The Impact of Derivatives on Cash Markets: What Have We Learned?

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October 27, 1999
Revised: February 3, 2000

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Abstract

This paper summarizes the theoretical and empirical research on how the introduction of derivative securities affects the underlying market. A wide array of theoretical approaches has been applied to the question of how speculative trading, the introduction of futures, or the introduction of options might affect the stability, liquidity and price informativeness of asset markets. In most cases, the resulting models predict that speculative trading and derivative markets stabilize the underlying market under certain restrictive conditions, but in general the predictions can go either way, depending on parameter values. The empirical evidence suggests that the introduction of derivatives does not destabilize the underlying market—either there is no effect or there is a decline in volatility—and that the introduction of derivatives tends to improve the liquidity and informativeness of markets.

1 Introduction

Writing in 1688, Joseph de la Vega describes various strategies used by a syndicate of bear traders to manipulate prices in the market for Dutch East India Shares at the Amsterdam Exchange. Some of these tricks involved trading options. For example, de la Vega reports that one strategy employed by the bears was to...

> ... enter as many put contracts as possible, until the receivers of premiums [assumed to be bulls] do not dare buy more stock [on their own initiative]. [Their hands will be largely tied] because they are already obliged to take the stock [covered by the put premiums, if requested to do so]. Therefore the speculation for the decline has free course and is an almost sure success.

Roger Lowenstein, writing in the Wall Street Journal, November 6, 1997, comments:

> When the Nobel Prize was awarded to the inventors of the formula for pricing stock options, the formula's practical utility was widely noted. Last Monday, when the market cracked, we saw how practical indeed.
>
> To start at the conclusion, the vast growth in the market for options unleashed tremendous selling pressure in the stock market and accentuated Monday's decline. Previously, the very same options had encouraged stock prices to rise above the level justified by business valuations.

The popular assertion that derivative securities tend to destabilize the underlying asset markets has persisted for more than three centuries. To what extent is this notion theoretically justified? To what extent has it been supported by empirical evidence? This topic has been the focus of much academic scrutiny. The purpose of the present article is to provide a comprehensive review of the theoretical and empirical literature on this issue, and more generally on the relationships between underlying and derivative markets.[1]

The debate on the effects of derivative trading is closely related to the more fundamental issue of the extent to which speculative trading in general influences market prices. Accordingly, we will begin by reviewing the theoretical literature on speculation and price stability. Much of the early literature in this area focused on the role of speculators in smoothing out seasonal price fluctuations in commodity markets. As we shall see, traditional models of this flavor generally conclude that under certain restrictive assumptions, speculative trading tends to stabilize prices. When these assumptions are violated, it is often found that speculative trading can stabilize or destabilize prices, depending on parameter values.

Next, we will discuss several models that explicitly incorporate forward contracting. Again, most of these models were developed in the context of a market for storable commodities. And again, most come to the ambiguous conclusion that under sufficiently restrictive assumptions, the introduction of futures stabilizes the cash market, but in general the result can go either way depending on parameter values.

Turning to the introduction of option contracts, the non-linear payoff structure of options adds an interesting dimension to the problem, that has inspired much insightful theoretical research. Still, no real consensus has emerged as to whether we should expect options to stabilize or destabilize the underlying market. As in the case for the introduction of futures, the range of theoretical possibilities is sufficiently broad as to accommodate nearly any conclusion, depending on what assumptions are made. Nevertheless, it can be quite instructive to examine this literature carefully, for in doing so we may gain valuable insights to help us gain a richer appreciation of the complicated relationships between derivative and primary assets.

The empirical literature on this issue is vast. Studies have been performed on data from commodity, fixed-income, individual stock, stock-index, and currency futures, as well as individual

[1] For earlier surveys related to this topic, see Damodaran and Subrahmanyam (1992), Hodges (1992) and Sutcliffe (1997).

stock stock-index, and currency options, including markets in the United States and in many other nations. Researchers have studied the impact of derivatives by comparing underlying market characteristics before and after introduction dates, by studying the behavior of the underlying market around the expiration dates of the derivative contracts, and by examining lead-lag relationships between cash and derivative markets.

As we shall see, most of the empirical evidence suggests that derivative markets do not increase volatility in cash markets, but do tend to make spot markets more liquid, and more informationally efficient. There is very little evidence from any market that volatility increases with the introduction of derivatives.

2 Theory

A variety of theoretical arguments have been advanced over the years to explain why speculative trading in general, or the existence of derivatives markets in particular, might affect the volatility of the underlying asset market. Let us first summarize the long-running debate on whether speculative trading stabilizes prices. Next we will discuss several theoretical models that specifically address the effects of futures markets. After that, we will review models that deal specifically with the introduction of options.

2.1 Effects of Speculation

Adam Smith (1776) observed that speculators help prevent extreme shortages (and by implication, extreme price movements) by buying and storing grain in periods when they forecast a shortage.[2] John Stuart Mill (1871) elaborated on this idea, explicitly observing that speculators play an important role in stabilizing prices.[3] Because they buy when prices are low and sell when prices are high, speculators improve the intertemporal allocation of resources and have a dampening effect on seasonal price fluctuations. Similarly, Mill observed, local price fluctuations are reduced as

[2] Book IV, Chapter 5.
[3] Book IV, Chapter II, sections 4-5.

speculators geographically reallocate goods, buying in regions where prices are low and selling them where prices are high. Mill recognized the possibility that speculators may attempt to manipulate prices, but argued that profitable manipulation should not be possible. He argued that speculation will only be profitable when speculators, as a group, buy low and sell high. The basic notion here is that destabilizing speculation cannot persist because it is not profitable. This argument was resurrected by Friedman (1953), who stated that "people who argue that speculation is generally destabilizing seldom realize that this is largely equivalent to saying that speculators lose money."

Various authors over the years have attempted to demonstrate the fallacy of this proposition. As noted by Kaldor (1939), it is possible that speculators as a group may indeed lose money. Conceivably, the population of speculators may be composed of two groups, one of seasoned traders who, on average, make money and one a "floating population" of novices, most of whom lose money and are driven out of the market.

Friedman's (1953) implicit suggestion that profitable speculation ought to stabilize prices, later dubbed "Friedman's proposition," inspired a new wave of attempts to demonstrate the contrary—that speculative trading can simultaneously be profitable and destabilize markets. This line of research soon transformed into an formal investigation of the conditions under which Friedman's proposition holds. This literature includes papers by Stein (1961), Baumol (1957), Telser (1959), Kemp (1963), Farrell (1966), Schimmler (1973), Jesse and Radcliffe (1981) and Hart and Kreps (1986).

