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An Equilibrium Model of the Crash

1. Summary

Presented in this paper is a view of the market break on October 19, 1987 that fits much of what we know. I assume that investors' tastes changed before the crash, and that their beliefs changed both before and during the crash. Before the crash, investors' tastes became more and more flexible. (Their tastes are "flexible" if they become more risk tolerant with rising wealth.) Also before the crash, investors' estimates of mean reversion grew much more slowly than actual mean reversion, so that the bias in their estimates increased. ("Mean reversion" is a change in expected return that moves in the opposite direction from a change in the market level after that change occurs.) In this view, the major trigger for the crash was the sudden awareness that actual mean reversion was higher than investors thought. This realization caused them to reduce their expected return estimates for markets around the world. Prices fell until expected returns were high enough that investors were willing to hold the existing supplies of common stocks. The turmoil that followed led investors to cut back their willingness to hold stocks at given expected returns, which pulled down the market's equilibrium level even more.

2. What Happened[1]

On October 19, 1987, the U.S. stock market showed its largest percentage decline on record for a single day. Other world stock markets showed large declines, too. Volatility rose sharply and market maker spreads widened dramatically.

No sensational headline triggered the break. Some have pointed to the progress of legislation in creating tax barriers to takeovers, and indeed takeover candidates did decline more than other stocks on October 19. But

1. These events are reported in Brady, et al. (1988).

this may have been due to the crash itself. Any large decline will increase the chance that an announced or prospective takeover deal will fall through.[2]

There were a few very large sellers on October 19. It seems that all of them were using dynamic strategies that call for increasing stock holdings after the market goes up, and decreasing stock holdings after the market goes down. Mutual funds were using these strategies because their shareholders were using them. Some of these strategies are called "portfolio insurance." A number of large investors adopted portfolio insurance in the months and years before October 19. Many of them used futures contracts to change their market exposure. During the week of the 19th, futures prices went far below their theoretical values just when portfolio insurers wanted to sell. As a result, many managers dropped their portfolio insurance strategies on October 19th, or in the weeks that followed.[3]

3. *Dynamic Strategies*

A dynamic strategy is any strategy that changes exposure to the market after changes in the market level. We can use the term "portfolio insurance" to describe a strategy where buying and selling are consistently related to market moves. An investor who consistently buys after a market rise and sells after a market fall is "buying" portfolio insurance. The reverse activity is "selling" portfolio insurance.[4] Portfolio insurance sellers must exist to balance portfolio insurance buyers. The sellers may call themselves "value investors," or users of "dividend discount models," or "tactical asset allocators." But whatever name is used, someone must sell portfolio insurance if anyone is to buy it.

When we analyze the behavior of the market, we often speak of the "typical investor." We say, for example, that the market acts as if the typical investor were risk averse. A model with only one class of investor may be easier to understand than a model with two or more classes. But, the typical investor cannot use a dynamic strategy. In equilibrium, he maintains his position; he neither buys nor sells.

2. Shiller (1987) reports that most investors reacted more to the crash itself than to outside news.
3. "66% Drop in Portfolio Insurance." *Pensions and Investment Age*, January 25, 1988, p. 2.
4. Brennan and Schwartz (1988), Brignoli (1988), Kling (1988), Leland (1987), Rubinstein (1988), and Shiller (1988) discuss the relationship between portfolio insurance and the crash. Their analyses are similar to mine, except that they generally assume that one group of investors is optimizing, while another group is using dynamic strategies. In my analysis, all investors act alike.

4. Flexible Tastes

In a model with several classes of investors, differences in taste for risk will not cause any of them to use dynamic strategies. We need investors whose tastes for risk increase with wealth at different rates.[5] We will say that an investor whose taste for risk increases rapidly with wealth has more "flexible" tastes than one whose taste increases less rapidly. Investors with more flexible tastes will buy portfolio insurance, while those with less flexible tastes will sell portfolio insurance, all else equal.

Even though the typical investor is neither a buyer nor a seller of portfolio insurance, he can have more or less flexible tastes. A change in the typical investor's tastes will affect the market equilibrium.

5. Mean Reversion

The market's "mean reversion" is the change in the market's expected return following a change in the market level. It is measured by the negative of the percentage point change in expected return per percentage point return in the market. The change in the market level may cause the change in expected return, or the change in expected return may cause the change in the market level. Causation flows in both directions. The change in expected return associated with a change in the market need not be permanent. In fact, it is likely to disappear over time if there is no other change in the market.

I believe that there is normally considerable mean reversion in the market—but it's very hard to estimate how much.[6] And it is doubly hard to detect a change in the market's mean reversion by looking only at stock returns. A long series of stock returns tells us mostly about the average expected return and the average mean reversion over the period.

6. Equilibrium

In this model, the factor that moves to bring the market into equilibrium is mean reversion. The inputs to the model are investors' tastes for risk and

5. Leland (1980) shows that investors with rapidly increasing taste for risk will be more likely to use portfolio insurance than other investors.
6. Fama and French (1986) and Poterba and Summers (1987) try to estimate the average mean reversion in the market. French, Schwert, and Stambaugh (1987) estimate mean reversion indirectly: they relate expected return to volatility, and volatility is negatively related to past return. Merton (1980) shows how difficult it is to find the exact relation between expected return and volatility. A similar argument would show how difficult it is to find the exact relation between expected return and market level. Black (1986) discusses observable and unobservable variables in general.

their beliefs about mean reversion. All else equal, when investors have more flexible tastes, actual mean reversion will be greater. Likewise, when the downward bias in investors' beliefs about mean reversion is bigger, actual mean reversion will be greater.

