amount of new information will have become available between each pair of trades. Even though there may be no new information on the company itself, there will be a great deal of information on events affecting the economy as a whole or the industry of which the company is a part. So while bid and asked prices may be continually available, they will change over time even when there is no trading in the stock, and successive trades may be at very different prices.

And whenever a large order is executed, it will be reasonable for a significant jump in the market price to occur. If it is the buyer who is anxious to execute a large order immediately, then the price will jump up; if it is the seller, then the price will jump down. Of course, it is possible for the buyer and seller to be equally anxious; and in that case, execution of a large trade may not change the market price at all.

Thus we expect to find that the change in price between subsequent trades a short time apart will be small. But if the second trade is large, or occurs a long time later, we will not be surprised to find a large change in price. (more next page)



Statistics on the percentage of trades occurring at a price not more than one-quarter (or some other fraction of a point) different from the price of the last trade are simply not meaningful in themselves. They can be interpreted only if we know the characteristics of the trading in the stock. Yet the exchanges continue to collect such statistics and to use them as measures of the quantity of the market in the stock.

Indeed, the continuity in the price of a stock will depend on the inherent volatility of the stock, as well as on the characteristics of the trading in the stock. For a given average volume of trading and average size of a trade, a more volatile stock will tend to have larger price movements between trades than a less volatile stock.

More price continuity is not generally better than less price continuity. There is a right amount of price continuity for every stock under any given set of market conditions, and either more or less than that is undesirable. Large changes in price caused by the arrival of new information affecting the value of the stock are desirable. Large changes in price that are caused by a temporary imbalance between supply and demand are undesirable. So the right amount of price continuity is determined by the relative impact of new information and temporary imbalances between supply and demand on the price. The greater the rate of arrival of new information between transactions, the less continuity we want in the price of the stock.

The idea that the specialist should "resist" large changes in price, by buying when large sell orders come in and selling when large buy orders come in, makes very little sense. Perhaps he should be buying when large sell orders come in, but only at a substantial discount. If the specialist tries to resist large price movements, he will tend to lose money to traders who have more information than he has. If he makes up for this by increasing his spread on all transactions, large and small, he will not lose money, but the costs of trading for those who do not have special information will be increased. By making the price sticky, he will allow those who have information to make more money than otherwise possible, at the expense of those who do not have the information.

We can make all of these things more precise by drawing on the economist's notion of a "perfect market." A perfect market for a stock is one in which there are no profits to be made by people who have no special information about the company, and in which it is difficult even for people who do have special information to make profits, because the price adjusts so rapidly as the information becomes available. One characteristic of this type of perfect market is that prices follow a "random walk." (See Fama<sup>1</sup> for an excellent discussion of the forces that cause prices to move randomly in an efficient market.) When prices move randomly, it is not possible to use past price movements to predict future price movements; and more generally, it is not possible to use statistics on both prices and volume of past transactions to predict prices of future transactions.

Thus we would like to see *randomness* in the prices of successive transactions rather than great continuity. Randomness will mean a large number of relatively small price changes, but a moderate number of intermediate price changes, and a certain number of large price changes. Randomness means that a series of small upward movements (or small downward movements) is very unlikely. If the price is going to move up, it should move up all at once, rather than in a series of small steps.

Randomness also means that a price movement in one direction is just as likely to be followed by a price movement in the same direction as by a price movement in the opposite direction. In particular, randomness means that a large price movement in one direction is just as likely to be followed by a price movement in the same direction as by a price movement in the opposite direction. Thus when a specialist buys from a large seller at a discount, the appropriate test of whether he tends to choose the right discount is in whether the trade is just as likely to be followed by another trade at a lower price as by another trade at a higher price. If the price rises following a specialist purchase at a discount much more often than it falls, then we can say that he is choosing too large a discount. Large price movements are desirable, so long as they are not consistently followed by price movements in the opposite direction.

Niederhoffer<sup>2</sup> has done a series of tests for randomness in the price movements between successive trades in six heavily traded New York Stock Exchange stocks. He finds very significant departures from randomness. He finds that reversals are much more common than continuations: a price movement in one direction is much more likely

<sup>1.</sup> Fama, Eugene F., "The Behavior of Stock Market Prices," Journal of Business (January, 1965), pp. 34-105.

<sup>2.</sup> Niederhoffer, Victor, "Market Making and Reversal on the New York Stock Exchange," Journal of the American Statistical Association (December, 1966), pp. 897-916.

to be followed by a movement in the opposite direction than by another movement in the same direction. He finds more complicated departures from randomness as well.

Niederhoffer explains his results by noting that the limit orders on the specialist's book do not move as market orders are executed. If there are a number of limit orders to buy at one price, and a number of limit orders to sell at a higher price, and if market buy and sell orders arrive in random order, then the only price changes that occur will be reversals, until either the buy limit orders or the sell limit orders at the original prices are exhausted.