Stein (1961) suggests that it is possible for foreign exchange traders to make positive profits and destabilize exchange rates by attacking a currency. In spirit, this argument is similar to that of Kaldor (1939). Both arguments rely on a group of unprofitable speculators to offset the gains of the profitable ones. In Kaldor's example, old speculators make profits at the expense of new speculators. In Stein's example, speculators make profits at the expense of the monetary authority.

An early attempt to construct a formal model in which speculative trading is destabilizing was made by Baumol (1957). In this model, prices in the absence of speculators have predictable seasonal fluctuations. When speculators enter, they accelerate price movements by buying when prices are rising, and selling while prices are falling. The model captures the popular intuition that speculators are momentum traders. By modern standards, Baumol's (1957) model seems awkward—there is no random component to prices, the speculative demand function is not derived from utility maximization, but is specified ad hoc, and stability is measured by the frequency and amplitude of oscillations of sinusoidal functions, not by variance. Moreover, as Telser (1959) pointed out, Baumol's model is subject to a logical pitfall explicitly addressed by Mill (1871). In particular, the speculators in Baumol's model generate only paper profits; it is not clear that they could ever realize these profits inasmuch as the trading activity necessary to unwind the position will affect prices.

In response to Baumol (1957), Telser (1959) constructed a model with a profit-maximizing monopolist speculator. Roughly speaking, prices are mean reverting and the speculator, having a noisy estimate of the long-run mean, optimally trades on this information. In this model, speculation unambiguously stabilizes prices, supporting the view espoused by Mill (1871) and Friedman (1953).

Kemp (1963) supplied another counterexample, in which supply is inelastic and the asset is a Giffen good, having a demand curve that slopes upward over a range of prices. Due to the perverse nature of the demand for the good, there are multiple equilibrium prices. In this framework, Kemp (1963) is able to construct an example where a relatively small change in speculative demand can cause a jump between equilibria, and this gives rise to the possibility of profitable speculation. For a linear excess demand function, however, Kemp showed that positive speculative profits imply price stabilization.

Farrell (1966) investigates this proposition further, showing that if consumer demand is intertemporally independent, as indeed it is in the models of Telser (1959) and Kemp (1963), a linear excess demand function is necessary and sufficient for Friedman's proposition to hold. In other words, Farrell (1966) demonstrated that if demand is intertemporally independent and linear, then whenever speculators are making profits, they are stabilizing prices. In addition, speculators may stabilize prices even if they are making losses, as long as their losses are not too large. However, if demand is not linear, then profitable speculation may be destabilizing. Schimmler (1973) showed that this result does not in fact require the independence assumption. In this framework, it turns out that Friedman's proposition is equivalent to the proposition that consumer demand is linear. Jesse and Radcliffe (1981) show that the same result holds when consumer demand has a random component and speculators are risk-neutral.

Hart and Kreps (1986) consider a market where supply is constant and demand is subject to large but rare shocks. Each period, a noisy signal of next period's demand is observed—the signal is always positive prior to a shock but a false positive is frequently observed. In the absence of speculative trading, prices are stable until the shock actually occurs. When speculators are added to this market, then the price increases in response to a positive signal as speculators buy the underlying asset in anticipation of a possible demand shock. If the signal turns out to be false, then the price in the subsequent period is depressed as speculators dump their shares. Thus, the presence of speculators increases price fluctuations, except in the rare case when the event actually occurs.

In the various models discussed above, speculators trade on the basis of legitimate information about future demand. Other authors have addressed the possibility that speculators can destabilize prices through pure price manipulation. Among others, Hart (1977), Allen and Gale (1992), Allen and Gorton (1992), and Jarrow (1992) have investigated the conditions under which profitable manipulation is possible.

2.2 Futures Markets

According to the traditional economic paradigm, prices are determined by the interaction of supply and demand functions, and prices change in response to shifts in these functions. In the absence of storage, supply is derived from the producers' cost function, and demand is determined by utility-maximizing consumers. If the product is storable, then the demand function for a given period may be augmented by speculative demand by investors who anticipate price increases. Likewise, supply is increased as speculators sell their inventories.

To the extent that changes in production costs and consumer demand are predictable, the intertemporal reallocation made possible by storage generates trading activity that more properly may be viewed as inventory management, as opposed to speculation. If there are random shocks, however, then the act of buying and storing an asset is inherently risky. In the absence of a futures market, we would presume that risk averse speculators will hold inventories only if the expected return from doing so is sufficient to compensate them for bearing this risk. Thus, in equilibrium, the amount of intertemporal price smoothing will depend on the extent to which the commodity is storable, the relative magnitude of the predictable and random components of supply and demand changes, and the speculators' level of risk aversion.

When forwards or futures are introduced, a dealer can buy commodities when prices are low, and immediately lock in a selling price using a forward. To the extent that carrying costs are predictable, price smoothing through storage becomes an arbitrage activity. If agents are risk averse, this should lead to increased intertemporal price smoothing.

Futures markets may also influence spot prices if they have an effect on the behavior of producers. Since futures markets allow producers to hedge price risk, the existence of futures may affect a producer's decision of what to produce, how much to produce, and what production techniques to use. In addition, the futures price may contain information about anticipated demand that can feed back into production decisions. As we shall see in the following sections, different authors have modeled various dimensions of this complicated problem, not only in the traditional Marshallian paradigm, but also in a rational expectations equilibrium framework, and in a general equilibrium context.

2.2.1 Traditional Approach

Various aspects of the relationship between futures markets, storage, and production are modeled by Peck (1976), Turnovsky (1979, 1983), Kawai (1983), Sarris (1984), Chari, Jagannathan and Jones (1990), and Chari and Jagannathan (1990).

In Peck's (1976) model, neither demand nor supply are random, and price movements are governed by an adaptive expectations model for the various agents. The result is that when storage decisions are made on the basis of the futures price, futures have a stabilizing effect on prices. But when both production and storage decisions use the information in the futures price, the effect depends on the parameter values. In Turnovsky's (1979) model, both supply and demand have stochastic components, and expectations about the future price are adaptive in the absence of a futures market, but rational when futures are introduced. Unlike Peck (1976), Turnovsky (1979) finds that futures markets may be destabilizing in the presence of storage alone, albeit for parameter values he considers to be implausible.

