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Futures and Options on Stock Indexes: Economic Purpose, Arbitrage, and Market Structure*

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Abstract

Stock index futures and options have been roundly criticized in the press recently, particularly since the Monday Massacre on October 19, 1987. Much of the criticism emanates from a lack of understanding about the nature of index contracts and the purpose they serve. This study attempts to clarify a number of issues related to index futures and options. First, it reviews the fundamental nature of stock index futures and options contracts and the economic service they provide. Second, it describes stock index arbitrage and the meaning of "program trading." Finally, issues of stock market volatility and stock market structure are discussed.

Futures contracts on the S&P 500 stock index began trading on April 21, 1982. Since then, trading in this contract has grown steadily and dramatically. Daily volume on the S&P 500 stock index, stated in terms of the value of the underlying contract, exceeds New York Stock Exchange volume. The option contract on the S&P 100 index, started on March 11, 1983, has experienced similarly dramatic growth. Trading interest in options and/or futures on certain other broad-based stock indexes—the Major Market Index (an index of 20 stocks), the New York Stock Exchange Composite Index, and the Value Line Index—has also been strong.

As has been the case with the development of other futures and options markets, the growth of stock index futures and options has led to concerns about the economic purpose of these new derivative instruments and their impact on the volatility of existing markets and the ability of existing markets to facilitate capital formation and risk sharing. This paper analyzes the economic uses of index options and futures and considers major issues raised in connection with the development of stock index futures and options markets.[1] Section I contains a discussion of the nature of futures and options contracts in general, and Section II contains a discussion of the economic uses of index futures and options in particular. In Section III, arbitrage-based pricing relations for stock index futures and options are presented and discussed. The paper next turns to a number of policy issues that have received attention, particularly since the October 19, 1987, Monday Massacre.[2] In Section IV, program trading is discussed, and its role in the Monday Massacre analyzed. The impact of index futures and options on stock market volatility is examined in Section V. Finally, a number of market structure issues are raised in Section VI. The conclusions are presented in Section VII.

I. Nature of Futures and Options Contracts

A futures contract is a binding agreement to buy or to sell an underlying commodity at a future date at a predetermined price—the futures price. Organized futures markets arise as a substitute for the underlying cash commodity market. The futures market allows one to take a position in the commodity more quickly and cheaply than buying or selling the cash commodity. If wheat, for current or deferred delivery, could be bought and sold instantly at low transaction costs, there would be little need for an organized wheat futures market. However, such is not the case. Storers of wheat take short positions in wheat futures until buyers of the underlying

[1]This paper is based in part on Stoll and Whaley [1988].

[2]Many articles about stock index arbitrage and program trading have appeared in the literature both before and after the Monday Massacre. An up-to-date bibliography is contained at the end of this study.

cash commodity can be found. Processors of wheat take long positions in wheat futures until the underlying cash commodity can be acquired. Analogously, portfolio managers buy and sell stock index futures because it is quicker and cheaper than buying and selling portfolios of common stocks.

An option contract conveys the right (but not the obligation) to buy or to sell an underlying commodity at a specified price—the exercise price—within a specific period of time. The right to buy is a call option, and the right to sell is a put option. Unlike futures contracts, which have a payoff structure similar to the payoff structure of the underlying commodity, options partition the payoff distribution. A call option buyer, for example, receives the benefit of commodity price increases and avoids the losses of price declines. To receive this favorable and asymmetric payoff distribution, the call buyer pays a sum of money called the *option premium* to the call option writer.

Futures and options often exist on the same underlying commodity because of their distinctly different characters: options as a means of altering the distribution of payoffs and futures as a means of substituting for the underlying cash commodity.[3] Typically, the option contract is written on the futures contract rather than on the underlying cash commodity. Instead of receiving wheat if a call option is exercised, the buyer of a futures option receives a long position in the underlying futures contract. This distinction is important whenever the underlying commodity is costly and cumbersome to deliver or is subject to quality variation, because the problems of dealing directly in the underlying commodity are avoided. Index options seem to violate this general rule in the sense that the most active index options are written on the cash index rather than the index futures. However, index options, like index futures, call for cash settlement, and cash settlement also avoids many of the problems imposed by delivery.

II. Economic Uses of Index Futures and Options

The economic uses of futures and options have been discussed in a number of recent studies and papers.[4] The benefits to society of futures and options trading are like the benefits derived from the trading of more traditional financial instruments such as stocks and bonds. First, futures and options contracts provide a means of allocating risk. Second, futures and options summarize price information that is useful in allocating the resources of the

[3] Jaffee [1984] emphasizes this distinction.

[4] A major study was carried out by an interagency task force: Federal Reserve Board, CFTC, SEC [1984] *A Study of the Effects on the Economy of Trading in Futures and Options.* A book by Kwast [1986] is based on the research of the Federal Reserve Staff. The American Enterprise Institute sponsored a series of studies that were subsequently published in two volumes edited by A.E. Peck—*Futures Markets: Their Economic Role*, Washington, DC: American Enterprise Institute (1985) and *Futures Markets: Regulatory Issues*, Washington, DC: American Enterprise Institute (1985). See, in particular, the studies by Silber [1985], Stein [1985], and Stoll and Whaley [1985]. The Columbia Center for the Study of Futures Markets organized a collection of papers appearing in the Fall 1984 issue of *Journal of Futures Markets.* See, in particular, the papers by Carlton [1984] and Jaffee [1984]. The University of Chicago organized a collection of papers appearing in the April 1986 issue of *Journal of Business.* See, in particular, the paper by Telser [1986]. A recent report of the Financial Products Advisory Committee of the Commodity Futures Trading Commission [1987] provides a complete discussion of the hedging uses of financial futures.

economy. Third, futures and options reduce transaction costs.

Financial futures and options are useful hedging and investment-management tools. As a hedging tool, financial futures and options provide financial institutions with the ability to eliminate certain risks of holding the underlying commodity. For example, in the normal course of business, market-makers are required to hold inventories of securities to accommodate investors who wish to buy or sell securities immediately. The risk-return characteristics of the portfolio that the market-maker holds are largely dictated by investor demands for particular securities rather than by any deliberate portfolio structuring by the market-maker. However, with the advent of active financial futures markets, the market-maker can hedge the price risk of his portfolio while he carries on with his business of maintaining active secondary markets. Hedging security price risk in this manner is identical to the more traditional hedging activities of distributors of agricultural commodities.

