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Program Trading, Portfolio Insurance and the Crash of 1987

1. Introduction

On October 19, 1987, the Dow Jones Industrial Average ('Dow') closed down 508 points. This fall of 22.62% in the value of the Dow was the largest fall in its history. By comparison, the fall on Black Tuesday was a paltry 12.8%. The Dow rebounded on the next two days by more than 250 points. Most observers seem to agree that changes in economic conditions around that day can explain much of the fall in stock prices[1]. The increase in the Dow subsequent to the crash as well as the obvious panic in the markets during the crash have, however, led many to argue that the fall in stock prices on October 19 was excessive and did not wholly reflect changes in the 'true' or 'intrinsic' value of common stocks.

This belief that the fall in stock prices during the crash was excessive started a search for culprits. The exchanges, the regulatory agencies and the Federal government have all formed commissions to investigate the crash. These commissions and the financial press have given considerable attention to program trading and portfolio insurance as the reason why stock prices on October 19 fell as much as they did. In this paper, we explore whether program trading and portfolio insurance are as guilty as they have been made out to be. While we believe that there were good economic reasons for stock prices to fall, we will not address these in this paper.

Before we proceed further, we have to define what we mean by portfolio insurance and by program trading. We will call portfolio insurance all asset allocation techniques that are designed to protect wealth against downfalls in stock prices. Portfolio insurance, as we will see, leads to program trades both directly when stock trades are used to implement it and indirectly when futures contracts are employed instead. While a program trade can be defined in a number of ways, we focus on the program trades that are trades of large predetermined baskets of stocks initiated by a single order[2]. By a basket of stocks, we mean a portfolio composed of shares of different stocks. For instance, a basket could be a portfolio comprised of ten thousand shares of each stock in the Dow. The basket is predetermined because the number of shares traded of a given stock does not depend on the price of that stock relative to the price of another stock when the trade is ordered. In other words, while the trade may depend on the value of the basket as a whole, the decision to trade does not require knowledge of the prices of the individual stocks that form the basket. A single order initiates the trade, in the sense that once a program trade is started, it is irreversible.

Program trades generally use a highly automatized trading system called DOT for Direct Order Turnaround System. The DOT System makes it possible to initiate a program trade by pressing one button, so that the trade effectively results from a single order. The program trader can register his basket in the DOT system and then, when he wants to trade the basket, can do so with one command that uses computers to direct the order for each stock to the specialist that handles that stock on the floor of the New York Stock Exchange. The specialist, who is the market maker on the exchange, receives the order within two minutes

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from the time that the program trader initiates the trade. If the program involves trades of at most two thousand shares per stock, execution is usually guaranteed within three minutes from receipt of the order by the specialist; otherwise, execution may take longer.

Program trading raises the natural question of why trades are made in baskets of stocks rather than individual stocks. We discuss this issue in Section 2. In Section 3, we explain how portfolio insurance is implemented and its implications for program trading. Section 4 reviews stock index arbitrage which is the motivation for a large fraction of program trades. Section 5 examines the impact of program trading stock sales on stock prices under a variety of assumptions. Section 6 addresses the issue of the role of portfolio insurance and of program trading in the crash. The concluding section points out briefly the public policy implications of our analysis.

2. The relevance of baskets of common stocks

Investors often buy or sell shares of a particular common stock because they believe that the price of the share is too low or too high relative to its 'true' or 'intrinsic' value. Such trades are based on private information or on different interpretations of common data. Modern finance has shown that there is a strong presumption that financial markets are efficient, in the sense that the price of a share reflects the information available about it. If financial markets are efficient, it is unlikely that most investors can find shares that are either under- or overpriced. To the extent that an investor cannot find shares whose 'intrinsic' value differs from their price, his best approach to manage his investments in common stocks is to hold a diversified portfolio of common stocks[3]. The investor alters his holdings of that portfolio only when his attitude towards risk changes or to finance his consumption.

The emphasis of modern finance on the efficiency of the stock market and the benefits from diversification has led to the development of portfolio strategies that are formulated in terms of investments in a predetermined basket of common stocks as opposed to trades in individual common stocks. An investor who believes that markets are efficient cares only about his total wealth and not about the price of one share of common stock relative to the price of another.

Among institutional investors who follow the teachings of modern finance, the Standard and Poor's 500 ('S&P500') index has attracted considerable attention. The S&P500 index is a weighted average of the share price of 500 different common stocks. The weight for each stock is its market value relative to the total market value of all stocks in the index. Since the S&P500 index is a value-weighted index that includes so many large capitalization stocks, its return is often viewed as a proxy for the return of a portfolio that holds all U.S. common stocks in proportion to their market value. The return of the S&P500 index can be obtained by a portfolio manager that holds stocks in proportion to their weight in the index. Hence, the return of the index represents a natural benchmark to evaluate the performance of active managers who are not content to hold a diversified portfolio of common stocks. There is little evidence that active managers perform better, after adjusting for differences in risk, than investors who buy and hold a portfolio whose return is perfectly correlated with the S&P500 index. We call such a portfolio simply an S&P500 portfolio and follow the widely used practice of calling such investors indexers.