The implicit charge that the specialist makes for buying and selling for his own account has the same result. The specialist may think of the market price as being  $52\frac{1}{2}$ , for example, and be willing to buy at  $52\frac{1}{4}$  or sell at  $52\frac{3}{4}$ . If a series of market buy and sell orders come in in a pattern that does not cause him to change his quote, we will see reversals but no continuations. This is just an artificial result of the way the specialist charges for his services. If he charged an explicit commission, then all the trades might be executed at  $52\frac{1}{2}$ , and he would get a separate fee of \$0.25 per share. This source of departures from randomness would vanish.

The fact that limit orders do not change in price as market conditions change is not so easily handled. This source of non-randomness is a serious defect in the way stock exchanges are currently operated. We will come back to this problem later.

## The Specialist

We have said that a liquid market is one in which almost any amount of stock may be bought or sold almost immediately, possibly at a premium or discount. One of the functions of the specialist is to maintain a continuous market in this sense.

It also appears that an efficient market is one in which there is at most one market maker, because there are economies of scale in market making. Thus the current structure of the market provides trading continuity in a rather inefficient way. The specialist provides continuity for small orders, and



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in some stocks he provides continuity for moderately large orders. For moderately large orders in most stocks, and for very large orders in all stocks, continuity is provided by block positioning firms.

There are a variety of possible explanations for this apparent inefficiency. Some say that the specialists do not have enough capital to take large positions, partly because the specialists' firms are not publicly owned. Others say that the specialists do not have enough direct contact with institutions, since the major stock exchanges do not allow specialists to take orders directly from institutions. On the other hand, many institutions want less contact with the specialist, since they feel that under current procedures he interferes with their ability to execute a large order at a favorable price. Whatever the explanation, it seems clear that the exchanges cannot handle large orders efficiently in many cases.

A second function of the specialist is to maintain a market that is "fair" to all participants insofar as possible. We can take this to mean that each buyer or seller is able to have his orders executed in the same way that they would have been executed had all potential buyers and sellers been standing at the post. No one should be able to buy at one price if other potential buyers are excluded who would have been willing to pay a higher price. And no one should be able to sell at a higher price than other potential sellers would have accepted.

It seems clear that the system fails to provide a completely fair market in this sense. A large sell order frequently drops the price to a point lower than the prices at which many other buyers would have participated. A large buy order that is executed at a premium frequently bypasses many potential sellers who would have had the effect of reducing the premium. Thus these occurrences are unfair both to the institution placing the large order and to the smaller buyers and sellers who did not have the opportunity to trade. Sometimes the specialist takes a position as part of the trade that allows him to satisfy the smaller buyers or sellers who missed the trade. This does not eliminate the unfairness to the institution that placed the large order, if the specialist makes a profit on his position.

In a sense, any participation by the specialist for his own account is unfair, if there are potential buyers or sellers who would have taken the same position the specialist took if they had been standing at the post. They are not standing at the post because the cost of doing so is prohibitive. The cost is high because the system is outdated. We will argue below that it is possible to give potential buyers and sellers access to the market at a cost that is smaller than the present cost, and that if this is done, the need for the specialist to participate will be greatly reduced or eliminated.

A third function of the specialist is to maintain an "orderly" market. This is usually taken to mean that he should dampen out large or erratic price movements, and attempt to provide price continuity. We have argued above, however, that the price of a stock in an efficient market will move somewhat erratically, and that large price movements are sometimes desirable. An orderly market, in economic theory, is a market in which price changes occur randomly. It is a market in which the history of past price movements in a stock gives us no information about the direction of the next price movement. If we can give a large number of potential buyers and sellers easy access to the market, then we can expect to find that the market will be orderly without the participation of the specialist.

# **Efficient Markets**

Let us summarize, then, the characteristics that an efficient market should have. In general, the total cost of trading, including both explicit and implicit costs, should be low. The market should be continuous, in that a buyer or seller can, if he wishes, execute his order almost immediately. All potential buyers and sellers should have easy access to the market. And price movements should be random.

1. Low Cost. The cost of trading in an efficient market should be very low. It should be possible for an investor who knows what he wants to buy or sell to have direct access to the market, without going through a salesman, floor broker, or specialist.

2. CONTINUOUS TRADING. It should be possible for an investor who wants to buy or sell immediately to do so. The bid and asked prices that represent prices at which small sales and purchases can be made immediately should be very close together. The execution of a small purchase or sale should not change these prices very much. The bid and asked prices for large purchases and sales may be far apart, however, and execution of such orders may cause all bid and asked prices to shift substantially. 3. FAIRNESS. The market should be structured so that large investors do not object to dealing with many small investors. The trading cost to the large investor should be the same, whether he is trading with one large investor or many small investors. The extra cost of handling a small order should be borne by the small investor. Orders should be executed at prices that would have occurred if all potential buyers and sellers were continually in direct contact with the market.