As an investment tool, financial futures and options offer two benefits. First, they make possible a more flexible structuring of the risk-return characteristics of portfolios at lower cost than would be possible without futures and options. Portfolio owners' welfare is increased when their portfolios more closely meet their investment objectives. Modifications in portfolio risk can, of course, be risk reducing or risk increasing. Futures and options cannot eliminate the aggregate amount of risk in the economy, but they can shift the risk more efficiently among different investors. Second, financial futures and options allow portfolio managers to specialize in securities analysis. Specialists in analyzing particular companies or industries, for example, may not have any expertise in predicting general stock market movements. For these specialists, hedging market risk by selling stock index futures will allow them to concentrate on identifying company- or industry-specific misvaluations without worrying about the effects of a general market decline. Similarly, the interest rate risk or currency risk inherent in stocks can be avoided or reduced by selling interest rate futures or currency futures. Other analysts, specializing in predicting market moves, interest rates, or currency rates, can accept the risk sold off by specialists in analyzing individual companies or industries. Financial futures and options thus permit a greater degree of specialization in information gathering and analysis. Typically, such specialization improves the quality of analysis.

We turn now to a more detailed discussion of the uses of index futures and options.

1. Hedging Price Risk with Futures

Underwriters facilitate the allocation of funds from savers to investors. They buy the shares of companies with finance needs and resell the shares to the general public. In the process, underwriters assume inventories of shares, and these inventories, in turn, impose risk. Such risk can be reduced by appropriately hedging in index futures markets. For example, consider an underwriter who purchases shares from a company at $18 and agrees to an offering price of $20 per share, the current market price. If the market price

falls below $20, the underwriter's compensation for underwriting is jeopardized and a loss may be incurred. By selling index futures, the underwriter is protected against a decline in the stock price that results from a general market decline—profits on the index futures short sale offset losses on the individual stock.[5] Note that this hedge is not perfect, since price movements of the stock market are not perfectly correlated with those of individual stocks.

2. Hedging Price and Quantity Risk with Options

Sometimes, underwriters enter into commitments that involve both price and quantity risk. For example, consider an underwriter who offers to buy the shares of a new issue at a fixed price per share and allows the issuing firm three days to accept or reject the offer. The underwriter faces price risk because the price of the stock could fall while the issuing firm is contemplating its decision. The underwriter also faces quantity risk because he does not know whether the bid will be accepted. In this case, options provide a better hedge than futures. If the underwriter buys index put options, he is provided downside price protection in the event the stock price falls and the bid is successful, and he is also provided with quantity protection if the bid is unsuccessful and the stock price rises. If the underwriter had instead sold futures contracts and the bid had been unsuccessful, a rise in market price would have imposed losses in the futures not offset by any stock position.

3. Hedging Cash Flows

Pension funds, mutual funds, and other investment funds often experience expected and unexpected cash inflows and outflows. Cash inflows can be difficult to invest quickly and cheaply in the securities specified by the funds' investment objectives. For example, the investment objective of a stock fund may require the managers to invest in a portfolio of stocks that have the risk-return characteristics of the S&P 500 stock index. In holding such a portfolio, cash dividends are received. Because the aggregate dividends received on any one day are probably insufficient to justify purchasing incremental shares of all stocks held by the fund, the fund manager may choose instead to buy stock index futures and invest the dividend income in Treasury bills. By using stock index futures in this way, funds can more readily guarantee that cash inflows will be invested in stock portfolios on the day the cash is received. When enough cash is accumulated to make buying all of the shares of the desired stock portfolio justifiable after accounting for transaction costs, the Treasury bills and the stock index futures can be sold and the desired stocks purchased.

Stock index futures also make "anticipatory hedging" possible. Suppose cash inflows tend to occur at month end. A fund manager might conclude that stock market prices are favorable 10 days before month end and buy stock index futures in anticipation of receiving a cash inflow. If the manager is right, the new funds are invested at favorable prices. However, even if the manager is sometimes wrong, anticipatory hedging reduces risk relative to a situation in which all the funds are invested at prices available at month end.

[5] In principle, the ability of the underwriter to hedge his inventory risk with futures contracts should reduce the underwriter's fee. Stein [1985] provides a theoretical model of such an effect.

4. Stock Selection

Securities analysts specializing in the selection of stocks pick stocks they believe are undervalued. These analysts likely have no expertise in predicting the future course of the market and may wish to avoid the risk of a market decline. By selling stock index futures, such analysts avoid general stock market risk and concentrate on stock selection. A portfolio of stocks totally hedged against market risk earns the riskless return plus a return that represents the analyst's stock selection skills.

5. Market Timing and Asset Allocation

Some analysts do not specialize in picking particular stocks. Instead, they make predictions about the behavior of the stock market relative to the bond market and to short-term debt instruments. *Asset allocation* generally refers to the fund's mix of stocks, bonds, and short-term debt. Stock index futures can be used to facilitate changes in that mix. Selling stock index futures against 30 percent of a diversified stock portfolio, for example, converts that portfolio into a mix of 70 percent stock and 30 percent short-term debt instruments. While this objective could be met by selling 30 percent of the stocks and buying Treasury bills, the use of stock index futures is generally less expensive and faster.

6. Portfolio Insurance

Portfolio insurance programs attempt to provide a floor below which the value of a portfolio cannot fall while, at the same time, retaining the possibility of gains from market price increases. Portfolio insurance can be accomplished by buying index put options. An index put option makes money if the market declines, which offsets the losses on the underlying portfolio. If stock prices increase, the put becomes worthless, but the underlying stocks participate in the gain.

Many portfolio insurance programs use synthetic puts. A synthetic put is a trading strategy that dynamically alters the mix between a stock portfolio and a debt portfolio.[6] If stock prices fall, a greater proportion of the assets is invested in debt to guarantee the minimum desired value. If stock prices rise, a greater proportion is invested in stocks because sufficient cushion is available to bear the risk of investing in stocks. The switch between debt and stocks is usually made by trading index futures rather than by trading the underlying stocks. The danger in using synthetic puts is that the trading strategy cannot always be implemented. If stock prices fall dramatically, as on October 19, 1987, stocks cannot be sold (either directly or via index futures) at prices that would maintain the floor.