While little wealth was invested in S&P500 portfolios in the 1970's and before, indexing has grown considerably in the 1980's. Evidence of this is that indexing seems to affect the price of securities included in the S&P500 index. An interesting study by SHLEIFER shows that the value of a firm increases upon the announcement that its common stock will be included in the index and that the percentage increase has grown over time[4]. He interprets his results as evidence that when a stock is included in the index, the demand for that stock increases because indexers purchase it. This price effect is a recent one and it seems to have grown as indexing became more important. It did not exist in the 1970's when indexing was negligible.

Portfolio strategies that involve taking a position in an S&P500 portfolio are so pervasive that they have led to the development of derivative assets whose return depends on the performance of the S&P500 index. The most important of these derivative assets are the futures contracts on the S&P500 index traded on the

International Money Market of the Chicago Mercantile Exchange[5]. A futures contract is similar to a forward contract in that it is a contract whereby one party agrees to sell to the other at maturity some commodity or financial asset at a price agreed upon at the inception of the contract. No payment is made when the contract is entered into. Futures contracts are traded on exchanges and performance on a contract is guaranteed by the exchange on which it is traded. Each party deposits some money, called the margin, in an account to show its good faith. The parties to the contract settle gains and losses daily. An S&P500 futures contract is therefore one whereby one party agrees to sell to another an S&P500 portfolio (whose value, to be precise, is equal to five hundred times the index) at a given price. An interesting twist of the S&P500 futures contract is that its delivery takes place in cash instead of common stocks.

The maturities of futures contracts are standardized and contracts trade up to the third Friday of the delivery month. One would expect the price changes for an S&P500 contract to be closely related to changes in the value of the index since the contract enables one to buy the index at maturity at the price in force when one enters the contract. This makes the S&P500 futures contracts useful for indexers and other investors who take positions in S&P500 portfolios. By buying or selling futures contracts, these investors can increase or decrease the exposure of their wealth to changes in the value of the S&P500 index. An investor who sells contracts, i.e., promises to sell an S&P500 portfolio at maturity, is effectively short in the index. This implies that S&P500 futures contracts can be used to hedge cash positions in the index (and in other portfolios correlated with the index). As will be seen in Section 4, the transaction costs of selling an S&P500 futures contract are small compared to those of selling the underlying basket of stocks. The fact that the S&P500 futures contract is a useful hedging tool in portfolio management is a major reason for the extraordinary success of this contract. Before October 19, trading in S&P500 futures on an average day involved the promise to exchange S&P500 portfolios for about 12 billion dollars, which was a substantially larger amount than the value of the trades in the cash market for the stocks forming the S&P500 index.

3. Portfolio insurance and program trading

Indexers who follow a buy and hold strategy make program trades only when they raise or invest cash. However, large investors who allocate their wealth between an S&P500 portfolio and a money market account or bonds and change frequently the fraction of their wealth invested in stocks generate program trades whenever they alter their asset allocation. One important class of such investors is formed by those investors who use portfolio insurance strategies. These strategies are designed to insure that at some date in the future an investor's wealth attains at least some predetermined level. These strategies and their implications for program trading are discussed in this section.

To explain portfolio insurance strategies[6], we consider an investor who believes that markets are efficient, has wealth of 10 million dollars that can be invested in a money market account that earns 10% interest per year and into common stocks, and wants to have at least 10 million dollars available one year from now[7]. The investor can place all his wealth in the money market account so that, at the end of the year, it has increased by 10%. To obtain a higher expected return, he can allocate a fraction of his wealth to an S&P500 portfolio. However, as the investor puts more of his wealth in the stock portfolio, he increases the size of his possible losses if he follows a buy and hold strategy. An investor who adopts a buy and hold strategy is therefore forced to seek a middle ground between making no losses but eliminating the potential for gains in excess of 10% or possibly making substantial gains but taking the risk of large losses.