Kawai (1983) formulates a model with rational expectations and three stochastic components: consumer demand, inventory demand, and supply. The resulting equilibrium is too complicated to analyze in general, but with additional restrictions, the model shows that futures are more likely to stabilize prices when the variance of consumer demand is high and the variance of inventory demand is low, with variance of supply having an ambiguous effect. Again, the net effect depends on the parameter values. Turnovsky (1983) comes to a similar conclusion, except that in his model, the inventory demand effect is also ambiguous. In Turnovsky's (1983) model, however, futures have a net stabilizing effect for a wide range of parameter values, as shown through simulations performed by Turnovsky and Campbell (1985). Another model worthy of note is that of Sarris (1984). This model focuses on the interaction between speculators in the cash and futures markets. In his model, futures markets unambiguously stabilize cash markets.

The models of Peck (1976), Kawai (1983) and Turnovsky (1983) predict that futures are unambiguously stabilizing in the absence of storage and production uncertainty. Chari, Jagannathan and Jones (1990), however, present a model where this is not the case. In their model, if supply and demand are linear, the demand shock is additive, and producers have constant absolute risk aversion, then the introduction of futures stabilizes prices. However, the authors use counterexamples to demonstrate that when these conditions are violated, the introduction of futures may destabilize prices. More details of this model are discussed in a second paper, by Chari and Jagannathan (1990).

Chari and Jagannathan (1990) also suggest another way in which futures markets may influence spot markets. Recall that the introduction of futures may affect current production levels, by allowing producers to respond to new information about anticipated demand shocks. Chari and Jagannathan (1990) point out that this may affect tomorrow's spot price, not only through storage activity, but also through intertemporal dependence in the production function. For example, suppose we have a non-storable good, for which the marginal cost function next year is an increasing function of the quantity produced this year. And suppose that demand is low this year but, by observing the futures price, producers learn that demand will be unusually high next year. Then producers may find it optimal to cut back on production this year in order to lower production costs for the following year. In this model, futures markets may stabilize or destabilize prices, with stabilization more likely when demand is inelastic and when supply is elastic. Even when prices are destabilized, however, in this model the introduction of futures improves welfare for all parties.

2.2.2 Rational Expectations Equilibrium Approach

Grossman (1977), Danthine (1978) and Bray (1981) develop fully-revealing rational expectations equilibrium models of futures markets. In these models, speculators observe a noisy signal of next period's market demand, and trade in the futures market. As usual in rational expectations equilibrium models, all sources of uncertainty are assumed to be normally distributed, and all traders have utility functions characterized by constant absolute risk aversion. The rational expectations equilibrium is fully revealing, meaning that all of the relevant information observed by speculators is impounded into market prices.

Danthine (1978) addresses the issue of price stability in this context. Because producers observe the futures price in making their production decisions, the equilibrium spot price will reflect the speculators' signals, including both the true information and the noise. The futures market in this model has a stabilizing influence insofar as the future price conveys information to farmers that help them adjust production to demand shocks. On the other hand, noise in the speculators' signals has an offsetting, destabilizing effect. This model is sometimes quoted as demonstrating that futures markets will stabilize prices. In fact, whether the futures market increases or decreases volatility depends on parameter values. Futures markets will stabilize spot markets more when the number of speculators is large, their signals are precise, and the variance of demand is high. If the speculators have poor information and there are not many demand fluctuations to stabilize, then futures markets can destabilize prices in this model.

Demers and Demers (1989) construct a partially-revealing rational expectations equilibrium model of the futures market. In their model, there are two sources of uncertainty, production risk and demand risk. Information is costly, and producers have a comparative advantage at collecting information on production uncertainty, while speculators specialize in collecting information about demand uncertainty. When information collection is costly, speculators will not pay to acquire poor information. In this model, futures markets unambiguously stabilize prices, unlike Danthine's (1978) model, where poorly informed speculators can destabilize prices. The Demers and Demers (1989) model also illustrates another interesting possibility. Information about production is more useful to producers when used in conjunction with information about demand. Thus, it is possible for producers, in the absence of futures markets, to rationally refrain from gathering costly information about production, but to begin gathering that information once the futures market opens.

2.2.3 General Equilibrium Approach

Weller and Yano (1987) analyze the effect of futures markets on spot prices in a general equilibrium model of an exchange economy with two agents, two goods, two periods and two states of nature. In the second period, agent one receives a random endowment of good one, and agent two receives a non-random endowment of good two. The authors examine equilibrium both with and without forward contracting in period one. The stabilization question is addressed by comparing the variability of the time-two equilibrium price around its time-one expected value. In this context, it is shown that the introduction of a futures market has two effects. First, in the absence of a futures market, the two agents may have a different marginal rate of substitution between wealth in state one and wealth in state two. The introduction of a futures contract completes the market, allowing state prices to equilibrate across investors, and this, in general, leads to a more stable spot price. When the agents are risk-neutral, the period two spot price is perfectly predictable in period one. Second, if one or both of the agents are risk averse, then the futures market plays a role in allocating risk. In this case, the extent to which, futures markets stabilize or destabilize the spot price depends on the agents' preferences with respect to the two goods, and their level of risk aversion. The more risk averse the agents, the more important the risk transfer feature of the futures market becomes. If the agents are highly risk averse, and if the agent that produces the risk-free good generally prefers to consume the risky good, while the agent that produces the risky good prefers to consume the risk-free good, then the introduction of futures may increase the amount of uncertainty in spot prices.

2.2.4 Other Models

Stein (1987) presents another information-based model, in which the increased speculation associated with the opening of a futures market may lead to price destabilization and decreased welfare. In this model, there are two periods, and the supply of the asset is subject to both permanent and transitory shocks. There are two types of traders, hedgers and speculators. The hedgers have an initial inventory position, can store the underlying asset costlessly, and observe the transitory shock. The speculators have no inventory, but observe information about the permanent shock. In order to assess the impact of futures markets, Stein compares the equilibrium with and without speculators. He finds two offsetting effects. As in other models, the influx of new traders has a stabilizing, welfare-increasing effect through improved risk sharing. However, there is also an information externality arising from the fact that the speculators may have new information unavailable to the hedgers. In the special case where the speculators have perfect information about the permanent supply shock, the market price becomes perfectly informative, and the introduction of futures markets stabilizes prices. Likewise, when speculators have no information, futures markets also stabilize prices. But when speculators have a noisy signal, the hedgers react to the possibility that the speculators may have additional information. Because the hedgers react, in part, to noise, there is a destabilizing effect. For some parameter values, this destabilizing effect outweighs the risk sharing benefits, prices are destabilized and welfare is reduced.