Portfolio insurance implemented through a dynamic hedging strategy can also be destabilizing because it calls for the sale of stocks (either directly or indirectly via stock index futures) whenever stock prices fall. This, in turn, can cause stock prices to fall more and thereby precipitate additional portfolio insurance sales. While portfolio insurance cannot cause a market decline, it can exacerbate a decline. Portfolio insurance must have played a role in the October 19, 1987, decline, but it is difficult to assess its magnitude. Estimates of money under portfolio insurance range from $60

[6]Grossman [1988c] clearly distinguishes between dynamic trading strategies designed to create synthetic put options and real put option contracts.

to $80 billion. Relative to the total stock market value of around $2.5 trillion or even the October 19 decline of $500 billion, that is not all that much. Relative to normal daily tading volume, the amount is more significant.

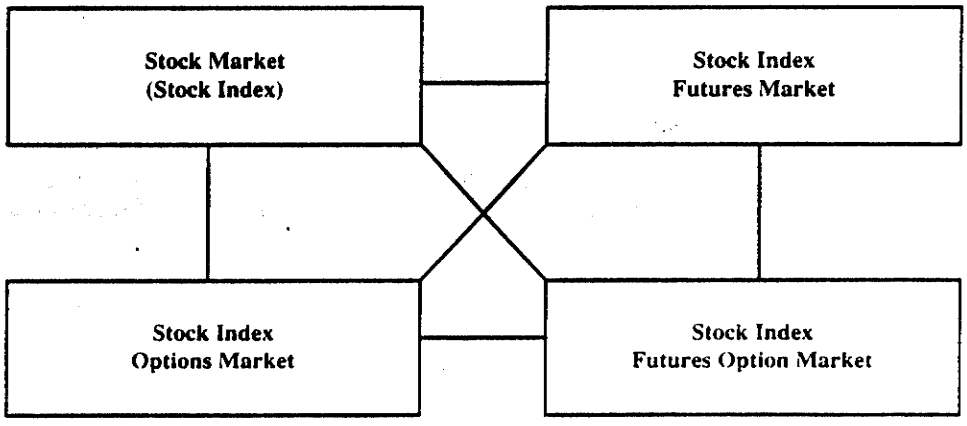
7. Managing Portfolio Managers

The advent of stock index futures and options has permitted pension funds and other investment funds to allocate their assets among portfolio managers so as to best use the managers' expertise. It is now possible, for example, to separate market timing and stock selection functions. One portfolio manager can select and purchase stocks for the portfolio, while the other can change the mix of stocks, bonds, and cash by buying or selling index futures and/or interest rate futures.

III. Arbitrage-Based Pricing of Stock Index Futures and Options

Index futures and options benefit users only if their prices are tightly linked to the price of the underlying index. If the price of a derivative instrument moves independently of the price of the underlying index, the derivative instrument will not be an effective risk-management tool. Arbitrage activity between index futures and options markets and stock markets links the prices of index options and futures to the underlying index. Figure 1 illustrates the arbitrage links of the derivative index products to the underlying index and to each other. Stoll and Whaley [1985] derive the arbitrage links shown in Figure 1 for a generic commodity and its derivative instruments. Stoll and Whaley [1986] discuss in detail the arbitrage process linking stock index futures and options to the underlying index. In this section, a somewhat simplified version of the index arbitrage links is presented.

Figure 1. Arbitrage-based pricing relations linking stock, stock index futures, stock index options, and stock index futures option markets



1. Index Futures Arbitrage

Index futures arbitrage takes place if the observed futures and index prices are configured in such a way that the cost-of-carry relation,

$$F = S(1 + r - d), \tag{1}$$

where F is the index futures price, S is the value of the index, r is the riskless rate of interest over the time period until maturity of the futures contract, and d is the dividend yield over the time period until maturity of the futures contract, is violated. If, for example, the observed futures price is above the theoretical futures price, arbitrageurs sell futures and buy the underlying stocks, driving the price of the futures down and the prices of stocks up. The arbitrage becomes unprofitable when the futures price reflects the cost of carrying the underlying stocks, that is, the interest cost, r, of tying up funds in the stocks less the dividend yield, d, on the stocks.

Equation (1) reflects the equilibrium at which no arbitrage would be profitable. In reality, the futures price will deviate from this theoretical futures price for several reasons. First, and most important, are the transaction costs involved in trading the underlying index stocks. These include the commissions and the market impact costs of buying stocks at the ask price or selling stocks at the bid price. Procedures for trading portfolios of stocks have improved dramatically in recent years and frequently involve the use of the New York Exchange computer entry system, DOT (Designated Order Turnaround). Nevertheless, these costs can be substantial, particularly if a number of portfolio transactions are hitting the market at the same time.

Second, uncertainties about the anticipated dividend payments on the underlying stocks can introduce uncertainties about the return to arbitrage and can, therefore, limit arbitrage somewhat.

Third, certain types of arbitrage may involve risk. In some cases, arbitrageurs do not trade all the underlying stocks in the index. Instead, they buy or sell a representative basket of stocks. If that basket fails to move exactly like the underlying index, the arbitrage is risky.

Fourth, certain rules and regulations can impede arbitrage. In particular, when arbitrage requires stocks to be sold and futures to be purchased, the short sale rule severely impedes arbitrage. Under the short sale rule, an uptick is required in each index stock before the stock may be sold short. The resulting time delay makes this form of arbitrage very difficult to implement. Instead, arbitrage to correct an overvaluation of the cash index relative to the futures is usually carried out by stock replacement. In stock replacement, institutions that hold diversified portfolios of stocks sell the stocks and replace them with index futures and a position in Treasury bills. The position in Treasury bills and index futures has the same risk and potential payoff that a position in stocks has, but it is cheaper than continuing to hold the underlying stocks because the futures are underpriced relative to the stocks.

Fifth, arbitrage is sometimes limited by the lack of capital. Brokerage firms may be limited by net capital requirement rules and the availability of higher-yielding alternative fund uses. Moreover, many institutional investors may not be authorized to do index arbitrage.

The efficacy of the index arbitrage process has been examined in a number of theoretical and empirical papers.[7] In general, these papers find that observed futures prices can deviate from the theoretical futures price specified by arbitrage conditions by more than normal transaction costs. This is particularly the case for deviations of the futures price below the theoretical price. Such deviations may be difficult to arbitrage because of the short sale restrictions and because of the lack of a sufficient number of institutions willing to engage in stock-replacement strategies.