Portfolio insurance and other dynamic allocation strategies make this tradeoff between increasing the expected gain and decreasing the risk of losses more palatable for many investors. The simplest example of a dynamic allocation strategy that insures the investor against losses can be described as follows. To have 10 million dollars available for sure at the end of the year, the investor must never let his wealth fall below a threshold level such that, if entirely invested in a money market account, his wealth would grow to 10 million dollars by the end of the year[8]. This threshold level increases over time since the amount of interest that will accrue to wealth invested in the money account before the end of the year is lower if the wealth is put in the money market account later in the year. As long as his wealth is above the threshold level, the investor can put all of it in an S&P500 portfolio. If the performance of the S&P500 portfolio is poor, so that the investor makes losses, he switches all his money into the money market account when his wealth reaches the threshold level. This simple dynamic portfolio strategy incorporates the main features of portfolio insurance: (1) it guarantees that the investor's wealth will be preserved as of a certain date, (2) it leads the investor to sell stocks when stock prices fall, and (3) it enables the investor to take advantage of the unlimited upside potential of common stocks. This strategy, however, is not as advantageous as more sophisticated portfolio insurance strategies to be described shortly. It has the defect of taking the investor out of the stock market if stock prices fall early in the year, so that the investor might be watching from the sidelines large subsequent stock price increases. In technical terms, this strategy has path-dependent payoffs, which means that the investor's wealth at the end of the year depends not only on stock prices at that point in time but also on the path of stock prices during the year. To understand better why this feature of the strategy is unattractive, consider two scenarios that lead to the same increase of 8% in the S&P500 index during the year. With scenario A, the index falls 10% and then increases 20%, while with scenario B, it increases 20% and then decreases 10%. Using the dynamic allocation strategy just described, the investor's wealth at the end of the year is 10 million dollars with scenario A and 10.8 million dollars with scenario B. This is because with scenario A the investor must switch from common stocks into the money market account before the index has stopped falling, since he cannot make up a loss of 1 million dollars through interest income on the money market account. With scenario B, the investor is wholly invested in stocks throughout the year. Hence, the portfolio strategy does not take full advantage of the increase in stock prices if prices first fall and then subsequently increase sufficiently to make them higher at the end of the year than at the beginning.

An alternative allocation strategy for our investor that does not produce path-dependent payoffs consists in investing in an S&P500 portfolio and buying a put option on that portfolio. To understand this suppose, for the sake of illustration, that the investor takes a position worth 9.5 million dollars in an S&P500 portfolio and buys a one-year European put option on that portfolio with an exercise price of 10 million dollars for 500 000 dollars. By definition, this option gives its holder the right to sell his S&P500 portfolio for 10 million dollars at maturity. In one year, the investor will not exercise this right if the value of his portfolio exceeds 10 million dollars. If the S&P500 is worth less than 10 million dollars, the investor exercises his right to sell his portfolio. In this case, he ends up having 10 million dollars since he can sell his portfolio for that sum. Therefore, the investor has an allocation strategy that makes no losses and has unlimited upside potential. This strategy enables the investor to make a wealth gain whenever the value of his S&P500 portfolio increases over the year by more than the premium paid for the put option, irrespective of the path of the value of his portfolio during the year. In particular, the investor has the same wealth at the end of the year whether scenario A or scenario B described in the previous paragraph takes place. This strategy is feasible irrespective of how the investor's wealth ends up being divided between the investment in the S&P500 portfolio and the premium paid for the put option. Obviously, the higher the price of the put option, the higher the gain required on the S&P500 portfolio for the investor's wealth to increase, since the investor's wealth gain is the increase in the value of his S&P500 portfolio in excess of the put option premium. Nevertheless, this strategy has some disadvantages of its own. There is no market for European put options on stock indices, but only one for American put options. An American put option gives its holder the right to sell the underlying asset, i.e., the S&P500 portfolio in this case, at any time until maturity. American put options are more expensive than European ones and introduce additional uncertainty in the allocation strategy because one does not know when it will be optimal to exercise such options. In addition, the market for American put options on indices is not liquid for options with maturity in excess of sixty days and typically options for maturities beyond three months are not listed. While portfolio insurance can be achieved by rolling over short-term put options, such a strategy is costly and produces path-dependent payoffs.

Since purchasing put options to implement portfolio insurance has obvious difficulties, most of portfolio insurance is achieved by trades in futures contracts and in common stocks. Option pricing theory provides a recipe that can be used to replicate the payoff of a put option on the S&P500 portfolio by trading in futures contracts or stocks and using a money market account to finance the losses and invest the gains on the contracts[9]. If the investor invests in a portfolio of common stocks that can be hedged effectively with S&P500 futures contracts, the transaction costs of replicating the put option with futures contracts are only a small fraction of those incurred when replicating the put option with common stocks. Hence, it is economical to trade common stocks to implement portfolio insurance only if the investor's portfolio cannot be satisfactorily hedged with futures contracts. The fact that so many investors hold portfolios highly correlated with the S&P500 index explains why so much portfolio insurance is implemented through trades in S&P500 futures contracts.

