Simulating A Central Securities Market

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On June 4, 1975, the Securities Act Amendment was passed into law mandating the future of securities trading: there would be one central market for the trade of all stocks and bonds - a single national market system.

This legislation touched off considerable controversy, not concerning the concept itself - this had been endorsed by various factions in the industry for years - but rather over the form the market should take. Although numerous proposals on the criteria for participation, the rules of trading and other similar problems were put forth, little effort was directed towards systematically evaluating the results of suggested alternatives. TRADE4 is an initial attempt at providing a framework for such an analysis: it is a model of a trading system characterized by:

1. Electronic execution of all orders.

2. Competing market makers.

With the joint cooperation of the IBM New York Securities Branch Office and the New York Stock Exchange, the model was developed in the form of a computer program written in APL/SV (an interactive language supported by IBM). The nature of the market system lends itself to this approach since it can be thought of as consisting of three major elements:

1. a source of orders.

2. a decision process carried out by market makers through which they arrive at their bids and offers.

3. a trading structure which enables orders and quotes to be matched.

ORDERS

Orders are directives from an individual, bank or institution to buy or sell securities. Since they come from a large number of unrelated sources, they can be approximated by random arrivals from a source with infinite population and a specified distribution of interarrival time.

DECISION PROCESSES

Describing problem-solving behavior - particularly those involving repetitive situations for which routine procedures can be developed - by means of a computer program has many precedents. In regard to market makers (e.g., a specialist of the N.Y.S.E. or a registered dealer on the C.B.O.E.), their activities can be described as a reaction (a new trading price) to a stimulus (a trade or change in stock price). Further, these decisions are made at forced speed: delay could significantly impact profit. Under these conditions, creative or original decision making tends to give way to processes involving rough internal guidelines tempered by feel or intuition. In the simulation, the decision process consisted of a series of yes/no criteria which determined the next bid, with certain probabilistic "fudge" factors introduced to mirror the non-exactness of human behavior.

The following should be noted:

1. The market maker's behavior focuses on his closeness to the market, tempered by an equally strong desire for profit taking. Profit is a recognized motivator, while a trader outside the market (i.e., one whose quote differs widely from market prices) will not be called in trades and hence will not participate. An underlying assumption to the entire structure is that market makers do wish to participate in the system.

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Central Market (continued)

2. The actions of the specialist are more predictable since he is required to regulate the fluctuations of the market.

3. The simulation is not concerned with intermediate processes but rather with final outcomes. Hence, the model would be successful if it predicts C, assuming a decision process of the form A-b-C, even though the actual process looked like A-e-b-f-g-h-j-C.

4. Quantification of all the parameters was based on suggestions from Chris Keith, a director at the N.Y.S.E. and members of his staff.

TRADING STRUCTURE

The "trading structure" is the logical mechanism by which an offer or bid is selected from an existing pool of quotes for match against an incoming order. Since the proposed central market is assumed to have electronic execution, once the rules of trade are defined, the system's outcome would be totally determined. As a result, a computer model is ideal for simulating the operation within a given environment.

BASIC CONCEPTS

To clarify the model, it is useful to consider the underlying concepts of securities and markets.

Securities: This term is generally used to refer to the ordinary instruments of indebtedness: stocks and bonds. These are the vehicles by which a large number of individuals (and/or institutions) each contribute a small investment in return for a share in the projected return of a company's endeavors and (in the case of stock) a fractional participation in the equity of the corporation itself.

Market: To counter the inherent drawback of the lengthy period of time involved in the investment in securities, a market - a way to disentangle the investors capital by providing a free exchange of securities - is required. Further, this market must encourage participation by providing the "best price" rather than a set price.

Central Market: Analyzing the above, it becomes clear that a successful securities trading structure should have the following characteristics:

1. frequency of sales - investors would be unwilling to participate unless they were assured that they could move their positions at will.

2. narrow spread between bid and offer to encourage movement.

3. significant depth of quote (number of shares bought or sold at a given price) - a market with a narrow spread offering only ten shares on either side is not providing either best price or satisfactory liquidity.

4. prompt execution or orders.

