

# 1

## Introduction

### 1.1 Introduction

The chapters brought together herein are related by the common theme that the very activity of trading conveys information that affects the outcome of the activity. Some of the chapters focus on this theme by explaining the informational role of prices (chapters 2–7), while others focus on the informational role of contracts (chapters 8 and 9). Rather than summarizing the chapters, I shall present my interpretation of the ideas in them in the light of recent developments in financial markets, and selected contributions to this literature since they were written. The reader will find a critical review and summary of many of the chapters in Kreps (1988).

### 1.2 The Informational Role of Prices

It is a common theme of most discussions of the competitive price system that prices convey information. Hayek (1945, p. 527) wrote, "We must look at the price system as ... a mechanism for communicating information if we want to understand its real function.... The most significant fact about this system is the economy of knowledge with which it operates, or how little the individual participants need to know in order to be able to take the right action ... by a kind of symbol, only the most essential information is passed on...." However, the models of competitive allocations developed by Marshall and Walras do show how people use the information contained in prices. No one learns anything from prices; people are merely constrained by prices. In their framework, prices determine the costs and benefits of various activities, and thus provide incentives to economize on the use of (or to increase the production of) relatively scarce resources. In some ways these models treat people like rats in a maze. Prices are like the walls that the rats are bumping into, which produce pain

and thus guide them in the right direction. The rats (presumably) do not get statistically useful information about the structure of the maze when they bump into a wall.

I have elaborated a model of economic equilibrium that is based upon the idea that prices have a dual role: They constrain behavior by affecting the costs or benefits of acts, but they also convey information about what will be the costs and benefits of the acts.

An example of such a model is one where an individual's demand for shares of a security depends upon his information about the future payoffs to holders of the security. Each individual knows that others have information about the security's future payoff. In the standard Walrasian model each consumer  $i$ , with information  $y_i$ , would have a demand function  $x_i(p; y_i)$ , and the Walrasian market clearing price would be a number  $p$  that depends on  $y = (y_1, y_2, \dots)$ , say,  $p(y)$ , such that the sum of the  $x_i$  equals the total stock of the security. If this price really clears the market, then there should be no desire to recontract away from the allocations associated with the price. This is what "market clearing" must mean. However, I shall now argue that there *will* be a desire to recontract after all the consumers learn that a particular price  $p(y)$  is "market clearing." Just consider a consumer, say Mr. 1, who observed a signal  $y_1$  that indicated that the payoff to the security is likely to be unusually high. His Walrasian demand would then specify that at each price  $p$ , a large amount of the security is desired. But suppose that other traders observe very bad news about the payoff to the security. This will cause the "market clearing" price to be very low. Consumer 1 will infer from the fact that a very low price "cleared the market" that his information is an outlier. He would thus revise his desired holdings downward after observing a very low "market clearing" price.

A trader is induced to adjust his "demand" function to reflect the fact that the price at which a market clears conveys information. Hence, his "demand" should be expressed as a function  $x_i(p; y_i, p(y))$ , which states his desired quantity of shares if the market clearing price process  $p(y)$  takes on a particular value  $p$ . It is a statement about how much is desired at prices that are market generated, rather than at arbitrary prices as in the Walrasian approach.

The Walrasian demand function is derived by finding the  $x$  that maximizes expected utility subject to each unit of  $x$  having a cost of  $p$ . The demand function specifies a desired level of holdings of the security at each particular price  $p$ , irrespective of whether or not  $p$  is a market clearing price. It is the outcome of a thought experiment in which the consumer imagines that he faces a particular price  $p$  chosen at random, and then decides how

much of the security to purchase given that it will cost  $p$ . The crucial deviation from this framework, which I have focused upon, assumes that the consumer faces a price that is a real offer of another person, or the outcome of a market process. Hence the fact that a particular price is offered is itself information about what someone else thinks about the future payoff<sup>1</sup> (see chapters 7 and 8).