To understand the implications of the put option replication technique, suppose the investor starts, for the sake of illustration, with 9.5 million dollars in an S&P500 portfolio and 500 000 dollars invested in a money market account. If the index falls, the investor loses money. He can almost perfectly hedge himself by selling S&P500 futures contracts for 9.5 million dollars when he invests in the S&P500 portfolio. However, if he does that, he gets no benefit from an increase in the value of the S&P500 portfolio in excess of 10% and hence may as well not hold the portfolio and invest all his wealth in the money market account. To gain from increases in the index, the investor wants to sell few contracts. If the index does not move much at a time, his S&P500 portfolio might fall to $ 9 400 000 after a month and he might make a small gain on his futures contracts that he would invest in his money market account. In this case, in the absence of any other changes in the value of his portfolio, the investor will not lose wealth for the year if he computed the size of his positions in the S&P500 portfolio, futures contracts and money market fund using the appropriate mathematical formulas. This is because, if his S&P500 portfolio does not change value until the end of the year, the value of his money market account at the end of the year will be 600 000 dollars. However, if the index falls more during the year, the investor will have to sell more and more contracts to make sure that further gains on futures contracts will increase the value of his money market fund investment to offset losses in his S&P500 portfolio. Hence, the investor wants to sell more contracts as the index keeps falling up to the point at which he is fully hedged. When the index increases, it becomes more likely that wealth will increase for the year and the investor can buy back some futures contracts he sold. Implemented with futures contracts, portfolio insurance requires that the index changes only by small amounts at a time. This is because incomplete hedges, i.e., selling few contracts, offer insufficient protection against large stock price changes. If the investor sold futures contracts for an amount equal to 10% of the value of his stock portfolio and the portfolio falls by 25%, he will make substantial losses.

As we have seen in this section portfolio insurance can be implemented in a variety of ways. Irrespective of the technique used to implement it, portfolio insurance reduces investors' exposure to the S&P500 index as the index falls. Portfolio insurance may therefore be viewed as having a destabilizing effect on the stock market, since it induces investors to sell stocks when they have become cheaper. Selling stocks to obtain portfolio insurance is done through program trading as defined in Section 1. By the nature of portfolio insurance, stock sales occur when the stock market has fallen. If portfolio insurance is implemented with futures contracts, sales of futures contracts put pressure on the stock index futures prices which leads indirectly to stock sales through program trades because of stock index futures arbitrage that we describe next. Typically, investors wanting to acquire portfolio insurance hire a specialized firm that insures their wealth through futures or stock trades for a fee. Before October 19, it was widely believed that these firms insured between 60 and 100 billion dollars of wealth. Hence, a substantial fall in stock prices that would force these firms to sell more futures contracts could have a substantial impact on futures prices.

4. Index arbitrage

Following a fall in the S&P500 index, portfolio insurers must sell futures contracts. This means that the price of S&P500 futures contracts must fall. However, because a purchase of S&P500 futures contracts is simply a purchase of the index for a future delivery date, there must be a link between the price of that contract and the cash market price of the index. In this section, we explain that link and show how it is maintained through time.

To simplify things, suppose that a futures contract on the index matures in thirty days and that no dividends will be paid on the stocks which comprise the index during these thirty days. An investor who wishes to hold the S&P500 index thirty days from now but at a price known today can do so in two ways. Let S be the value of the index today and F the futures price. The investor can buy the index today and borrow to pay S. In thirty days, he pays back his borrowings plus interest at the rate R and owns the index. Alternatively, the investor can buy a futures contract on the index so that, in thirty days, he can buy the index for the price F. If the investor uses the cash market plus borrowing, he pays $S(1 + R)$ in thirty days for the index, while he pays F if he uses the futures markets. Since using the cash market plus borrowing or the futures market are two equivalent ways of buying the index, it must be the case that F equals $S(1 + R)$.

The relationship between the futures price and the cash market price of the index derived in the previous paragraph must hold exactly in the absence of transaction costs. To see this, suppose that F is smaller than $S(1 + R)$. In this case, the futures price is too low. It then pays to buy the futures contract, short the S&P500 index and invest the proceeds from the short-sale in a money market account that pays interest at the rate R for thirty days. At the end of the month, one must buy the S&P500 index to give the stocks back to the investors that were willing to lend them. However, since one bought the futures contracts, one can buy the stocks at the price F and has $S(1 + R)$ to pay for that. One is left with a profit of $F - S(1 + R)$. This transaction, called a short arbitrage, involves selling stocks short and enables one to make money for sure. It brings the futures price closer to its theoretical value, since it increases the demand for futures contracts and increases the supply of stocks. Hence, the arbitrage activity makes the arbitrage opportunities disappear and is therefore self-defeating. Alternatively, suppose that the futures price is too high compared to its theoretical value. In this case, one uses a long arbitrage whereby one sells the futures contract, which decreases its price, and one buys stocks, which increases their price. Individuals who undertake such arbitrage transactions are generally called stock index arbitrageurs.