5. minimum price changes between transactions.

A Central market with more participants and more trading clearly provides better liquidity and so more profit opportunities for investors.

Types of Market: The most significant factors characterizing a market are the nature of the trader activities (agency or dealer) and the means by which price is determined (negotiation or auction).

Basically, an agency market is one in which an investor uses a third party or broker to consummate his trade for him. The broker acts strictly as an agent and is prohibited (by the legal principle of conflict of interest) from trading for his own account. A dealer, on the other hand, acts as principal in the transaction, buying for his own account and selling from his own inventory.

An auction market is a structure which provides for the best stated bid to be matched with the best stated offer. Negotiated markets permit prior negotiation between those involved on the monetary value and amount of shares to be traded.

THE ENVIRONMENT - CURRENT TRADING STRUCTURES

In America today, there are over twenty formalized trading structures including: the New York Stock Exchange, the American Stock Exchange, the regionals, the Over-the-Counter or third market, the C.B.O.E., the fourth markets and investment banking institutions. Of these, the largest organized market is the New York Stock Exchange. Since there is a high probability that a Central Market would either be based on or actually evolve from this market, it is worthwhile to discuss its development.

History: As far as can be ascertained, the N.Y.S.E. traces back to 1725 when securities were regularly traded in a market which also held auction for physical commodities such as cloth, wheat and tobacco. Originally, dealers in stock met each noon at 22 Wall Street and conducted a one-sided market consisting of five auction brokers selling in rotation. With increasing volume, traders in the physical commodities began to act as agents for individuals who wished to sell their stock. In 1792, rebelling against the monopoly of the auctioneers, the agents or "brokers" drew up the Buttonwood Tree Agreement, in which they pledged that they would deal only with each other (bypassing the auctioneers). Trading continued to flourish and, by 1817 the brokers had adopted

a formal constitution and a new name: the New York Stock and Exchange Board. At this time, a "call" market was established. Beginning at 11:30 each morning, the president of the exchange would call each stock sequentially. Trading in a particular stock could take place only at its call although, on payment of a twenty-five cent fine, a member could request the president to revert to a previously called stock. When all stocks had been called, the exchange closed.

In the late 1800's, the inflexibility of the call system gave way to continuous trading in all stocks by all members. During this period, the specialist function evolved: an appocryphal story attributes the practice to a broker who had broken his leg and so was forced to remain stationary at one post during the trading sessions. Not until the Securities Exchange Acts of 1933 and 34 was he actually charged with the responsibility of maintaining a "fair and honest market."

While there have been a number of policy changes, the trading procedures used today are essentially unchanged from those of the end of the last century.

Characteristics of the N.Y.S.E. as a Securities Market: The N.Y.S.E. is an auction market: all bids and offers on the floor are made at a designated location (the "posts") in a public manner. All transactions must be consummated so that the stock is sold at the highest bid and purchased at the lowest offer. In the case of equal bids, priority is determined first by time and then by size, with the stipulation that in the case of simultaneous bids equal to or greater than the amound of stock offered, the bidders must toss a coin. Finally, all bids for greater than one trading unit must be exercised for that amount or any smaller number of units.

The two major types of market makers at the Exchange are the commission brokers (agents for the non-member public) and the specialists. The latter can operate either as a broker or a dealer but are under the requirement to make a market in the stock in which they specialize. That is, he must maintain a continuous market with price continuity and close bid/ask price, if necessary selling from his own account when others wish to buy and buying when others are selling. In practice, it is extremely difficult to determine whether he is, in fact, performing this function.

The Other Markets: Sacrificing exactness for brevity, the AMEX and the eight regional exchanges operate in a similar manner. The members of the C.B.O.E. are dealers, not agents. The over-the-counter or third market (terms used to refer to all stock transactions not occurring at a formal exchange) is negotiated. That is, market makers list their quotes in the daily "pink sheets" or on an electronic system called NASDAQ. A retail trader obtaining his name from one of these sources will call him and negotiate a trade.