2. Index Options Arbitrage

The arbitrage link between index options and the underlying index is more complicated than in the case of futures because options have an early exercise privilege. In the absence of the early exercise privilege (i.e., if the options are European-style), the theoretical relation between put and call prices and the price of the underlying index is given as follows:

$$C - P = \frac{S(1 + r - d) - X}{1 + r} \tag{2}$$

where C is the index call price, P is the index put price, S is the value of the index, r is the riskless rate of interest over the time period until maturity of the option contracts, d is the dividend yield over the time period until maturity of the option contracts, and X is the exercise price of the index options. If the relation (2) is violated, an arbitrage opportunity similar to the index futures arbitrage opportunity becomes available. If call prices are too high, it becomes desirable to sell calls and buy puts. The sale of an index call and the purchase of an index put is equivalent to a short position in the index. To offset that short position, the arbitrageur takes a long position in the underlying index stocks, thereby hedging stock market risk and completing the arbitrage. In other words, such a position is equivalent to a short position in futures and a long position in the underlying index stocks. Correspondingly, if calls are underpriced relative to puts, the arbitrageur purchases calls and sells puts, which is equivalent to a long position in the index. The arbitrageur must then sell the underlying index stocks to complete the arbitrage. Arbitrageurs in options face the same costs and risks that index futures arbitrageurs face. In addition, they face the risk that one of the options will be exercised early. Early exercise causes the arbitrage position to be broken up before maturity so the arbitrageur cannot carry the position to expiration. This introduces additional transaction costs and certain amounts of additional risk.

An arbitrage similar to the arbitrage between the index option and the underlying index exists between an index futures option and the underlying

[7]Cornell and French [1983], Figlewski [1984a], Gastineau and Madansky [1983], Modest and Sundaresan [1983], Peters [1985], Stoll and Whaley [1986], and Whaley [1986] examine the arbitrage process and consider possible explanations for observed deviations from theoretical prices. Other papers, notably Brennan and Schwartz [1989], Garcia and Gould [1987], and Gould [1988] analyze strategies for trading on mispricing.

futures contract.[8] Index futures options are much less actively traded than the options on the cash index. As a result, this pricing link has received much less attention.[9]

IV. Program Trading

Index arbitrage requires the simultaneous purchase and sale of the portfolio of stocks that comprise the index that underlies the futures contract. Because such trading requires the use of computers and high-speed communications lines, it is sometimes called *program trading*. In the wake of the October 19 stock market plunge, commentators have frequently criticized the role of program trading and computers in the market decline. But most critics of program trading have only a vague notion of what it is. Usually they are thinking of a combination of three elements.

1. Program Trading Is Portfolio Trading

Program trading is the trading of an entire portfolio of stocks pursuant to a single order. For example, portfolio trading is used by index funds and other diversified investment funds to invest incoming cash or to realize cash by selling a portfolio of stocks rather than selling a few stocks.

Portfolio trading is actually an implication of efficient markets. In efficient markets, investors hold diversified portfolios because stocks are fairly priced—the only gains to be made are by reducing risk through diversification. If it is desirable to hold diversified portfolios, it is desirable to trade diversified portfolios, ergo, portfolio trading.

Portfolio trading can be direct, via the stock market, or indirect, via the index futures market. Because trading of portfolios of stocks is very costly, many portfolio managers trade index futures as a substitute, particularly when speedy market timing adjustments are desired. The most actively traded futures contract is on the S&P 500 index. Thus, if a portfolio manager wants to get out of stocks, he might sell S&P 500 index futures. If stock prices fall (as feared), he still loses on the stocks in his portfolio, but he makes it up on the short position in futures. Overall, he is even—and at a lower transaction cost than if the 500 stocks had been sold in a direct portfolio trade.

Sales of index futures might drive the index futures price to a discount from the cash index price. If that happens, equation (1) is violated and index arbitrage becomes profitable (assuming you can get your transactions carried out, something that was hard to do on Massacre Monday). Index arbitrageurs will buy futures and sell the component index stocks in a direct portfolio trade. In practice, index arbitrage is an important source of direct portfolio—"program"—trading. In effect, index arbitrage converts an indirect portfolio trade into a direct portfolio trade, and, in this example, the end result is the same as if the underlying stocks had been sold directly. Sometimes, sellers of index futures are offset by buyers so that prices are not

[8] An arbitrage-based pricing relation also exists between index options and index futures. Figlewski [1988] empirically investigates this relation for NYSE Composite Index futures and options.

[9] An exception to this statement is a study by Whaley [1986], who investigates the empirical relation between S&P 500 futures options and the S&P 500 futures.

pushed out of line with respect to cash prices. In such cases, index arbitrage does not occur and direct portfolio trading does not take place. The volume of trading that might have taken place in the stock market (if it were not so costly) is thereby transferred to the futures market. That was not the case on Massacre Monday and the days following. Selling pressure pushed index futures to unheard-of discounts. That diverted trading to direct portfolio sales in the stock market for two reasons. First, index arbitrage became profitable (assuming the discount reflected prices at which transactions could actually be carried out). Second, portfolio managers chose to sell stocks directly, since futures were at such a discount.

2. Program Trading Is **Computerized Trading**

The volume of trading in today's financial markets would be impossible without the computer. Computers are necessary to submit orders, print order tickets, clear transactions, and maintain transaction records. This applies to individual stocks or to portfolios of stocks.

Program trading is not done in large blocks. The SEC study of the September 11 and 12, 1986, market decline found that program trades in the S&P 500 averaged $24 million. That means most of the transactions in individual stocks were for 100 shares. Heavily weighted stocks have larger trades, but they are not large relative to their respective daily volumes of trading.

Most program trades are executed over the New York Stock Exchange DOT (Designated Order Turnaround) system, which is an order-entry system designed for small orders (up to 2,099 shares for market orders after the opening, with larger amounts applying at the opening and in the case of limit orders). The DOT system is intended to speed the access of individual investors to the market and to economize on floor brokers' time. In the week of October 19, the DOT system overwhelmed the capacity of the specialists to handle the flow of orders coming through DOT. The NYSE responded by requesting member firms to refrain from using DOT for program trading.