The theoretical relationship between the futures and the cash market price of the S&P500 index never holds perfectly because stock index arbitrage is fraught with difficulties[10]. These difficulties arise because of transaction costs, the necessity to sell stocks short when the futures price is below its theoretical value, and the fact that dividends are paid on stocks. We review these difficulties in turn. STOLL and WHALEY (1987) estimate the costs of a long arbitrage as follows. For the arbitrage to be economically feasible, it must involve trades in round lots of stocks. Consequently, it requires capital of the order of 15 million dollars and futures trades in multiples of 100 contracts. Suppose one sells 100 futures contracts. The commission is $ 1250. The commission on the stocks bought is, if one pays on average seven cents a share, $ 17 500 each way. Further, one must buy at the ask and sell at the bid, so that one incurs what is generally called a market impact cost. This cost is evaluated at $ 25 000 for the stocks and $ 1250 for the futures contracts. Note that if one keeps the futures positions to maturity, one pays the futures market impact cost only once since one takes delivery at maturity rather than sell the contract. If one unwinds the arbitrage before maturity, one must pay the market impact cost twice on the futures contracts. It follows from this that if the position is held to maturity the total cost of the arbitrage is $ 62 500 or 0.5% of the value of the stocks bought initially. Hence, to undertake the arbitrage, one wants to make sure that the futures price is sufficiently far away from its theoretical value to make the arbitrage profitable net of transaction costs. Small deviations of the futures price from its theoretical price do not imply the availability of arbitrage profits.

The cost of a short arbitrage is typically higher than the cost of a long arbitrage because it involves selling stocks short which is costly. Once the stocks are borrowed, the arbitrageur must sell them. The rules of the New York Stock Exchange require that short-sales take place only following an up-tick, i.e., an increase in the price of the stock. This makes arbitrage take time, so that the arbitrage opportunity may disappear while one is trying to create the short position. With a long arbitrage, this risk is minimal since program trades usually take little time to be executed.

Dividends have the effect of making it cheaper to buy the index today for delivery at a future date. To see this, suppose one uses the cash market to buy the index for delivery at a future date. If the present value of the dividends to be paid during the month is d, one can use these dividends to repay part of the loan before the end of the 30 day period. Consequently, in thirty days, one repays only (S–d) (1+R). Hence, if dividends are paid, one pays only S–d to establish the cash position and the futures price must be equal to (S–d) (1+R). Now, however, one must know d to arbitrage. While this is possible when the futures contract matures quickly, it is impossible when the futures contract matures in several months because dividends to accrue are not known now. One can try to guess what futures dividends are going to be. Suppose that, given our guess, $\underline{d}$, the futures price is too low and we implement a short arbitrage. If we overestimated the dividends to be paid, so that actual dividends are smaller than $\underline{d}$, it might well have been the case that, when we started our short arbitrage, the futures price was too high, so that we engaged in the wrong form of arbitrage. While uncertainty about dividends is small, it makes arbitrage risky. To be sure that one will make money, one wants the discrepancy between the actual and the theoretical futures prices to be large to provide some insurance against the adverse effect of mistakes in dividend forecasts.

When practicing index arbitrage, one can reduce transaction costs and the time it takes to establish a position by buying or selling a basket of stocks which has fewer stocks than the index, say 200, but mimics its performance. The problem with this approach, however, is that now one has what is called tracking risk. A portfolio of 200 different stocks can mimic the S&P500 index for some time and then start to drift away from the index, so that the value of the index at maturity is not perfectly related to the value of the S&P500 index at that time. While the tracking performance of the stock portfolio can be monitored continuously, using a smaller portfolio increases the risk of the arbitrage while decreasing its cost.

Although stock index arbitrage is difficult to undertake, program trades resulting from stock index arbitrages take place frequently and use large amounts of capital. Further, investors who hold an S&P500 index portfolio can take advantage of deviations between the theoretical and actual futures price by substituting futures contracts and bonds for stocks in their portfolio or inversely. That so many trades seem to be motivated by departures of the futures price from its theoretical value is puzzling since one expects these trades to eliminate arbitrage opportunities. However, this argument neglects the fact that the stock index futures market is extremely large so that there may just not be enough liquid capital available to keep the futures price at a value which implies no profitable arbitrage opportunities.

The hypothesis that not enough liquid capital has been available for stock index arbitrage seems to make sense of the existing empirical evidence. For instance, MacKinlay and Ramaswamy (1987) use minute by minute S&P500 index cash market and futures quotes to examine the frequency with which arbitrage opportunities arise. For 10 different contracts from June 1983 to December 1985, they compute the deviation between the theoretical and the actual futures price every 15 minutes during trading hours. They assumed that profitable arbitrage opportunities existed only if the theoretical futures price was at least 0.6% higher or lower than the actual price. In this way, they obtained 15918 observations. Among these observations, more than 4000 implied profitable arbitrage opportunities. For some contracts, arbitrage opportunities were available for what would appear to be long periods of time. For instance, the average time during which an arbitrage opportunity was in existence for the December 1984 contract was in excess of four hours. Since stock index arbitrageurs use computers to monitor futures and cash market prices continuously and can execute program trades in a very small amount of time, such results are unexpected.