In fact, we may have a lot of trouble distinguishing the effects of tastes and beliefs about the equilibrium. More flexible tastes and a larger bias in beliefs about mean reversion will have similar or identical effects on the equilibrium.

In this model, a small shift in tastes can have a large impact on actual mean reversion and volatility. Suppose that investors' beliefs about mean reversion remain constant, while their tastes for risk become more flexible. There will be no equilibrium. Actual mean reversion cannot be high enough to create equlibrium. What brings the market to equilibrium is the fact that beliefs about mean reversion must eventually change. As actual mean reversion rises, it will become clear that the bias in investors' beliefs about mean reversion is large. Thus a shift to more flexible tastes must give an increase in expected mean reversion, though there may still be a difference between actual and expected mean reversion.

7. The Crash

Stock prices declined sharply on a day when there were no major headlines. In the absence of big news in the ordinary sense, the price decline may have reflected changing interpretations of past news or changing tastes for risk. If investors had become more risk averse, their reaction would have made prices drop. The big sellers were using dynamic strategies, which suggests that the decline was at least accelerated by them. The increasing use of dynamic strategies was a signal that the typical investor's tastes or beliefs had been changing. To me, the most important fact in sorting through the story behind October 19 is the termination of portfolio insurance strategies after the crash. That suggests that the crash was not triggered solely by news plus the normal operation of dynamic strategies. Instead investors' beliefs, especially those of large investors using dynamic strategies, changed. Here is a story that I find plausible:

In the months leading up to October 19, investors' tastes were changing. They were becoming more flexible. This led to a moderate increase in volatility while the market was rising, whereas normally volatility falls when the market rises.[7] As investors' tastes became more flexible, the market's mean reversion increased. But the typical investor's expected mean reversion increased less. As the market rose during 1986 and 1987,

7. Black (1976) looks at the relation between market return and volatility change.

the true expected return on the market was falling, but investors thought it was falling less. This means the market rose more than it would have if they had seen the expected return clearly.

By the morning of October 19, investors had become aware of how the typical investor's tastes had changed. Some people had added up the assets used in portfolio insurance strategies and realized that lots of sell orders were due that day. The market's behavior during the day gave further clues to the typical investor's tastes. As investors became aware that the typical investor had more flexible tastes than they thought, they increased their estimates of the market's mean reversion and reduced their estimates of the market's expected return. This made them less willing to hold stocks. The market fell sharply.

As estimates of expected return fell for the U.S. market, they fell for other world markets. Equilibrium could be restored only after world markets fell. The decline increased estimates of expected return again, to the point where investors were willing to hold existing quantities of common stock.

What makes this story consistent with equilibrium, in my view, is that expected return and mean reversion are both unobservable. It is very hard to estimate either one of them. So investors can have incorrect beliefs about these factors without violating normal equilibrium conditions. The story is not consistent with rational expectations, but standard statistical tests won't show this, because investors can do those same tests. The clues that lead us to believe that investors' tastes had become more flexible could not have been derived from observing the path of the stock market alone.

Note that the equilibrium I describe is fragile.[8] A small change in tastes or beliefs gives a large change in mean reversion and volatility. This is consistent with the fact that only a small proportion of investors had adopted formal portfolio insurance strategies, and their trading played a minor role in the market activity of October 19.

8. Noise Trading

This can be viewed as a noise trading story.[9] Noise traders, as I define them, trade on noise as if it were news. An example would be buying stock on news that has already been discounted in the price. There is no general way of finding out whether a given piece of news has been discounted. That fact is unobservable, in the same sense that expected return or mean reversion are unobservable.

8. Kling (1988) has another model with fragile equilibria. Both models may have played a role in the crash. Leland (1987) describes a fragile equilibrium model related to mine.
9. It seems consistent with the story told by De Long, et al. (1987).

In this model, the noise is the bias in estimated mean reversion. Though we have direct evidence of a change in tastes, the market's volatility could just as well have been caused by a change in the bias. Probably, it was a mix of a change in tastes and a change in the bias.

9. The Psychological Factor

There is one more element that may play a part in an equilibrium model of the crash: psychology.

The level of the market is affected by the public's confidence in the market and the breadth of its participation. The market will be higher when participation is broad instead of narrow. When more people are willing to share in the risk of the market, each one bears less risk. This means that the expected return on the market can be lower and the market level higher.

We might call this element "liquidity." Liquidity often refers to the breadth of interest in a specific stock. When a stock has a liquid market, you can buy or sell a relatively large amount in a relatively short time without affecting the price too much. Here we are applying a similar concept to the market as a whole. When there is broad public participation in the stock market, the level of the market will be high, and a change in one group's desired holdings won't cause a big change in price; other groups will take up the slack. Such a market will be less volatile than one with narrow participation, all else equal.

The problem is that breadth of participation is affected by things that are hard to capture in a model. This is what I mean by "the psychological factor." People may avoid trading because they have little confidence in the market. They may feel that the market is "too volatile;" that it may close unexpectedly just when they want to trade; that it may be so congested at high volume times that trading will be hard; or that traders with computers have an unfair advantage.

Feelings that have no apparent factual basis can affect liquidity too. An increase in volatility can scare people off, even when it is due to a change in tastes or technology. Since the causes of volatility are not observable, even economists may decide that an increase is capricious, and they may urge investors to be cautious.

Whatever the original reasons for the crash, it frightened people. The sharp decline, the high volatility, the mispriced securities, and the congestion caused people to withdraw from the market. This led to a decline in the equilibrium level of the market that was greater than the decline a model would have figured—unless it accounted for the psychological factor.

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