In the long run, suspending program trading is not a reasonable solution to what appears to be an operational problem. The appropriate response to the problem is to increase the amount of computer trading, not to decrease it. One possibility is to increase the capacity of DOT. Another is to computerize many of the specialist's functions currently performed manually.

3. Program Trading Is **Computer Decision-Making**

One of the critics' greatest concerns is that computers will make investment decisions according to mechanical rules. Market instability increases because all the computers follow the same rules. Computers have not, in fact, reached the stage of making many decisions, but they are very useful in identifying and acting on mispricing or in executing technical trading strategies.

Using computers to identify mispricing ought to receive everyone's approval. Such activity maintains market efficiency and is a stabilizing force. Two of the relations that computers monitor continuously are the relations between stock index futures and options and the underlying index, that is, equations (1) and (2) above. If index futures or options are out of line with respect to the underlying index, the computer signals the availability of index arbitrage.

The arbitrage is essential in maintaining pricing links between derivative markets and the underlying market and in maintaining liquidity in both markets. Similar types of arbitrage link interest rate futures and bond prices, foreign exchange rates and interest rates in different countries, wheat futures prices and wheat spot prices, and many other futures prices with their underlying commodity prices. The increased complexity and the globalization of financial markets make the use of computers to monitor pricing relations essential.

A second type of computer decision-making, which is more troublesome, is the computerized technical trading rule. A technical trading rule bases investment decisions on the past sequence of prices, volumes, and other factors. A trading rule is destabilizing if it calls for sales after price declines and purchases after price increases. Portfolio insurance, as it is usually implemented, is a trading rule that allocates funds from stocks to bonds or Treasury bills when the stock market falls to protect previously realized portfolio gains. Portfolios of stocks can be sold directly or, more typically, indirectly in the index futures market. Either way, downward pressure on stock prices results, which can generate additional portfolio sales and additional downward pressure. The process is cumulative and destabilizing.[10]

It is important to remember that portfolio insurance is no different than any other technical trading rule that bases a trading strategy on the history of observed prices. For example, a rule might be to sell stocks if the market declines by a certain percentage on high volume. Any such rule is inherently destabilizing, whether implemented by the computer, point-and-figure charts, or other means. The market's protection against the destabilizing effect of technical trading rules is to have a sufficient number of traders that trade on the fundamentals. Fundamental traders can be most effective in countering technical rules if they know when the rules are in effect and in what amounts. In the case of portfolio insurance trading strategies, for example, less dramatic price movements would likely be observed if insurers would disclose both the trigger prices and the size of the orders that will be initiated if those trigger prices are hit.[11]

V. Impact of Stock Index Futures and Options on Stock Market Volatility

Stock prices are determined by interest rates, earnings expectations, risk perceptions, and other economic factors. Changes in these economic factors produce changes in stock prices and are the fundamental sources of stock market volatility. It is difficult to understand how stock index futures and options can induce volatility over and above what is attributable to fundamental factors. The major players in the stock market and the derivative markets are the same—the big institutional money managers. What happens in one market tends to happen in the other market. If it does not, arbitrage tends to keep the markets in line. Unfortunately, on October 19 and the days following, the arbitrage link was broken, causing futures to sell

[10]Portfolio insurance can also be implemented by buying index puts. In the face of sudden market declines like the Monday Massacre, the use of real put options will be a much more effective, and much less destabilizing, strategy.

[11]Grossman [1988c] provides some compelling arguments in favor of "sunshine trading."

at apparently large discounts ("apparent" because reported prices did not always accurately reflect market conditions). But that pricing discrepancy was an indication of the disruption of markets and the inability to carry out index arbitrage, rather than an indication that index futures and underlying stocks respond to different forces.

The volatility of stock market prices induced by stock market structure—for example, the volatility at stock market openings, or the volatility on index futures expiration days—is considered in the next section. In this section, the links between price changes in futures and price changes in the underlying cash index are examined, and the evidence on the impact of stock index futures and options on the observed variability in stock prices is reviewed.

1. The Dynamics of Stock Index and Stock Index Futures Returns

Stoll and Whaley [1987b] examine the lead-lag relation between relative price changes in the futures and the underlying cash index price. The research shows that, in general, index futures lead the cash market.[12] This is not a causal relation, necessarily. It reflects only that investor opinions about the stock market movements are registered more quickly in futures markets than in the stock market. To register an opinion about the stock market by trading individual stocks requires that 500 individual stocks be traded (in the case of the S&P 500 index). Such transactions take time. As the stocks are traded, the cash index is updated until it reflects the changes that have already occurred in the index futures price. As a result, the index futures price appears more volatile than the index price. But that is not necessarily so. The index futures price is simply a speedier barometer of underlying investor opinions—of the true volatility of the market. When markets are as volatile as on October 19, the distinction is accentuated—index futures will look much more volatile than the cash index.

The introduction of a financial market tends to increase the appearance of volatility simply by registering transactions that previously went unregistered. Consider, for example, small closely-held companies for which there is little or no active secondary market. Such stocks appear less volatile simply because there is less trading and fewer prices are recorded. But, in fact, such stocks are more volatile because, in addition to fundamental economic volatility, they are subject to the volatility caused by the illiquidity of their markets. As trading in such stocks becomes more active, volatility may appear to go up, but it simply reflects more frequent recording of investor opinions.

The introduction of financial futures and options can have an analogous effect. Stock index futures prices tend to appear more volatile than the underlying cash index (to the extent allowed by deviations from the arbitrage link, equation (1)). This simply reflects the greater speed with which market opinions may be registered in the futures markets as compared with the stock market. The cash index represents an averaging of investor opinion through time because it takes time for stocks to be traded. The futures index price reflects opinions at each moment of time. In addition, index futures could

[12]Kawaller, Koch, and Koch [1987a,b] and Laatsch and Schwarz [1988] reach similar conclusions on this point.

make the stock market appear to be more volatile if the presence of stock index futures speeds up the process by which investor opinions are registered in the individual stocks. Recent trading innovations, such as portfolio trading, suggest that this is the case.

Unfortunately, investor opinions are not always correct. Investors overreact. Some critics of futures and options appear ready to eliminate financial instruments that so quickly reflect overreaction. But, to follow that approach would require most financial innovations, including stock market trading itself, to be eliminated because the effect of most financial innovations is to reflect underlying opinions more speedily, even if those opinions turn out to be wrong. We do not think society would be better off if traders were not able to register those opinions. If traders are wrong, it is better to know about it as quickly as possible so that others who think they are right can do something about it. The existence of futures and options markets can speed the response to a market overreaction as well as reflect an overreaction.