The Central Market: Historical precedence, economic arguments and the political clout of current organized markets make it highly probable that the central market will be based on the auction system. Beyond this point, there is considerable controversy over topics political in nature (membership requirements, commission structure, etc.) and those affecting trade forms. It is the latter type, in particular questions such as the number of specialists (if any), a quorum requirement for quotes, the matching of corsses, etc., that TRADE4 attempts to address.

TRADE4 - A SIMULATION OF THE CENTRAL MARKET

TRADE4 can be described as an auction market whose participants exhibit primarily dealer characteristics. It is based on projections of the future form of the central market made by C. Keith, Director, SIAC and J. Libretti, of the same organization. On a macro level, it is characterized by the fact that it assumes electronic execution of orders (hence, there is no delay in execution once an order and available quote have been matched) and competing market makers.

The formal computer model consists of three quasi-independent subsystems: the source of orders, the trading structure and the decision-making activity of the market makers. These subsystems are labeled as A, B, and C in Figure 1. The outputs of the order generation system are inputs to the trading structure. The decision making activity is triggered by the execution of a trade with the new decisions or "quotes" supplying the trading structure with its new market. The output of the entire system consists of executed trades with associated prices and times.

The following comments should be made: to keep the simulation manageable, trading in only one stock was modeled; a seed price of $40 was chosen on the basis of historical data; and round lots only were used. Further, the reaction of stock prices to exogenous variables is beyond the scope of this study.

Subsystem I - Order Generation: The order generation subsystem has as its inputs the following parameters which give the relevant characteristics of an order:

1. time of arrival - this is generated by randomly choosing an interarrival time according to a specified distribution and adding it to the time of the preceeding order. The model has facilities for specifying interarrival times according to an approximation of an Erlang K, mean u distribution.

2. Buy or Sell - specified as percentage of buys.

3. Quantity - specified by associating a probability with a given round-lot size.

The output of the order subsystem is a log with orders numbered sequentially by arrival time.

Subsystem II - Trading Structure: Based on an auction market of competing market makers, the essential elements of the system are the trading regulations, the system of outstanding quotes, the

order queue and the execution log. In addition to the order log, the inputs into this subsystem are: the quotes determined by the decision module, the quorum of market makers required and prohibition (or permission) of crosses. Its outputs are a log of executions, a log of best offers and bids, the log of queue structure.

Outstanding quotes: A market maker's quotation is the highest stock price at which he will buy and the lowest at which he will sell at a given time, with a size (in round lots) associated with each side. The composite is a binding promise on his part, which he must exercise for any number of round lots up to the amounts he has specified. Each quote also has associated with it the time it was entered by the market maker. Thus, the market consists of two arrays (bids and offers) arranged in priority sequence by price, time, size and random toss. Each time a new quote is entered, the arrays are resequenced since the primary order is price. Additionally, if an order executes and clears a quote, there is a delay or "react time" before the next quote can be entered. This registers as a "not available."

Trading regulations: In addition to priority sequencing of orders, there is a barrior function: a requirement that a given quorum of quotes be active before an order can be executed. If the quorum is high relative to the number of market makers, there will be an increase in execution time and the size of the order queue.

The model permits crosses between two market makers (e.g., trading if offer and bid prices match). An executed cross, creates a trade not associated with any order on the order log.

Order queue: Orders may enter the system but not be executed either because there are other prior orders awaiting execution or because the quorum requirement on quotes is not satisfied.

Execution: When all trading restrictions are satisfied and an order is matched against an appropriate quote either:

1. The order size So is greater than or equal to the quotation size Sq. In this case, a trade for Sq shares at the quoted price is logged, the size value of that quote is set to zero and So is set to So-Sq. Provide the quorum is met, the remainder of the order is matched against the next best quote until the size is zero. If a quorum is not active, the decision modules are triggered and the remainder of the order waits until the required number of new quotes are entered.

or 2. So is less than or equal to Sq. Under these conditions, the trade is logged, order size is set to zero and the size value of that quote is set to Sq-So. At this point, the decision module will be entered.

Subsystem III - The Decision Structure: This section of the model attempted to simulate the decision process by which the individual market makers arrive at their quotes. Each decision involved four factors: should a new quote be made, (assuming it was): price, size and time of entry into the system.