Subrahmanyam (1991) presents an information-based model specific to "basket trading," which may be applied to stock index futures. This model is based on that of Kyle (1985), in which informed and uninformed traders submit orders to a competitive market maker. In Kyle's model, the equilibrium pricing schedule is directly related to the level of informed trading—the greater the level of informed trading, the greater is the adverse selection problem faced by the market maker, the more sensitive will be the stock price to order flow, and, from the point of view of uninformed traders, the less liquid will be the market. Subrahmanyam (1991) extends Kyle's framework to allow simultaneous trading in individual stocks and baskets of stocks. Under the assumption that most informed trading is based on firm-specific information, it is shown that uninformed investors can reduce the deleterious effects of informed trading by trading the basket, rather than the individual stocks. Thus, this model predicts that with the introduction of stock index futures, uninformed investors will migrate from the stock market to the index futures market. This would leave a greater concentration of informed traders and poorer liquidity in the stock market.

Newbery (1987) analyzes another channel through which futures markets may increase spot price volatility. Since futures markets allow producers to hedge production risk, they encourage producers to adopt more risky production technologies. Newbery illustrates this concept using a simple model where the producer may choose between two production modes, one in which output is certain and one in which output is uncertain but has a higher mean. In the absence of futures markets, producers, being risk averse, optimally select the safe production mode. When a futures market is introduced, producers move to the risky production mode and transfer the risk to speculators. The net effect is an increase in the variance of spot prices. It should be noted that even though futures markets destabilize prices in this model, welfare increases with futures introduction, both for the producers and the speculators.

A similar intuition is modeled by Artus (1990). He constructs a simple model of the equilibrium interaction between producers and speculators, both with and without futures markets. In the basic model, futures markets stabilize prices, but the addition of production uncertainty may have a destabilizing effect, as in the model of Newberry (1987). Artus (1990) also examines other extensions of his basic model under which the introduction of futures may destabilize prices. For example, destabilization may occur when market imperfections prevent arbitrageurs from stabilizing prices or when market participants have false expectations and learning is slow. In a subsequent paper, Artus (1996) examines the "market imperfections" model in more detail. Here, it is shown that whether futures markets stabilize or destabilize the underlying spot market may depend critically on the nature of the financial constraints faced by market participants. In particular, Artus (1996) considers two models. In one model, there are wealthy and poor investors, where poor investors face a binding wealth constraint on their desired investment position. In the second model, the two groups of traders have different access to credit. In both cases, futures markets tend to have a stabilizing effect, but the effect of risk aversion and asymmetric information is different in the two models. In the first model, futures markets stabilize spot markets less when market participants are risk averse, while in the second model, the opposite result is true. In both cases asymmetric information causes futures markets to be less stabilizing. In the second model, but not the first, asymmetric information can, for some parameter values, reverse the result, causing futures to destabilize the spot market.

Zhou (1998) analyzes the interaction between producers, consumers and speculators in a continuous-time equilibrium model. He derives equilibrium conditions in an economy where producers may face liquidity constraints and consumers' relative risk aversion is a decreasing function of the level of consumption. In this model, the effect of speculation is to induce a positive relationship between volatility and the futures price level. In particular, speculation makes futures prices more volatile in states of the world were futures prices are high, but less volatile in states where futures prices are low. Moreover, when prices and volatility are high, liquidity constraints will dampen volatility, but when prices are volatility are low, liquidity constraints lead to increased volatility. Finally, in Zhou's (1998) model, the effect of agricultural price subsidies is to dampen volatility, especially in states when futures prices are low.

The Brady Commission (1988), in their analysis of the 1987 market crash, suggested that stock index futures markets may have contributed to the crash through yet another channel. Although they develop no formal model, they suggest that

> ... the market's break was exacerbated by the failure of institutions employing portfolio insurance strategies to understand that the markets in which the various instruments trade are economically linked into one equity market. Portfolio insurance theory assumes that it would be infeasible to sell huge volumes of stock on the exchange in short periods of time with only a small price impact. These institutions came to believe that the futures market offered a separate haven of liquidity sufficient to allow them to liquidate huge positions over short periods of time with minimal price displacement.

2.2.5 Market Manipulation

If the underlying asset market is not perfectly competitive, the introduction of futures may induce large producers to manipulate the cash prices through their production and storage decisions. Newbery (1984) analyzes a futures market on a commodity that is produced by one dominant producer with market power and multiple "fringe" producers. A number of interesting results may arise. The dominant producer may find it beneficial to deliberately destabilize prices by randomizing production or storage decisions, in order to impose costs on smaller competitors. This is particularly likely if the large producer is less risk averse than the small producers. The dominant producer in this model will generally be harmed by the introduction of a futures market. It should be noted that in this type of model, various different results may obtain, depending on what assumptions are made about risk aversion, and about the extent to which the producers have information about each others' production plans. For further analysis of this issue, see Anderson and Sundaresan (1984).

Other authors have advanced explicit models of market manipulation involving derivative markets. Most of these models find that under certain assumptions, profitable manipulation is possible. For a review of this literature, see Pirrong (1995). Papers in this literature include, among others, Kyle (1984), Kumar and Seppi (1992), Jarrow (1994), Pirrong (1995), and Cooper and Donaldson (1998).

2.3 Option Markets

To a large extent, the results described above on the introduction of futures markets may be extended to the introduction of options. If both calls and puts are introduced, then synthetic forward positions may be created, and in this sense listing options is like listing futures.

There may be further effects of option introduction, however, arising from the special role of options in completing the market, as discussed by Ross (1976). To illustrate this concept, suppose that today the stock index is at 100, and tomorrow there are three possible states of the world, in which the stock index goes to 99, 100, or 101. Two investments are available, an index fund, which, using vector notation, will be worth [99 100 101] and a risk-free bond, which will be worth [100 100 100]. There are various payoff profiles that can be achieved using portfolios of the bond and the index fund, but there are some that can never be achieved. For example, one cannot create a portfolio with a payoff vector [1 0 0].