2. Evidence on Stock Market Volatility Over Time

It is very difficult to determine if stock index futures and options make the stock market more volatile because it is difficult to determine what volatility ought to be. It is possible, however, to measure stock market volatility before and after the introduction of index futures. Edwards [1987] finds that the variance of daily rates of return of the S&P 500 stock index is lower in the period September 1982 to December 1986 than in the prefutures period 1973-1982.[13] While the evidence is not conclusive, fundamental economic volatility may have declined. Indeed, it is most likely that changes in underlying economic volatility explain changes in observed stock market volatility.

It is hard to see how the introduction of index futures and options could increase observed stock market volatility very much. The introduction of index futures and options did not change the number or composition of investors in the financial markets. The same investors who used to trade exclusively in the stock market now have the opportunity to trade both in the stock market and in the index futures market. Index futures may have some short-run effects on volatility of the kind already noted: to increase the speed with which investors opinions are reflected in prices and thereby increase short-run volatility. But fundamental economic uncertainty is not altered by the introduction of instruments that reduce the cost and increase the speed with which economic uncertainty is managed.

A second source of increased volatility that might be associated with the introduction of index futures and options is that caused by the failure of our market structures to keep up with the rate of financial innovation. Inadequacies in market structure may induce short-run volatility that is not

[13]Using a shorter prefutures period and a longer postfutures period, Aggarwal [1988] finds that the volatility of the S&P 500 index increased after the introduction of futures. However, Aggarwal then goes on to point out that the volatility of all equities increased during her sample period and that the relative increase in volatility for OTC stocks is considerably larger than the relative increase in volatility of the S&P 500 stocks.

justified by economic fundamentals. We now turn to those issues.

VI. Market Structure Issues

In assessing the functioning of index futures and options, it is important to understand the nature of the markets in which they trade vis-à-vis common stock markets. This distinction is particularly important in view of the criticisms leveled at stock index futures and options and program trading in the wake of the October 19, 1987, Monday Massacre. In our view, there is not too much that one could have done to avoid a stock market crash based on fundamental factors, which in our opinion is the case in the crash of 1987. But the functioning of the financial markets left a lot to be desired.

Rapid technological change in communications and trading, particularly in upstairs offices of brokers and money managers, has placed strains on other components of the financial system, particularly the exchanges. These strains are of two forms. First, there is an inevitable clash between trading procedures on exchanges that date to the 1800s and new high-speed communications and computer trading technologies. Second, the advent of derivative instruments and the globalization of markets has increased the number of markets that trade the same or closely related financial instruments. Markets have changed from a single sequential market in each financial instrument to a set of simultaneous markets. That simultaneity can cause problems in a highly volatile atmosphere.

1. The Exchanges and Technological Change

It is inevitable that the imposition of a high tech, globalized financial system on stock exchanges and futures exchanges developed 100 years ago will cause some dislocations, especially in a volatile economic environment. Adapting the new realities of financial markets to the structure of exchanges is a little like putting a high-performance engine into a Model T. The solution is not to throw out the engine, but to upgrade the Model T.

Upstairs brokerage offices and money managers are linked worldwide with instant communications, instant data access, and the ability to send orders at high speed to many market centers. The exchanges have made tremendous strides in adapting their cultures and institutions to this new environment, but the Monday Massacre revealed a couple of pressure points.

The level of automation on the exchanges has not matched the level upstairs. On October 19 and the days following, the DOT system of the NYSE was unable to handle the complete order flow, and specialists on the floor were unable to handle the flow of orders that got through. Because DOT is an order-entry system, not an automated execution system, it does not speed up the execution of orders at the specialist's post. It only speeds up the arrival of orders on the floor. Enhancements in DOT to handle large-volume days is desirable, but even more important is the need to enhance the ability of specialists to execute orders on large-volume days.

One way to rationalize trading on stock exchange floors is to improve mechanisms for portfolio trading. The stock exchanges are set up to handle order flow in individual stocks; they are not well organized for portfolio trading. Because different stocks trade at different locations on the floor, it is

cumbersome to carry out a portfolio trade other than on DOT; and even if the trade is carried out over DOT, it is difficult for the exchanges to determine the amount of portfolio trading. There is no single location on the floor at which the portfolio trading order flow can be assessed and imbalances in portfolio trading determined. One solution to the problem is the establishment of a portfolio post on the exchange floor. At that post, transactions in standard portfolios could be crossed and imbalances assessed. In other words, it ought to be possible to create a market in standard portfolios.[14]

The futures markets, initially established to trade futures in agricultural commodities, may be ill-suited for the volume of trading and the institutional nature of trading that are common in financial futures. The pits of futures exchanges are dominated by short-term traders—scalpers—who provide an important source of liquidity in a normally functioning market. But, on Massacre Monday, many scalpers took heavy losses and withdrew from the market or quoted large spreads. This made it difficult to get transactions done. A variety of modifications might be appropriate. For example, thought should be given to procedures by which the ultimate buyers and sellers—the institutional investors—can be brought together directly. On stock exchanges, this has been accomplished by block trading. Just as the capitalization of the specialist on stock exchanges is insufficient to handle block transactions, so the capitalization of floor traders on futures exchanges is insufficient to handle blocks of index futures contracts.

2. Simultaneous versus Sequential Markets

In a sequential market, a transaction is made, a price is posted, and market participants observe the price before the next transaction. Traditional stock exchange trading procedures tend to be sequential. When volume increases and many orders in the same asset or its derivatives are placed simultaneously from many upstairs trading rooms, markets become simultaneous, and it is difficult to tell what the market price is. Computers and the globalization of markets have increased the number of decision-makers able to access the market at any one time. When markets are simultaneous, each market participant may believe that he knows the current market price as his order goes in; but, as the orders are traded, each may be surprised by the resultant price change. This is because large unexpected trading imbalances induce substantial price changes that no one anticipated and that can overshoot equilibrium. These price changes induce another round of trading, which is also subject to the same type of uncertainty.