Input to this system is the "last trade" from Subsystem II, e.g., the decision module is triggered by the execution or partial execution of a trade. The output, which acts as input into the trading structure, is the system of quotes which constitutes the new market for incoming orders.

For all market makers, it was assumed that:

1. If the trade occurs while the market maker is in the midst of a react cycle from a previous trade, he would continue in that cycle acting on the basis of past, not new, information.

2. If the market maker's last quote was executed against and cleared he must make a new quote.

Three types of decision makers were defined:

Type I - Without Profit Motivation - This initial attempt concentrated on a reaction to last trade information. Each market maker was defined by the following parameters:

1. skittishness - in addition to placing a new quote if his past quotes were exhausted, a market maker will change his position if his current quote is "too far away" from the market, that is, if the difference between the last trade price and the price on which he based his current quote is larger than some preassigned skittishness factor, he places a new quote to bring his position back into line. (See Figure 2).

2. spread - the quote is placed around the current makret, e.g., his bid will be a little higher than the last trade and his offer a little lower. (Spread = bid - offer). (See Figure 3).

3. range - the difference between the last trade and the bid he will make. (See Figure 3).

4. react time - specified by an average react time and a "react function" consisting of a range of positive and negative time deltas with a probability associated with each. For a given quote, the delay is the average time plus the random output of the react function.

5. offer and bid size - as in react time, an average value and variations from this average with associated probabilities can be specified.

Decision Maker Type II - With Profit Motivation - In addition to the type I considerations, a type II could change his spread and range in response to his dollar value position or position relative to the market:

Relative to profit:

Change in spread if the MM's position were not profitable - moving it closer to the market.

Change in range if he has executed only sells or buys - if this occurs, his position is out of line with the market. This parameter is used to reposition his quote.

Relative to market position:

Change in spread if the market maker has not executed any trades - pulling his quote closer to trading activity.

fast market - this defines a fast market in terms of orders/minute fraction of fast market desired, fraction of slow market desired expressed in terms of volume of trades.

Change in spread for a fast market (and slow market) - to enable him to achieve the percentage of the market he wants.

decision modulus - this allows the profit position routine to be entered only every n decisions rather than on every decision.

Decision Maker Type III - The Specialist - Two problem situations were defined which would force the specialist to take action to insure a more orderly market:

1. too rapid movement of the market: offers rising or dropping too quickly.

2. too large a spread between the best offer and best bid.

As a result, the specialist's parameters include:

S - the maximum allowable spread between best bid and offer.

S' - the spread a specialist will use when S is exceeded.

O, ON, O' - if the offer price has changed by O in the last ON trades, the specialist will enter a new offer price at the last offer price minus O'.

B, OB, B' - same as above for bids.

SYSTEM MEASUREMENT

To arrive at some criteria for measuring the results of the various model runs, three things were considered: the purpose of the market, the measurements used by the N.Y.S.E. to evaluate itself and the standard characteristics of a teleprocessing system. The following were felt to best indicate the simulations results:

A. Volatility or price movement - measured in terms of:

- absolute change in price, absolute change weighted by share value.
- average change in price, average change weighted by share value.
- continuity (the percentage of total executions taking place not more than one quarter of a point away from the prior execution).
- average difference and standard deviation, in successive trades.
- weighted average price, standard deviation, maximum deviation.

B. Speed of execution - measured by average wait time, standard deviation of weight time, queue formation.

C. Number of trades vs. number of orders - measuring number of trades executing against multiple quotes and the number of crosses.

D. Market maker activity - share quantity, dollar value and the number of trades by type.

THE EXPERIMENTS

While it initially seemed that each simulation should be run for a fixed time, this approach resulted in a widely varying number of executions when the interarrival time was changed. As a result, each simulation was run for approximately one hundred trades.