Suppose we introduce a call option with strike price of 100. This has payoffs [0 0 1]. Now, the payoff vectors of the available securities span the entire state space—any payoff function may be achieved using a portfolio of the bond, the index fund and the option. For example, to achieve the payoff [1 0 0], one would buy one unit of the bond, short the index fund, and buy one call option. If there are four states of the world, then the market can be completed by introducing two call options with different strike prices. If there are n states of the world, the market can be completed by adding $n - 2$ options. Alternatively, the market could be completed by adding put options or Arrow-Debreu securities.

Although moving from an incomplete market to a complete market is welfare-enhancing (in the sense that it represents a Pareto improvement), Hart (1975) demonstrated that the same cannot be said for a market expansion that fails to complete the market.[4] As illustrated by Hodges (1992), the volatility of the underlying asset may increase or decrease with the addition of new derivative securities that complete the market.

If an option can be synthesized using a dynamic trading strategy in the stock and cash, then the option would appear to be redundant. One might suspect that the introduction of a redundant option ought to have no impact on the underlying stock. Surprisingly, this is not necessarily the case. As argued by Grossman (1988), the price of a traded option can convey information that would otherwise be unobservable in an economy where the option can only be replicated. An option that appears redundant, in the sense that it can by dynamically replicated, might not actually be redundant, since introducing it might convey information that will change state prices.

[4]Hakansson (1982) explores the relationship between market changes and welfare in more detail.

Grossman (1988) illustrates this point using a simple model where a random number of traders elect to follow a dynamic replicating strategy. The volatility of the stock price depends on the number of traders intending to follow the dynamic strategy. In the absence of a traded put option, the number of traders following the dynamic strategy, and therefore the volatility, is unknown. After the option is introduced, its equilibrium price conveys information about the anticipated volatility of the stock, and therefore about the fraction of traders intending to follow a dynamic trading strategy. Grossman (1988) also suggests that derivative markets help curb excess volatility that might be induced by dynamic trading strategies, by lowering transaction costs and thereby allowing institutional traders to trade more smoothly over time.

Back (1993) extends Kyle's (1985) continuous-time model of informed trading in the presence of noise traders to include trading on an option. In Kyle's model, the underlying stock in equilibrium follows a Brownian motion with constant volatility. Back (1993) shows that the introduction of options causes volatility to be stochastic. It does not, however, change the expected average level of volatility. The basic intuition underlying Back's model is the similar to that of Grossman's (1988)—option trading conveys information not available in a similar market where options may be synthesized with dynamic trading strategies. Even though an option may be replicatable before it is introduced, that does not mean that introducing it has no effect on the spot process.

A third model that captures the same intuition has been proposed by Kraus and Smith (1996). This model highlights the fact that there is a distinction between market completeness and option replicability. Here, it is shown that it may be possible for each individual investor to dynamically replicate an option with portfolio of stock and cash, even if markets are not dynamically complete. In this case, different investors may have different information sets and different state prices, and value the option differently. Once options are introduced, the option price aggregates information across investors, allowing different investors' state prices to equilibrate. In this context, the introduction of options may affect the equilibrium stock price even if each investor views it as redundant.

Detemple and Selden (1991) analyze the interaction between stocks and options when markets are incomplete. As a general result, they show that in incomplete markets, the equilibrium stock price depends on the characteristics of the option contracts available for trading. There are no comparative statics describing the direction of the effect for the most general model. However, examining a special case where the agents have quadratic utility and the heterogeneity of their beliefs is modeled in a simple way, the authors find that the introduction of options leads to an increase in the equilibrium stock price, and a reduction in the stock's volatility.

An alternative theoretical framework, based on the noisy rational expectations model of Hellwig (1980), is explored by Brennan and Cao (1996) and Cao (1999). In this framework, Brennan and Cao (1996) show that the introduction of an option with a quadratic payoff function can lead to a Pareto-efficient allocation, and thus effectively complete the market. Option introduction in this model leads to increased market depth in the underlying market, and an indeterminate effect on trading volume in the underlying market, but has no effect on the price process for the underlying asset. Cao (1999), however, extends the model to show that this result changes when the acquisition of information is endogenized. He shows that the introduction of a "generalized straddle,"—of which the quadratic option considered in Brennan and Cao (1996) is a special case—increases the incentive to collect information, and leads to an increase in the price and a decrease in the volatility of the underlying stock. It also leads to an increase in the price of other assets that are positively correlated with the underlying asset.

John, Koticha and Subrahmanyam (1991) examine the simultaneous trading of a stock and option in the presence of an informed investor, using the sequential order arrival framework of Glosten and Milgrom (1985). In this model, there are risk-neutral market makers and noise traders in both markets, and the informed trader optimally trades in both markets. Comparing the resulting equilibrium to the case without options trading, it is shown that the introduction of options leads to an improvement in liquidity and a reduction of volatility in the underlying stock market, but stock prices become less informative. Also, the insider's optimal trading strategy and equilibrium bid-ask spreads in both markets are shown to depend on the margin requirement in the option market.

A similar model is considered by Biais and Hillion (1994). In their model, the market is incomplete without the option, and the option completes the market. The liquidity traders are risk averse and trade to hedge endowment shocks. This endogeneity of liquidity trading turns out to have important implications. For some parameter values, the introduction of the option decreases the informativeness of the stock price, as in John, Koticha and Subrahmnayam (1991). But the authors show that the introduction of the option makes it less likely that the market will break down due to adverse selection. In cases where the option prevents the market from breaking down, the option improves the price informativeness of the stock. Another result of this model is that the profitability of insider trading may increase or decrease with the introduction of options, depending on parameter values.

A third sequential-trade model of simultaneous trading in option and stock markets is advanced by Easley, O'Hara and Srinivas (1998). In this model, it is shown that the propensity of the insider to trade in the option market depends on the leverage achievable through the option and the depth of the two markets. In some cases, there is a corner solution and the insider trades only in the stock market.

3 Empirical Evidence

3.1 Commodity Futures

Table 1 summarizes the results of several studies that have examined the effects of futures introduction on cash market stability in commodity markets.

The papers summarized in this table employ various methods to test whether futures markets stabilize prices. The earliest papers simply compared price ranges or standard deviations between periods or across markets. For example, Emery (1896) examined the annual high-low range before and after the advent of corn and wheat futures in the United States, and Hooker (1901) compared

Table 1: Results of various studies on the volatility effect of the introduction of commodity futures.