The classical notion of a demand schedule should be contrasted with demand schedules that are actually used in real securities markets. The New York Stock Exchange sets the opening price (each morning), for each stock based upon a procedure that solicits demand schedules, and then determines the price where excess demand is zero. A common method by which demand is expressed is through the use of "limit orders." A single limit order (to buy shares) specifies, for example, that a particular quantity  $q(p)$  will be bought at a price of  $p$  or lower. The submission of a list of such orders will generate (by summation) a statement about how much of the security the person is willing to buy, say,  $Q(p)$ , for each price  $p$ . These orders state that if the market clearing price is  $p$ , then he will accept  $Q(p)$  shares. No statement is implied about what he would accept at a "price"  $p$  that was not a market clearing price. An extreme type of limit order is a "market order" for  $q$  shares that specifies that a person is willing to buy  $q$  shares at *any* price, as long as it is the market clearing price.<sup>2</sup> A person who submits these types of orders takes into account that the price at which his trade is executed will incorporate the information possessed by other traders.

Once the Walrasian notion of "demand" is modified to be an expression of desired holdings at prices that are "market clearing," it is easy to define a notion of "market clearing" in which there is no desire to recontract after observing that a particular price is the market clearing price. To do so, define a Rational Expectations (R.E.) price function  $p(y)$  such that, for each  $y$ , if  $p(y) = p$ , then the total market demand equals total supply given that each individual chooses his demand at  $p$  to maximize his expected utility conditioned on both his private information *and on the information contained in the event that  $p$  is a market clearing price* (i.e., that  $p(y) = p$ ).

The crucial characteristic of an R.E. equilibrium is that each consumer forms his demand as if he possessed far more than his own information. I have shown that  $p(y)$  can be a sufficient statistic for the information of all traders; i.e., if individuals form their demands cognizant of the fact that the prices at which their trades will be executed represent market clearing prices, then the final allocations are as if each person possessed *all* of the economy's information.

The R.E. model is capable of capturing the idea that prices *inform* individuals as well as *allocate* resources. It has been used to formalize the idea that if markets are complete, but information is dispersed throughout the economy, then there exists an R.E. equilibrium that yields allocations that could not be Pareto dominated by a central planner in possession of all the economy's information [see Grossman (1981) and chapter 2]. This is a much stronger theorem than the fundamental theorem of welfare economics for Walrasian equilibrium, and it summarizes the idea that prices convey information that has an impact on the resource allocation process.

The ability of prices to aggregate information perfectly is limited by the extent to which individuals must be able to earn a return for resources they expend on information collection. If prices fully aggregate information, why would any individual expend resources on information collection? If securities prices are perfectly efficient in the sense that *everyone* should hold the market portfolio no matter what the prices of individual securities may be, then who will collect the information to price individual securities appropriately? The answer to these questions is that the excess demand for a security varies for noninformational reasons (some of which are elaborated below) that obscure the informational movements in prices. The supply of traders with costly-to-collect information adjusts to make prices noisy signals for information to an extent necessary to reward, at the margin, information collection and processing [see chapter 5 and Admati (1985), Diamond and Verrecchia (1981), and Verrecchia (1982)].

### 1.3 Interpreting a Financial Panic

The enormous stock price volatility during October 1987 provides an interesting example of the informational role of prices, and the failure of the Walrasian notion of demand. It is a tautology that the value of a stock is determined by (1) information about expected future payouts (such as dividends), (2) uncertainty about the size of the payouts, (3) the opportunity cost of holding a risky asset (as represented, for example, by the return on a riskless asset), and (4) the premium that the marginal investor must be paid to bear risk rather than hold a relatively riskless asset. If the stock market falls, then economists tend to search for news items about the size of expected payouts. Often this search is fruitless.<sup>3</sup> It is now well established that the short term volatility of the stock market cannot be attributed to volatility in the expectation of future payouts.<sup>4</sup> Some have suggested that this is strong evidence against investor rationality, and point to the October 1987 episode as another example of irrational be-

havior. In contrast, I think that these events and the excessive volatility of stock prices relative to the volatility of expected payouts are evidence in favor of the type of “rationality” embodied in the R.E. approach outlined above, rather than evidence for irrationality. As I argue below, once the Walrasian notion of demand is eliminated, the volatility phenomena can be seen as an expression of a sophisticated trading strategy (used by relatively uninformed individuals) rather than irrationality.