Over thirty experiments were conducted exercising all the major variables in an effort to test the consistency of the model. In reality, many of the variables (e.g., order characteristics) are low in controllability. Others, such as trading regulations, are totally determined by those developing the Central market. For this reason, I would like to review two experiments in this category:

1. Number of Market Makers (Type I): NOMM = 1, 5, 10

Fewer queues formed and the average time of execution decreased as the number of market makers increased. Market continuity, maximum price variation and the distribution of multiple order execution exhibited a u-shaped pattern: 5 gave the best performance. There seems to be a point of diminishing returns after which multiple quotes work against each other.

2. Quorum: Q = 1, 2, 3 and 5

Queues were dramatically impacted by increasing the quorum requirements. There were no trends in the continuity measurements but the price change measurements all exhibited a u-shaped behavior. It seems that, with a quorum of one, orders execute off the best price at the moment: there is no time lag to allow another, better quote. On the other hand, with larger quorums orders queue. When the quorum if filled, multiple queued orders execute, often clearing against the third or fourth best quote.

Finally, some results on the market maker decision modules.

There are a total of twenty-eight parameters which can be associated with a market maker: 9 for Type I, 19 for Type II, 28 for Type III. Of these, only those unique to the specialist can be considered controllable and this control lies only in the amount of surveillance and regulation done by the market.

Briefly reviewing the results of some of the experiments:

1. Spread and range: As the spread increased, execution speed decreased and the market became more volatile. Actually, smaller spreads force the market to stay closer to the base price for a longer period. Further, since the quote stays within skittishness range longer, there is less quote refreshing, orders confront N/A less often, and average time of execution was improved.

2. Skittishness - the smaller the skittishness, the more queues were formed but, on the other hand, the more discontinuous the market. Basically higher K values result in market makers refreshing a non-exhausted quote less often. The market churns less, quotes stay active longer and price movement decreases.

3. Including market makers type II - continuity improved as did the average difference in price. Maximum spread decreased and, in general, buys and sells diverged far more slowly than in any other run. The conclusion is that the decision structure has significant results on the simulation's outcome and should be carefully studied to determine the values for "base cases" against which to run the other parameters.

4. Systems with specialists: 0, 1, 2 specialists - Continuity was bettered as specialists were added to the system and a study of the market movement showed that buys and sells tended to both move in the same direction. However, the statistics showed that the specialists were only executing buys. This suggests that, while the decision module did effect market regulation, it should be modified to equalize the specialists participation.

SIGNIFICANCE OF THE RESULTS

The Central Market is, as of today, an amorphous concept existing only in the minds of Congress and the S.E.C. This model is only a "ball park" estimate: its purpose is not to give absolute answers to either these groups or any of the other interested parties. Hopefully, however, a systematic modeling effort such as this can point out potential bottlenecks and hitherto unrecognized interrelationships in the system, and as such, aid the final design of the future national trading structure.