Author	Market	Volatility
Emery (1896)	Cotton	Lower
	Wheat	Lower
Hooker (1901)	Wheat	Lower
Working (1960)	Onions	Lower
Gray (1963)	Onions	Lower
Powers (1970)	Pork bellies	Lower
	Cattle	Lower
Tomek (1971)	Wheat	Lower
Johnson (1973)	Onions	No effect
Taylor and Leuthold (1974)	Cattle	Lower
Brorsen, Oellermann and Farris (1989)	Cattle	Higher
Weaver and Banerjee (1990)	Cattle	No Effect
Antoniou and Foster (1992)	Crude Oil	No Effect
Netz (1995)	Wheat	Lower
Kocagil (1997)	4 Metals	No Effect

the standard deviation of wheat price changes in Berlin to those in Chicago and Liverpool before and during a three-year trading suspension in the Berlin market.

Subsequent authors have suggested various methodological refinements, particularly with respect to how the data should be de-trended, and how "variance" should be defined. For example, Brorsen, Oellermann and Farris (1989) correct for seasonality by regressing daily price differences on sinusoidal functions with six- and twelve-month periods. Then, for each year, they calculate the standard deviation of the residuals from the first-stage regression. Finally, they subject these standard deviations to another regression analysis, with dummy variables for three subperiods. Antoniou and Foster (1992) estimate a Generalized Auto-Regressive Conditional Heteroskedasticity (GARCH) model for crude oil prices before and after the introduction of futures, and test for structural changes in the GARCH parameters using a Chow test. This approach allows for non-constant volatility in the pre- and post-event subsamples.

Netz (1995) performed a more careful study of commodity futures introduction by directly analyzing the effects of wheat futures markets on storage decisions from 1858 to 1890. Another interesting feature of Netz's (1995) analysis is the inclusion of dummy variables corresponding to known attempts to corner the market. While she does find that attempted corners do tend to raise volatility, markets are still more stable with futures markets than without.

In addition to those mentioned in the table, other authors have examined the effects of futures introduction by testing whether the degree of price autocorrelation changed with the introduction of futures. Cox (1976) studied the Onion, Potato, Pork Belly, Hog, Cattle and Orange Juice contracts. After the introduction of futures, he found less autocorrelation, and that the price forecast error is lower. This suggests that futures markets improve the information content of spot prices. Kodres and Schachter (1996) examine the impact of the introduction of wheat and corn futures options in January, 1926, and report a significant decline in the volatility of the underlying futures prices.

3.2 Fixed Income Futures

Table 2 reports results from various studies testing for volatility effects associated with the introduction of GNMA and other fixed-income futures. Most studies find either no significant effect, or else a decrease in volatility following futures introduction. Simpson and Ireland (1985) and Edwards (1988b) find mixed results, depending on the size of the event window. Only Figlewski (1981) reports higher volatility following futures introduction.

3.3 Stock Index Futures

Results on the introduction of stock index futures are somewhat ambiguous. Many authors find no significant volatility effect associated with stock index futures listing. Others, including Maberly, Allen and Gilbert (1989), Brorson (1991), Lee and Ohk (1992), Antoniou and Holmes (1995) and Gulen and Mayhew (2000) report a volatility increase in highly developed markets such as the United States, United Kingdom, and Japan. On the other hand, Antoniou, Holmes and Priestley (1998), Salih and Kurtas (1999) and Gulen and Mayhew (2000), find evidence that volatility decreased with futures listing in many other countries. The results of these and other studies are

Table 2: Results of various studies on the volatility effect of the introduction of fixed income futures.

Author	Market	Volatility
Froewiss (1978)	GNMA	Lower
Figlewski (1981)	GNMA	Higher
Dale and Workman (1981)	T-Bill	No Effect
Simpson and Ireland (1982)	GNMA	No Effect
Bortz (1984)	T-Bond	Lower
Corgel and Gay (1984)	GNMA	Lower
Moriarty and Tosini (1985)	GNMA	No Effect
Simpson and Ireland (1985)	T-Bill	Mixed
Edwards (1988b)	T-Bill	Mixed
	Eurodollar	Lower
Ely (1991)	Interest Rates	No Effect
Hegde (1994)	T-Bond	No Effect

summarized in table 3.

Many of these papers are reviewed by Sutcliffe (1997), so we will not go into too much detail here. These papers use one of three basic approaches to analyze the effect of futures on the cash index. The majority of these papers compare the volatility of the index before and after the introduction of the futures contract, either using an unconditional measure of volatility, or using an ARCH/GARCH framework. Most of these papers look at only one market, making it somewhat difficult to compare results across markets. However, there are a few exceptions, including papers by Lee and Ohk (1992), Antoniou, Priestley and Holmes (1998), Salih and Kurtas (1999) and Gulen and Mayhew (2000).

A second approach, exemplified by Harris (1989), Laatsch (1991), and Kumar, Sarin and Shastri (1995), is to compare the volatility of individual stocks within the index to a control sample of stocks that are not in the index. Harris (1989) reports that after futures listing, the volatility of stocks in the S&P 500 increased, relative to the volatility of stocks in a control sample. Laatsch (1991) performs a similar test for the introduction of futures on the Major Market Index (MMI), and finds no significant effect. Kumar, Sarin and Shastri (1995) find that in Japan, the

Table 3: Results of various studies on the volatility effect of stock index futures.

Author	Market	Volatility
Santoni (1987)	S&P 500	No Effect
Edwards (1988a, 1988b)	S&P 500 Value Line	Lower No Effect
Aggarwal (1988)	S&P 500	No Effect
Harris (1989)	S&P 500	Higher
Mabery, Allen and Gilbert (1989)	S&P 500	Higher
Fortune (1989)	S&P 500	No Effect
Becketti and Roberts (1990)	S&P 500	No Effect
Lockwood and Linn (1990)	DJIA	Higher
Brorson (1991)	S&P 500	Higher
Chan and Karolyi (1991)	Nikkei 225	No Effect
Laatsch (1991)	MMI	No Effect
Gerety and Mulherin (1991)	S&P 500	No Effect
Hodgson and Nicholls (1991)	Australian AOI	No Effect
Baldauf and Santoni (1991)	S&P 500	No Effect
Bessembinder and Seguin (1992)	S&P 500	Lower
Board and Sutcliffe (1992)	FT-SE 100	No Effect
Kamara, Miller, and Siegel (1992)	S&P 500	Mixed
Lee and Ohk (1992)	Australian AOI Hang Seng US, UK, Japan	No Effect Mixed Higher
Koch and Koch (1993)	S&P 500/MMI	No Effect
Bacha and Vila (1994)	Nikkei 225	No Effect
Brenner, Subrahmanyam and Uno (1994)	Nikkei 225/TOPIX	Mixed
Choi and Subrahmanyam (1994)	MMI	No Effect
Robinson (1994)	FT-SE 100	Lower
Antoniou and Holmes (1995)	FT-SE 100	Higher
Brown-Hruska and Kuserk (1995)	S&P 500	Lower
Chen, Jarrett and Rhee (1995)	TOPIX	No Effect
Darrat and Rahman (1995)	S&P 500	No Effect
Kumar, Sarin and Shastri (1995)	Nikkei 225	Lower
Kan (1996)	Hang Seng	No Effect
Reyes (1996)	CAC 40 KFX (Denmark)	Lower No Effect
Galloway and Miller (1997)	MidCap 400	No Effect
Pericli and Koutmous (1997)	S&P 500	No Effect
Ragunathan and Peker (1997)	Australian AOI	Mixed
Antoniou, Holmes & Priestley (1998)	S&P 500, Nikkei225 FT-SE 100, IBEX 35 DAX 100, SWISS MI	 No Effect Lower
Chang, Cheng and Pinegar (1999)	Nikkei 225	Mixed
Gulen and Mayhew (2000)	US and Japan 8 Countries 15 Countries	Higher No Effect Lower