Why has there not been enough capital available for arbitrage between the cash and the futures markets? One reason is that while arbitrage opportunities are numerous, they allow only for small profits. Another reason has to do with the fact that brokerage houses are best equipped to take advantage of arbitrage opportunities, since they face the lowest transaction costs. Brokerage houses are constrained by capital requirements, are typically borrower of funds, and may have had better investment opportunities. An indication that index arbitrage has not yielded high profits for brokerage houses is that they have offered to clients the opportunity to participate in stock index arbitrage activities. It may also have been the case that brokerage houses were reluctant to expand their program trading activities because the exchanges and the regulatory agencies viewed such activities with a great deal of suspicion.

5. A chain reaction

Is it possible for portfolio insurance and index arbitrage to interact so as to lead to a large fall in stock prices? Did such an interaction contribute to the fall in stock prices on October 19? In this section, we try to answer the first of these questions, while in the next section we address the second one.

A fall in the S&P500 index leads portfolio insurers to sell futures contracts. The futures sales by portfolio insurers decrease the price of stock index futures unless, at the same time, there is a matching increase in the demand for these futures contracts. A fall in futures prices, for given stock prices, leads to short arbitrage transactions whereby arbitrageurs sell stocks and buy futures. These short arbitrage transactions depress stock prices further, so that the index falls. At this point, investors who are not portfolio insurers may buy stocks because they find their prices attractive. However, suppose that sales by program traders are massive and the offsetting demand for stocks is small. In this case, stock prices fall sufficiently to trigger another wave of selling by portfolio insurers which brings another wave of program trades, and so on. A 'meltdown' of the market is taking place.

Since portfolio insurers and arbitrageurs sell futures and stocks with no regard for their 'intrinsic' value, sales by these program traders can make stock prices fall below that value. Hence, for markets to be efficient, there must be investors who are willing to buy large amounts of stocks quickly to offset the sales by program traders in a way that stock prices still reflect all available information. When portfolio insurance was small, this was not an issue. However, portfolio insurance has grown so much that it can no longer be ignored. When the thinking about efficient markets was developed, nobody thought that it would ever be the case that billions of dollars of stocks would be sold without regard for their underlying value and without any new information about that value. Efficient market theory requires that trades that do not reflect new information do not affect prices. This requires investors to take the other side of informationless trades at close to existing prices. The only change in prices that results from portfolio insurance transactions has to do with the changes in the compensation for bearing risk. Such a change takes place because, following portfolio insurance sales, other investors have to hold more stocks.

The problem with program trading is that, for it not to affect prices excessively, there must be investors that are willing to take offsetting positions within minutes of the program trade. While this is likely to happen for small trades, it is unlikely to occur when many large orders reach the market within a short time span. There are two reasons for this. First, the stock market is not organized in a way to make this possible[11]. Second, nobody knows why a particular trade is made, so that taking a counterpart to a program trade always has the risk that the trade was made by an investor who had valuable information or that the trade was the first one to be followed by many others[12]. We review these issues in turn.

On the New York Stock Exchange, the market for each stock is made by a specialist. A specialist has a monopoly. He is the only trader who sees the order book for a stock, i.e., all placed orders which are not market orders. This gives him a substantial informational advantage on other traders. The specialist must keep the market for the stocks he handles orderly by committing his own capital. Hence, the specialist bridges demand and supply gaps by smoothing out price changes. The tools of his trade are his quotes of a price at which he is willing to buy and another one at which he is willing to sell. However, the actions of the specialist are constrained by his capital. If a specialist buys stocks in a rapidly falling market, at some point, he will exhaust his capital and will also end up making large losses. It is risky for other traders to provide liquidity when the specialist appears unable or unwilling to absorb a large sell order without a sharp fall in price. If the specialist does not buy, it may be because he has information which leads him to believe that there are lots of sell limit orders at slightly lower prices. Hence, other traders could buy the stock but be unable to prevent a large fall. They would end up making large losses. The specialist system therefore leads to a lack of liquidity precisely when it is needed the most, since it cannot deal effectively with large sell orders for many stocks.