Portfolio managers, knowing that exchanges handle orders sequentially, place an inordinate premium on submitting their orders ahead of their competitors, with the result that exchanges are overwhelmed by an influx of orders. In this kind of environment, a temporary trading halt, properly

[14]Stoll [1987b] recommends creating a market in standard portfolios. A similar proposal is also contained in the Katzenbach Report. Recently, the American Stock Exchange, among other exchanges, applied to the SEC to begin trading "equity index participations" on the S&P 500 index. These participations will have one tenth the value of the S&P 500 index and will be traded on the floor of the Amex.

structured, is not unreasonable. Trading halts are common in individual stocks whenever an order imbalance becomes too great. What may be different in the future is a trading halt that applies to all stocks or all index futures contracts. A trading halt is not intended to put a halt to the price-formation process. It is not an admission of market failure, but a mechanism to help discover the true underlying price. Indeed, a trading halt is useless unless accompanied by procedures to determine the new equilibrium price. At present, the procedures for determining the price at which a security should reopen are inadequate or nonexistent. What would be required is the dissemination of information on the size of imbalances and the likely opening price. In response to such information, money managers should be allowed to withdraw orders or place additional orders. Providing information on the potential price is likely to reduce trading and make markets more orderly. Why rush to trade ahead of your competitor if both of you are going to trade at the same price? And, if that price is down 100 points, maybe it will no longer be worth trading.

3. Expiration Day Volatility

Stock index futures expiration days are a microcosm of many of the structural issues facing the markets today. On quarterly expiration days, stock market volume has been high, and order imbalances, large. Much of the order flow has been simultaneous—in the last few minutes of the expiration day—rather than sequential. Much of the volume is portfolio trading related to the unwinding of index arbitrage positions.

Thus, expiration days contain many features of trading that led to market disruptions on October 19 and the days following. There is one important difference, however. On expiration days, the motive for trading and the source of the price effect is almost entirely structural. Because of the cash settlement feature of index futures and options, arbitrageurs must dispose of their positions in the underlying stocks, and they must do so at the settlement price of the futures if their hedge is to be maintained. (Until June 1987, the settlement price was the cash index closing price. Since then, settlement of the S&P 500 futures and certain other derivative instruments is based on the cash index opening price.) The need to sell (or buy) the index stocks at the settlement price of the index generated large-order imbalances that were difficult to accommodate and therefore caused temporary price effects.

Volatility does increase at index futures expiration days. Day and Lewis [1988] show that implied volatilities in the expiring index options increase relative to implied volatilities in longer-term options. Stoll and Whaley [1986, 1987a] estimate the average price effects of expirations to be about 0.30 percent—about one eighth of a dollar on an average-priced stock. While this average effect is not large, large effects were observed on certain expiration days.

Most of the price volatility on October 19 was fundamental. But some of the market chaos—large volume and large trade imbalances—corresponded to what happens on expiration days, in exaggerated form.

While fundamental price volatility cannot be eliminated, structural volatility

such as that on expiration days can be reduced by modifications in trading arrangements. The use of the opening price as settlement price seems to be a structural change that has reduced the apparent effect of expirations. But all the evidence is not yet in. As noted in Stoll [1987a], the benefit of the opening is that it gives the specialist time to assess the imbalance. The drawback is that the specialist has great economic power at the opening because, under current procedures, full disclosures of opening order imbalances are not required. If only the specialist knows the opening order imbalance, he can open the stock at a price that generates a quick rebound. A rebound allows the specialist to make a quick profit by buying (selling) at the open and selling (buying) on the rebound. Evidence in Amihud and Mendelson [1987] and Wood, McInish, and Ord [1985] indicates that prices are more volatile at the opening than at other times; and rebounds tend to occur.

4. Adequacy of Market-Making

A decline like Monday Massacre cannot be blamed on market-makers because market-makers cannot be expected to stem a decline justified by economic fundamentals. First, market-makers on stock exchanges and scalpers on futures exchanges do not have the necessary capital to stem a decline even if they wanted to. Second, no market-maker, whatever his capital, should be expected to take losses in order to stem a decline justified by fundamentals. Instead, the responsibility of the market-maker is to bring that decline about as efficiently and in as orderly a manner as possible. When markets are disorderly and imbalances are large, it is difficult to determine the new equilibrium price of securities. In such cases, a trading halt might be appropriate.

The purpose of a trading halt is to determine a new price at which buyers and sellers can be matched. On days like October 19, the problem lies less with market-making than with the adequacy of procedures to determine rapidly changing new equilibrium prices. This includes procedures to determine if and when a trading halt should be instituted and procedures for determining a new equilibrium price if a trading halt is put into place.[15]

Market-makers tend to make profits only if prices rebound. If prices move only in one direction, market-makers tend to take losses on their inventory position. Critics of market-makers point to the ability of market-makers to engineer excessive rebounds (as at the opening, or by posting an excessive bid-ask spread).[16] On a day like Monday Massacre, it is possible that market-makers quoted excessive spreads or traded market orders at prices that are unfair even in light of the large price moves on that day in order to engineer a price rebound. But, on Monday Massacre, market-makers took losses that overwhelmed such gains.

With the growth of institutional investing in the last 25 years, the size of transactions has grown relative to the size of market-makers on the floors of exchanges. As a result, market-making activity has moved to upstairs

[15]Stoll [1987a] provides a critical analysis of NYSE procedures for establishing a new equilibrium price at each day's opening.
[16]A critical analysis of the stock exchange specialist system is provided in Stoll [1985].

block-positioning firms. Over time, the amount of capital devoted to market-making has increased, but most of the increase has been in the capital of upstairs trading firms rather than exchange market-makers. Market-makers on exchange floors are small relative to institutional investors and block trading firms, and they cannot cushion major price moves emanating from these sources. Instead, the role of the exchange market-maker is more that of a referee—and sometimes that of a bystander. Market-makers cannot be expected to solve problems that they cannot solve.

VII. Conclusions

The rapid growth of stock index futures and options since their introduction in 1982 and 1983 has attracted considerable attention from Congress, regulators, and a puzzled public. Until the October 19, 1987, Monday Massacre, most of this attention was focused on the quarterly expirations of index futures and options—The Triple Witching Hour—and certain other days—September 11 and 12, 1986, and January 23, 1987—on which stock market prices changed dramatically. Today, the price changes on these days seem mild by comparison to the market chaos on October 19 and the days following. But, as before, commentators frequently blame stock index futures and "program trading" for the decline and for most of the market turmoil.