volatility of indexed stocks decreased relative to non-indexed stocks with the listing of index futures. This is interesting in light of the results reported by various other authors that Nikkei 225 index volatility either increased or remained unchanged at the time of futures listing. Chang, Cheng and Pinegar (1999) analyze the effect of index futures listing on the underlying stocks by decomposing portfolio volatility into the average volatility of component stocks and the cross sectional dispersion of returns. They find that when Nikkei 225 futures were listed in Japan, the cross-sectional dispersion of returns across stocks in the index decreased, and index volatility increased proportionally more than the average volatility of the individual stocks. No such result was found for stocks outside the index, nor was any effect found at the time of off-shore listing of Nikkei 225 futures in Singapore.

A third approach, used by Bessembinder and Seguin (1992, 1993) and others, is to test whether the introduction of stock index futures affects the volume-volatility relationship in the spot market, and whether spot market volatility is contemporaneously related to trading volume or open interest in the futures market. These authors find that the unexpected component of futures trading activity (measured by volume or open interest) is positively related to spot market volatility, suggesting that futures market volume responds to unexpected volatility events. The expected component of trading activity, however, was found to be negatively related to spot market volatility, suggesting that futures markets help stabilize cash markets. Gulen and Mayhew (2000) verify that open interest is negatively related to stock index volatility in many other countries, but with respect to trading volume, they do not find any effect that is robust across countries.

In addition, some effort has been made to test whether futures volume by different types of traders has a different effect on volatility. For example, Hogan, Kroner and Sultan (1997), using a bivariate GARCH model and four years of data from the S&P 500 index futures market (1988-1991), find that the positive relationship between volume and volatility is driven primarily by program trading. Chatrath, Ramchander and Song (1998) analyze the relationship between futures volume and volatility using the CFTC's "Commitments of Traders" data, in which traders are classified as commercial traders (hedgers), non-commercial traders (speculators), small traders or spreaders. Using S&P 500 data from January 1986 through March 1995, they find that volatility is more sensitive to changes in non-speculative trading volume than speculative volume. They also find that volatility is not sensitive to changes in the number of speculators or the size of their positions. Daigler and Wiley (1998) use the Chicago Board of Trade "Liquidity Data Bank" to differentiate the trading volume of floor traders and trading volume by the general public. Examining two years of daily data on MMI stock index futures and four other futures contracts, they find that the positive volume-volatility relationship is driven by public volume, not by floor-trader volume.

Jegadeesh and Subrahmanyam (1993) examine whether the introduction of stock index futures had any effect on the liquidity of the component stocks. Although trading volume in the component stocks did increase, Jegadeesh and Subrahmanyam (1993) find that after controlling for changes in price, volume, and volatility, bid-ask spreads on the component stocks increased significantly with the introduction of S&P 500 index futures. The component of the bid-ask spread attributable to adverse-selection was also estimated to be higher after the introduction of index futures, but this result was not statistically significant.

3.4 Currency Futures

Most research on derivative markets has concentrated on exchange-listed derivatives, for which data are readily available. In the FX market, exchange-traded futures represent only a small portion of the total forward trading activity. It is not surprising, therefore, that relatively few authors have studied the impact of currency futures on the volatility of exchange rates.

Clifton (1985) documents a positive relationship between currency futures trading in Chicago and exchange rate volatility. His study is based on the Japanese Yen, Swiss Franc, German Mark and Canadian Dollar futures markets between January 1980 and October 1983, and he uses the daily high-low spread as a measure of volatility. Chatrath, Ramchander and Song (1996) confirm this result. Their study is based on the same four currencies plus the British Pound, they use a much longer time period (ranging from twelve to seventeen years depending on the currency), and they employ a GARCH framework for modeling volatility. Adrangi and Chatrath (1998), examining eleven years of data on the Yen, Mark, Pound, and Canadian Dollar, find exchange rate volatility to be positively related to the temporary component of the speculators' and small traders' futures market positions. The volume-volatility relationship for currency futures is also examined by Bahr and Malliaris (1998).

Jochum and Kodres (1998) study the relationship between futures trading and volatility for the Mexican Peso, Brazilian Real and Hungarian Forint, and find no significant effect. Shastri, Sultan and Tandon (1996) document a decrease in exchange rate volatility associated with the listing of currency options.

3.5 Individual Equity Options

Many authors have examined the impact of option listing on the volatility or systematic risk of the underlying stocks. The results reported by various authors are summarized in table 4. In this table, a down arrow indicates that the authors report a significant decrease in volatility following option listing, and a question mark indicates that the result was not statistically significant, or that it went in opposite directions in different subsamples.

A number of comments are in order. First, it should be noted that nearly all of these papers, the only exceptions being Trennepohl and Dukes (1979) and Chaudhury and Elfakhani (1997), fail to find a significant change in beta at the time of option introduction.