Suppose now that a program trade arrives on the floor, so that the specialist receives an extremely large sell order. Clearly, the specialist and the traders around him do not know why the trade is made. The trade could come from an arbitrageur, but it could also come from a portfolio manager who wants to decrease his stock position. It might be an isolated program trade, or might be followed by more. This makes it risky for anybody to take the opposite side. If it is an isolated trade, then there is little problem, since it is likely to have only a temporary effect on stock prices. Suppose however that the specialist and other traders absorb a large sell order believing it to be an isolated order only to discover that it is followed by many other orders. In this case, they will have a large long position in the stock that develops losses. This makes it risky for investors to offset the effect of program trades and means that these trades will have more impact on prices than if investors are all very small.

This analysis implies that one would expect program trades to have little impact when they are small and isolated. However, a cascade of informationless program trades can lead to a substantial fall in stock prices. Traders cannot be sure what these trades really imply. They also do not have the capital it takes to offset these trades should they believe that they are truly informationless. Traditionally, specialists have performed a useful role by providing liquidity on the stock market and keeping trades orderly. However, the system whereby stocks are traded was not designed to cope with extremely large short-term discrepancies between sell and buy orders for stocks. In futures markets, any trader can make a market. Competition among market makers on these markets leads to greater liquidity. Similarly, one would expect competition among market makers on stock markets to have positive effects on liquidity.

6. Was there a chain reaction on October 19?

Is it possible that the type of chain reaction discussed in the previous section contributed to the fall of stock prices on October 19? While program trades and portfolio insurance can explain at most part of the fall, there are some good reasons to believe that they played an important role on that day. Stocks had already fallen substantially during the two months prior to October 19. In addition, the crash followed a week during which both the S&P500 index and the Dow registered large decreases. The Dow was more than 200 points lower at the end of Friday October 16 than it had been the Friday before. During the same week, the S&P500 index fell by close to 10%.

Our previous discussion implies that, when stock prices have fallen substantially, portfolio insurers want to sell large amounts of futures contracts. This indeed happened on Friday October 16. At the start of trading on October 19, there were large sell orders for S&P500 futures contracts. The futures price for the contract maturing in December 1987 was much lower than the cash market price at the opening of trading, while it should have been slightly higher to satisfy the theoretical relationship. Throughout the day, the futures contracts kept selling at large discounts which at times exceeded 10% of the cash market value of the index. One obvious *ex post* interpretation of this phenomenon is that stock prices were lagging futures prices. However, on October 19, this interpretation was not as clear. Some portfolio insurers thought that futures prices were too cheap and stopped selling futures contracts. Consequently, fewer futures sales were made by portfolio insurers than would have been the case had the futures prices stayed closer to their theoretical values.

When market-wide price movements occur, they manifest themselves faster in futures prices. Just one price has to change on futures markets for a market-wide price movement to be noticed, while on the cash market, changes in the index result from the price changes of 500 stocks. Market making on futures markets is more competitive than on cash markets, which also helps making price quotes more timely. To some extent, therefore, the futures discounts on October 19 were artificial. In particular, during the morning, many stocks had delayed openings, so that quotes did not really correspond to market prices. Nevertheless, when futures prices are below their theoretical values, arbitrageurs want to sell stocks and buy futures contracts.

What was the extent of portfolio insurance activity and index arbitrage on October 19? Existing estimates all seem to indicate that portfolio insurance futures sales accounted for less than one fifth of futures trades, while stock sales by arbitrageurs represented much less than a fifth of stock trades. One of the most authoritative estimates was computed by a regulatory agency, the Commodities Futures Trading Commission (CFTC) using survey data[13]. They found that, on October 19, futures sales by institutional investors for portfolio insurance purposes represented between 12 and 24% of the total volume of trading. On that day, 162000 S&P500 index futures contracts changed hands. Hence, using a point close to the middle of the range of the CFTC estimate, it makes sense to think that portfolio insurers sold about 25000 contracts. Since a contract represents the promise to sell around $ 150000 worth of common stocks, a rough estimate is that portfolio insurers on that day contracted to sell 4 billion dollars worth of stocks. During the same day, 604 million shares changed hands on the NYSE. The CFTC estimates that sales of shares due to stock index arbitrage amounted to 9% of the trading volume of the NYSE on that day, which represents more than 50 million shares. Clearly, the CFTC estimates are incomplete, since they are based on surveys of a limited number of firms. Further, they do not include program trades made by indexers and portfolio insurers which seem to have been large. One major firm implementing portfolio insurance partly through stock trades is rumored to have sold more than 1 billion dollars of stocks in tranches of 100 million dollars during that day.

One attitude one can have towards these estimates is that the fraction of stock trades made by program traders was small on October 19. To make sense of these numbers, it is important to note that there had been previous days when the fraction of trades made by program traders was much larger without being accompanied by similar falls in stock prices. In particular, according to the CFTC, on September 11 and 12, seven brokerage firms made arbitrage-related stock sales that accounted for 17% of the trading volume on these days. Yet, the fall in stock prices during these days was small compared to the one taking place on October 19.