The R.E. models of the stock market explored in chapters 2–5 assume that a stock exists for two dates, and that there is uncertainty and asymmetric information regarding the value of the stock’s payoff at the final date. At the first date traders receive information about the size of the final payoff. The information, denoted by  $y$  (as above), is one of the determinants of the price at date 1. It is assumed that there is another determinant of the price, namely, the excess demand of traders (henceforth called uninformed traders) who are trading for reasons unrelated to information about the date 2 payoff, and this factor is denoted by  $n$ .<sup>5</sup> Therefore the date 1 price,  $p$ , is some function of  $y$  and  $n$ , say,  $p(y, n)$ .

In this model, suppose a price  $p(y, n)$  is observed by a trader  $i$ , whose information  $y_i$  about the final payoff is, say, pessimistic. He does not know whether this price is high because uninformed traders have a high demand or because other informed traders (observing variables other than  $y_i$ ) have a high demand. Trader  $i$  wants to disentangle these two sources because the latter source of high demand indicates that there is very optimistic information about the final payoff, while the former source of high demand indicates nothing about the final payoff. Put differently, if most of the variability in  $p(y, n)$  is due to variability in  $y$  rather than in  $n$ , then a high value of  $p$  indicates that the final payoff on the stock is likely to be high. In this case, the trader will find it optimal to send a limit order to the market expressing a willingness to buy even at a price somewhat higher than average (since he knows that if his order is executed at a high price, then this will be a state of nature where the stock will have a final payoff higher than average). In contrast, if most of the variability in  $p(y, n)$  is due to variability in  $n$ , then a trader with pessimistic information would not be willing to buy the stock at a price higher than average since he knows that the price is probably high only because uninformed traders have a high excess demand for it. He might instead offer to sell the stock when its price is unusually high.

The above discussion is somewhat artificial since it posits a two-period world, and gives no hint as to why there is noninformation based trading. I believe that a major source of noninformation based trading derives from

the use of dynamic trading strategies that exist precisely because there are many trading periods. In much of the literature on multiperiod consumption and portfolio optimization, there is no clear focus on preferences that require systematic, nonlinear, portfolio rebalancing. Quite to the contrary, there is a strong focus on homothetic preferences, where it is optimal to invest a constant proportion of wealth in stocks [see, e.g., Merton (1971)]. This should be contrasted with preferences that exhibit a desire for “portfolio insurance” [see Leland (1980)]. An example of such preferences is given by an objective such as, Maximize end-of-horizon expected utility of wealth *subject to the constraint that wealth surely remains above a predetermined “floor.”*<sup>6</sup> If a floor is chosen such that it can be achieved if all the portfolio wealth is invested in a risk free asset at the initial date, then this objective is meaningful and is achieved as follows. When wealth is substantially above the floor, a large fraction of the portfolio is invested in risky assets (such as common stock) to expose the portfolio to the high expected returns offered by risky assets. However, if wealth falls toward the floor, then risky assets are replaced by risk free assets, so that the portfolio is invested exclusively in risk free assets as wealth reaches the floor. If the risky asset value follows a logarithmic Brownian motion, then the optimal strategy is to trade the asset dynamically so as to synthesize the payoff of a put option with a strike price given by the floor.

In 1987, prior to October, approximately \$70 billion worth of equity was managed by a dynamic trading strategy involving the synthesis of put options.<sup>7</sup> On October 19, 1987, approximately \$5 billion in equity was sold pursuant to the above strategy.<sup>8</sup> This may well be the “tip of the iceberg.” It is possible that a substantial number of investors have preferences that lead them to follow less formal “portfolio insurance” trading strategies. This strategy is a formalization of a classic risk management strategy that attempts to lock in capital gains by selling after each fall in the stock market, so that the exposure to downside risk is limited. Unfortunately, these types of strategies cause investors to respond to price moves in a highly correlated manner that can cause an enormous rise in volatility. It is obviously impossible for all investors to lock in capital gains by selling when the stock market reaches a particular level. Their attempts to do so will cause the price to jump down below that level. Dynamic trading strategies that cause an investor to want to hold less of a risky asset as the price falls, and more as it rises, obviously raise the sensitivity of the market clearing price to news about underlying asset payoffs. Chapter 6 discusses this in more detail and explains how the use of “strategies” (such as those designed to synthesize a put option), rather than the direct trading

of appropriate contingent claims, can raise volatility. In particular, securities that are redundant in the Black-Scholes (1973) model are actually not redundant because of the important informational role of real securities prices.