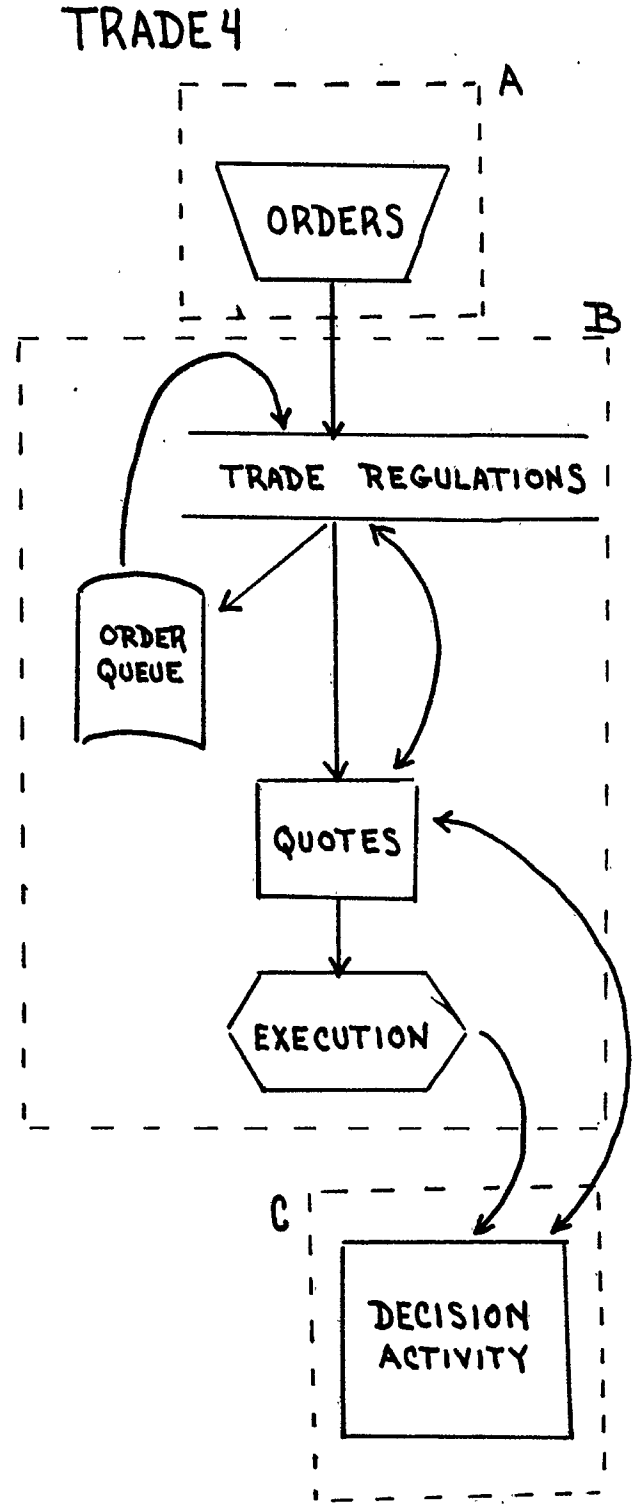

FIGURE 1

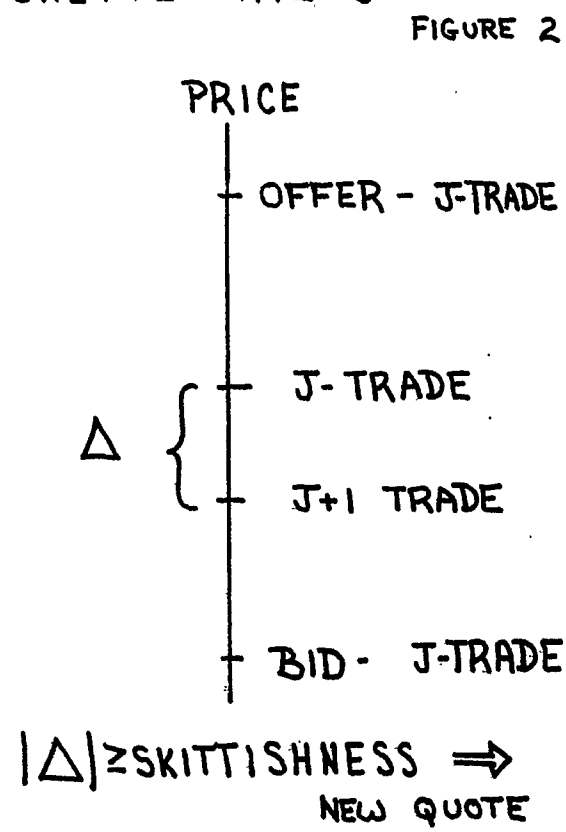

FIGURE 2

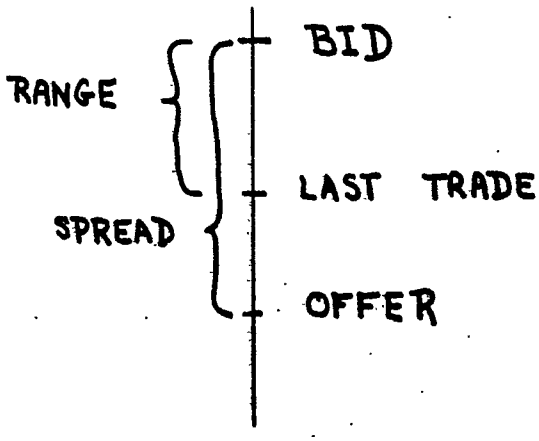

FIGURE 3

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