On October 19, because of the large trading volume, the DOT system was backed up in the afternoon and did not function normally, so that fewer program trades took place than otherwise. Given the large stock index futures prices discounts, massive program trades were expected that are likely to have made traders reluctant to buy stocks except at prices which made it unlikely that they would register losses if stock prices fell in step with futures prices. In that sense, the anticipation of large program trades may be as damaging as the actual execution of such trades. The fact that program trade sales represented a small fraction of total trading volume does not mean, therefore, that the existence of program trading played no significant role in the collapse of stock prices. Paradoxically, however, more stock index arbitrage would have increased the demand for futures contracts and hence reduced the fall in futures prices. There were extremely large order imbalances at times on October 19, since specialists had an unusually large inventory of stocks at the end of the day. While previously their largest amount of capital invested in stock holdings had been of the order of 500 million dollars, at the end of trading on Monday October 19, it was about 2 billion dollars. Undoubtedly, during that day, they were called to bridge temporal gaps between demand and supply of stocks more than ever before. They may have done so to the limit of their capacity. Is it really the case, however, that if their capacity to do so had been larger, that they would have been able to keep the markets more orderly? This seems unlikely, since keeping markets orderly when prices are falling quickly involves making large losses.

7. Concluding remarks

During the last ten years, the way trading decisions are made for stocks has changed dramatically under the influence of computerized programs that focus on prices of baskets of common stocks as opposed to individual common stocks. During that period of time, while technological improvements made it easier for orders to reach the markets quickly, almost nothing was done to match sell and buy orders more quickly. The specialist system has not been changed to adapt to new circumstances.

Many, in the wake of the crash, have suggested that limits be imposed on computerized trading. Some have wanted restrictions to be put on portfolio insurance. However, increased regulation of trading activities is more likely to make investments in common stocks less attractive. Because of the growing role of institutional investors, who control vast amounts of wealth, it is to be expected that trades in common stocks will still become bigger. Markets must therefore be organized so that they can accommodate large trades. This means that the specialist's role must be changed so that liquidity increases. Competition among market makers seems to be necessary. Also, more efforts ought to be made for electronic matching of trades. Since baskets of stocks play a role of such importance, if would be useful to introduce ways in which such baskets can be traded directly in the cash market.

Trades that are made without information about the 'intrinsic' value of stocks can wreak havoc in the markets because investors who take the counterpart of such trades have no guarantee that these trades are truly informationless and have to make a guess about the numbers of such trades likely to reach the market in the immediate future. Rather than banning such informationless trades, which cannot really be done anyway, ways should be found to make it possible for investors to execute such trades in the most transparent way. Increased opportunities for disclosure of trading strategies ahead of actual trades would therefore be beneficial since investors who take the counterpart to presumably informationless trades would be better informed about the nature of trades to be made and better able to respond to them.

Footnotes

[1] Commentators who have provided economic reasons for the fall in stock prices have generally focused on the following events that occurred immediately before October 19: (1) U.S. trade deficit data published on October 14 was much worse than expected; (2) House of Representative committees dealing with tax reform examined various proposals to impose confiscatory taxes on takeover activity during the week prior to October 19; (3) some banks increased their prime rate during the same week; (4) during the weekend, the U.S. attacked an Iranian base in the Persian Gulf; finally, (5) on Sunday, the Secretary of the Treasury made a statement to the effect that, because of increases in German interest rates, the stabilization of the dollar had failed.

[2] This definition is similar, but slightly more precise, than the one given by STOLL and WHALEY (1987).

[3] For a good discussion of modern portfolio theory and the concept of efficient markets, see ELTON and GRUBER (1986).

[4] See SCHLEIFER (1986).

[5] For a good description and analysis of stock index futures contracts, see MODEST and SUNDARESAN (1983).

[6] For more detailed presentations of portfolio insurance, see SCHWARTZ (1986) and RUBINSTEIN (1985).

[7] To implement portfolio insurance, one has to define the amount of wealth one wishes to insure as of a given date. If the investor always wants to have at least 10 million dollars, he cannot take risks in the short run and must start by investing all his wealth in a money market account. This is because any loss on his investment in common stocks would lead his wealth to fall below 10 million dollars.

[8] Formally, the threshold level at any point in time is equal to the present value at that time of 10 million dollars, using the money market interest rate as the discount rate.

[9] For a presentation of option pricing theory, see COX and RUBINSTEIN (1985).

[10] For a discussion of the practical aspects of stock index arbitrage, see STOLL and WHALEY (1987).

[11] For excellent papers which make this point, see MILLER and GROSSMAN (1987) and KLING (1987).

[12] This issue and its implications have been stressed in a remarkable paper by GROSSMAN (1987).

[13] See CFTC (1987).

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