I believe that a major component of a financial panic is the desire of a large fraction of equity holders to reduce their equity exposure at the same time (after observing a fall in price). They do so not because they are informed about future payoffs, but simply to limit their exposure to risk. It should be noted that on October 19, 1987, over 600 million shares were traded on the New York Stock Exchange, and this was almost three times the previous record high volume day. This suggests that a primary component of a panic is not only the revaluation of the worth of equities but a desire to reallocate substantially the holding of risky assets in the economy.

How do these remarks relate to Rational Expectations? As noted earlier, an investor with private information looks to price for a summary of the information of other traders. At the instant at which a large number of sell orders arrive at the market, a trader does not know whether this represents strongly negative information about future payoffs or merely the fact that some equity holders have become more risk averse (say, through the implementation of a dynamic trading strategy) after receiving minor bad news about payoffs.<sup>9</sup> The pessimistic component of the information in the observed selling event tends to lower the value that an investor who observes no other negative information puts on equity payoffs, because a large current sell imbalance at the last price is always partially a signal that some traders currently possess information indicating that the last price overvalued the stocks' payoffs. Thus, the fact that investors extract information from price makes a rational expectations price  $p(y, n)$  much more sensitive to  $n$  (i.e., to preference related shifts in the demand for equities) than occurs in the standard Walrasian model.

A panic is therefore the compounding of two phenomena. First, even if all investors have the same information, then the use of "portfolio insurance" types of trading strategies will greatly increase the sensitivity of the market clearing price to small amounts of news when that price is near the desired "floor" of investors. Second, if investors do not all share the same information, then even an investor who does not have "portfolio insurance" preferences will have a demand function very sensitive to small price movements when he rationally attempts to infer information from price movements. Ex-post, we label an event a "panic" when a group of investors has shifted out of equities for noninformational reasons, and this shift has caused substantial numbers of other investors to shift out of

equities because they think that the price has moved for informational reasons. Of course, at the time the “panic” occurred, the uninformed investors actually used their rational expectations to infer that the price move had its normal informational component; they did not know that it actually represented a shift in risk aversion by some other group in the economy.

## Notes

1. See the following for discussions of models where the assumption of perfect competition is dropped but the same type of idea is used: Kyle (1984), Milgrom (1981), Milgrom and Stokey (1982).

2. What would happen if *everyone* submitted “market orders”? The market clearing price would be indeterminate. Indeed, the R.E. models where price fully aggregates information [e.g., Grossman (1976) and chapters 2 and 3] often have the property that demand (evaluated at the market clearing price) is independent of the realization of  $p(y)$ . As Hellwig (1980) has pointed out, such models should be considered as the limiting case of models where price does not fully aggregate information, and thus where each person’s demand varies with price and his private information.

3. See, e.g., Roll (1986).

4. See, e.g., Shiller (1987). Though some writers have criticized Shiller’s assumptions, e.g., Marsh and Merton (1986); no one has succeeded in explaining short term stock price variability.

5. These traders are (with unjust condescension) called “noise” traders by Kyle (1985) and Black (1986).

6. See Rubinstein (1985).

7. See Leland and Rubinstein (1988, p. 46).

8. See Gammill and Marsh (1988, p. 29). To put these numbers in perspective, note that a New York Stock Exchange average trading volume of 175 million shares, and an average price per share of \$35, gives a dollar volume of \$6.125 billion.

9. They have become more risk averse, not because their preferences have shifted, but because at values of wealth close to their desired “floor” on wealth, their indirect utility function of wealth exhibits higher risk aversion.

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