The objectives of this paper are to: (a) review the nature and purpose of index futures and options, (b) explain the determinants of index futures and options prices, (c) assess the meaning of "program trading" and its role in the Monday Massacre, (d) consider the impact of stock index futures and options on stock market volatility, and (e) point out inadequacies in market structure that may exacerbate short-run market volatility.

1. Index futures and options are useful portfolio-management and hedging tools, enabling inventories and cash flows to be hedged, enabling security analysts to concentrate on stock selection while avoiding general market risk, facilitating market timing, asset allocation, and dynamic hedging, and permitting a division of responsibilities among portfolio managers. Index options make it possible to deal with more complex risks than do index futures (quantity risk as well as price risk, for example). Index put options also provide portfolio insurance without the trading uncertainties encountered in the dynamic hedging replication of portfolio insurance.

2. Index arbitrage links the market prices of derivative instruments and the underlying cash index. Index arbitrage is a stabilizing force that keeps the prices of any related financial instruments from deviating from the prices of other related financial instruments. Index arbitrage is a form of comparison shopping that keeps the prices of the same commodity in different stores from diverging.

3. Index arbitrage is limited by transaction costs, regulatory restrictions on arbitrage (such as the short sale rule), the lack of capital, and other factors. Futures and options can be more tightly linked to the underlying index by improving the arbitrage process. This would require reductions

in transaction costs and the elimination of other impediments to arbitrage.

4. In the wake of the October 19 stock market plunge, commentators frequently criticize the role of program trading and computers. But program trading means many things—portfolio trading, computer trading, portfolio insurance, and index arbitrage.

5. Portfolio trading is an important trading innovation that is a natural outcome of an efficient market and the desire of investors to remain diversified. Portfolio trading is the trading innovation of the 1980s, much like block trading was the trading innovation of the early 1970s. Like block trading, it has been initially viewed with suspicion and concern; and, like block trading, it will take markets some time to adjust.

6. Computer trading and order processing are essential in managing the order flow in today's financial markets and in controlling costs. Innovations have taken place more rapidly in upstairs offices and in the order-entry systems than on the floors of the stock exchanges and futures exchanges. What is needed is more computer trading on exchange floors—not less.

7. Portfolio insurance trading strategies can be destabilizing, like other technical trading rules that base investment decisions on the historical sequence of prices. (Portfolio insurance based on the purchase of index puts does not have the same destabilizing effect.) The best defense against any technical trading rule that is destabilizing is the presence of a sufficient number of value traders who go by the fundamentals.

8. The process of index arbitrage sometimes requires substantial amounts of portfolio—or program—trading. But such portfolio trading is a stabilizing force. Index arbitrage will be more effective if the cost of portfolio trading can be reduced.

9. Major stock market moves like the Crash of 1987 can be attributed to fundamental economic factors such as increasing interest rates, reduced earnings expectations, international tensions, and uncertainties about government policy. Stock index futures and options may increase stock market volatility slightly by increasing the speed with which new information is reflected in market prices. Our research on minute-by-minute price changes in the stock index futures and the underlying cash index shows that index futures lead the cash market. This reflects the fact that investor opinions are registered more quickly in the futures market than in the stock market because it takes time to trade the many individual stocks that comprise the index. Thus, the introduction of index futures may increase the appearance of volatility as much as the introduction of any financial market increases the appearance of volatility simply by causing prices to be registered.

10. The volatility of the S&P 500 index appears to have decreased since the

introduction of S&P 500 futures contracts, at least relative to stocks with no derivative instruments written on them.

11. The Crash of 1987 highlights some of the market structure issues arising from the clash between the highly computerized upstairs financial markets and the floor trading procedures of futures and stock exchanges that date to the 1800s.

12. Stock exchanges ought to examine ways to improve their ability to handle portfolio trading. Under current procedures, trading in each stock is carried out at a separate location on the floor. This makes it difficult to detect and deal with portfolio trading affecting the market as a whole. For example, it would be possible for exchanges to establish a trading location devoted to the trading of standard portfolios.

13. Futures and options exchanges need to find ways to increase the direct participation of major institutional investors in the financial futures markets. The floors of futures exchanges are dominated by small floor traders—scalpers—who may be forced to withdraw in highly volatile markets. Mechanisms for bringing about direct trading, in large size, among major institutional money managers, ought to be sought.

14. When simultaneous selling imposes a large imbalance of sell orders on exchanges, a temporary, properly structured trading halt is not a bad idea. But a trading halt is useless unless accompanied by procedures to determine a new price.

15. We have learned something from structurally induced expiration-day volatility. While the volatility at the "Triple Witching Hour" is small by comparison to the volatility on October 19, many market structure questions are common to both types of days. The use of the Friday opening price as the settlement price for stock index futures (a change from basing settlement on the Friday closing price) may lessen expiration-day volatility. This is so because the use of the opening provides a temporary trading halt prior to the determination of the settlement price on the stock exchange and thereby provides time to deal with imbalances. Current procedures for determining the opening price could, however, be improved by increasing the dissemination of information about the size of imbalances and the likely opening price. Under current procedures, the specialist has too much discretion.

16. The problem of our market-making systems is not necessarily the capital inadequacy of market-makers. One cannot expect a market-maker, no matter how great his capital, to buy stocks in the face of a major decline. The proper role of a market-maker in such circumstances is to determine a new price at which the ultimate investors are willing to buy. We need more adequate procedures for determining prices in volatile markets. Increasing the amount of capital does not do that. Most of the trading in stock markets, and now futures markets, is among major institutional investors such as pension funds and mutual funds. The capital for

positioning large institutional transactions is provided by upstairs market-makers. Market-makers on stock exchanges and scalpers on futures exchanges are small in comparison to institutional investors. Their role is not to attempt to cushion major price changes but, rather, to determine a market price at which institutional investors would trade directly with each other.

The recent turmoil in the financial markets should not be an excuse to restrict unnecessarily important new financial instruments like index options and futures or to limit trading innovations like portfolio trading. Instead, the recent volatility of markets and the massive volume of trading have disclosed some failings in the resiliency and vitality of our market structure. It is a good time to see in what ways trading procedures can be modified more appropriately to deal with the changing financial markets.

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