4. RANDOM PRICE MOVEMENTS. The price of a stock should follow a random walk. When new information changes the value of the stock, its price should move in one large jump rather than a series of small steps. A large price movement should be followed by a further movement in the same direction as often as it is followed by a movement in the opposite direction. A series of movements in one direction should be followed by a movement in the opposite direction as often as it is followed by another movement in the same direction.

It is worth emphasizing again that price continuity or "stability" is not in itself a desirable characteristic of an efficient market. It is both undesirable and unprofitable for a specialist or market maker to "resist" changes in the price of a stock.

### Helping the Specialist

One of the functions of a specialist, market maker, or block positioner is helping to maintain a continuous market by buying for his own account or selling from his own account when necessary. Under current practices, the specialist is risking his own capital when he takes a position (either long or short) in a stock, so the size of the position he is willing to take tends to be limited, and the amount he charges for performing this service tends to be high. It becomes necessary for the specialist to be supplemented by other market makers such as block positioners, and the entire CONTINUED ON PAGE 44



need to justify these expectations by an apparent imbalance between institutional demand and the net new supply of equities.  $\blacklozenge$ 

#### FOOTNOTES

- 1. These data do not include such other institutional categories as bank administered personal trust funds and hedge funds. With these included, the ratio would probably surpass 40 per cent in 1970.
- 2. Recently, the SEC has revised its figures to accord more closely with the NBER estimates. It is for this reason that the SEC data presented in Table 2 are described as "old estimates."
- 3. There are a number of other reasons, particularly statistical "noise," which influenced the measure of total stock outstanding but none seem as significant as the factor discussed above.
- SEC, Institutional Investor Study Report, Volume 1, March 10, 1971, p. 115.
- Financial Institutions, Random House, 1968, pp. 196-197.
- 6. For confirmation, cf. Friend, Blume & Crockett, Mutual Funds and Other Institutional Investors, McGraw-Hill Book Co., N. Y., p. 14 ff.
- 7. Perspectives on Planning, No. 5, "The Demand for Corporate Equity: Projections to 1975 and 1980." This document, available on request, was prepared by Prof. Arnold Saffer of Long Island University.
- 8. Ibid., p. 114.
- 9. Another factor supplying stock has been the retirement of stock in small, closely-held companies selling out to larger corporations. The result of such mergers with publicly-traded companies is to increase the supply of marketable shares.
- 10. Perspectives on Planning, No. 5, Technical Appendix.

# Automated Stock Exchange ...

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process of making a continuous market becomes very costly.

One obvious solution to this difficulty is to allow the specialist to supplement his own capital with money raised in the capital markets, so he can share the risk with others. (He should then probably be allowed to charge a fee for buying and selling for this collective account, and to replace some of the profits he is giving up.) This might be accomplished simply by allowing specialist firms to sell stock to the public, and paying the individual specialist a salary to supplement his share of the trading profits.

There is a simpler solution, however, that will reduce the cost of trading in addition to helping make continuous markets. This is to allow an investor to place a "participating order" with the specialist. A participating buy order will share in any purchases the specialist makes for his own account, and a participating sell order will share in any sales the specialist makes for his own account, thus supplementing the specialist's capital.

A specialist buying a large block may buy only 10 per cent of the block for his own account, and may match the rest of the block with participating buy orders. For fairness, he may be required to apply the same proportions when buying or selling small amounts of stock too. The participating orders will be executed at the same price as the orders for the specialist's own account.

Because the specialist's transactions for his own account will exactly match his transactions using participating orders, he will have every incentive to treat the participating orders fairly. The reasons that the major exchanges now give for preventing the specialist from handling discretionary orders will no longer apply.

Participating orders will have the advantages of limit orders, without some of their disadvantages. They allow an investor who does not need to execute his order immediately to get a better price, on average, than an investor who uses market orders. Unlike ordinary limit orders, however, they will be executed at prices that reflect market conditions at the time they are executed.

The fact that investors will be allowed to place participating orders puts pressure on the specialist to handle non-participating orders as fairly as participating orders. If he fails to handle ordinary market and limit orders fairly, he will find that investors would place a very large number of participating orders, and he will lose most of his opportunity to buy and sell for his own account.

The existence of participating orders will force the specialist's spread to be very small for the same reason. The larger the spread, the more incentive investors would have for using participating orders instead of market orders. The spread will have to be kept small to keep the number of participating orders (plus limit orders) approximately in balance with the number of market orders.

Because of their flexibility, participating orders will probably be used much more extensively than limit orders. Thus the specialist, with a large supply of participating buy and sell orders as well as the ability to buy or sell for his own account, can handle much larger orders on an immediate basis than he can at present, and the need for block positioners becomes greatly reduced.

(Second article will appear in next issue)