Second, it should be noted that of all these papers, only one reports a significant increase in volatility following option listing—that of Wei, Poon and Zee (1997), who studied the listing of options on OTC stocks. Most authors report a decrease in volatility. As demonstrated by Lamoureux and Panikkath (1994), Freund, McCann and Webb (1994) and Bollen (1998), however, this effect is probably due to market-wide phenomena—similar volatility declines may be observed in a control sample of firms that did not have options listed. While the results reported by these

Table 4: Effect of Stock Option Listing on Volatility and Beta

Author	Sample	Period	Market	Volatility	Beta
Nathan Associates (1974)	16	1973	USA	↓	
CBOE (1975)	40	1974-75	USA	↓	
Trennepohl and Dukes (1979)	32	1973	USA		↓
Klemkosky and Maness (1980)	103	1973-75	USA	?	?
Whiteside, Dukes and Dunne (1981)	35	1973-75	USA		?
Whiteside, Dukes and Dunne (1983)	71	1973-81	USA		?
Nabar and Park (1988)	390	1973-86	USA	↓	
Bansal, Pruitt and Wei (1989)	175	1976-86	USA	↓	?
Conrad (1989)	96	1974-80	USA	↓	?
Skinner (1989)	293	1973-86	USA	↓	?
Detemple and Jorion (1990)	300	1973-86	USA	↓	
Haddad and Voorheis (1991)	327	1973-86	USA	↓	?
Rao, Tripathy and Dukes (1991)	45	1985-87	USA	↓	
Damodaran and Lim (1991)	200	1973-83	USA	↓	
Fedenia and Grammatikos (1992)	438	1973-87	USA	?	
Watt, Yadav and Draper (1992)	39	1973-83	UK	↓	
Chamberlain, Cheung and Kwan (1993)	37	1979-87	Canada	?	?
Stucki and Wasserfallen (1994)	11	1988	Switzerland	↓	
Lamoureux and Panikkath (1994)	527	1973-88	USA	?	
Freund, McCann and Webb (1994)	685	1973-90	USA	?	?
Long, Schinski and Officer (1994)	111	1985-90	USA (OTC)	?	?
Gjerde and Sættem (1995)	7	1990-94	Norway	?	?
Elfakhani and Chaudhury (1995)	119	1979-87	Canada	↓	?
Becchetti (1996)	174	1984-1989	Japan (warrants)	↓	
Chaudhury and Elfakhani (1997)	30	1975-89	Canada (puts)	↓	↓
Kabir (1997)	35	1978-93	Netherlands	?	
Niendorf and Peterson (1997)	110	1985-91	USA	?	
Wei, Poon and Zee (1997)	144	1985-90	USA (OTC)	↑	
Alkebäck and Hagelin (1998)	32	1985-94	Sweden	↓	
Bollen (1998)	1,010	1973-92	USA	?	
St. Pierre (1998)	140	1973-90	USA	?	

authors do cast serious doubt on previous findings, they do not necessarily imply that option listing has no effect. If the introduction of an option on one stock helps complete the market, this might, in equilibrium, affect all stocks, not just the stock underlying the option. Detemple and Jorion (1990) have argued that the introduction of options on individual stocks has led to a decrease in market volatility. In this case it is unclear whether the control sample methodology is entirely appropriate. Proponents of the control-sample approach might argue that it is unreasonable to expect the introduction of options on one stock to affect the volatility of another stock. On the other hand, if a cross-stock listing effect does exist, one might expect it to be strongest within the same industry. In this case, selecting a control sample using stocks matched by industry would bias the researcher against finding a volatility effect.

Third, one would think that if there is a robust volatility effect, it should go the same direction in different subperiods, yet this does not appear to be the case. Bollen (1998) and Freund, McCann and Webb (1994) report different volatility effects in different subperiods. One interpretation is simply that the option listing effect is spurious. On the other hand, Detemple and Jorion (1990) argue that we should expect to see a difference between early option listings and late option listings, since the early option listings had more of a "market-completing" role than the later listings. The earliest stock option listings occurred prior to the introduction of stock index futures and options. Options on large stocks may be viewed as substitutes for options on the market. The introduction of the first stock options thus represented a significant increase in the variety of investment and risk-management strategies available to investors. Now that index futures and options, industry sector options and a wide cross section of individual stock options are traded, the introduction of additional options on new stocks has only a marginal impact on market completeness.

Fourth, many studies have verified that volume in the underlying stock tends to increase after stock options are listed. Among the authors who have addressed this issue are Hayes and Tennenbaum (1979), Branch and Finnerty (1981), Skinner (1989), Bansal, Pruitt and Wei (1989), Rao, Tripathy and Dukes (1991), Gjerde and Sættem (1995), Wei, Poon and Zee (1997) and Kumar, Sarin and Shastri (1998). It is possible that the apparent change in volatility may be related to a concurrent change in liquidity. In support of this hypothesis, Niendorf and Peterson (1996) have found evidence that changes in volume and volatility at the time of option listing are cross-sectionally related.

Fifth, it has been found that after the introduction of options, prices tend to reflect new information more quickly, bid-ask spreads tend to narrow, and the adverse selection component of the bid-ask spread becomes smaller.[5] This effect could be related to the increased volume and decreased volatility. Fedenia and Grammatikos (1992) find that bid-ask spreads become narrower for NYSE stocks but wider for OTC stocks, for which Wei, Poon and Zee (1997) reported a volatility increase. Using a vector augoregression approach, Güner (1996) analyzes the relationship between price changes and trading volume for stocks with and without listed options. Among other results, she reports that stock trading volume is more informative for optioned stocks than for non-optioned stocks. Güner (1996) also finds that for non-optioned stocks, long volume in the stock is more informative than short volume, but the same result does not hold for optioned stocks, suggesting that options markets significantly lower the cost for informed traders to take short positions in the underlying asset.

Sixth, several authors have tested for abnormal stock returns associated with option listing. A positive price effect is documented by Branch and Finnerty (1981), Rao and Ma (1987), Conrad (1989), Detemple and Jorion (1990), Kim and Young (1991), Watt, Yadav and Draper (1992), Stucki and Wasserfallen (1994) and Gjerde and Sættem (1995). These studies differ with respect to whether they examine the announcement date or the event date, and disagree as to whether this price response is permanent or transitory.[6] Rao and Ma (1987) report a negative price effect on the announcement date and a positive price effect on the listing date, while several other authors find no significant announcement day effect. In some respects, this price effect is reminiscent of the

[5]See Jennings and Starks (1986), Rao, Tripathy and Dukes (1991), Fedenia and Grammatikos (1992), Gjerde and Sættem (1995), Niendorf and Peterson (1997) and Kumar, Sarin and Shastri (1998)

[6]See Broughton and Smith (1997).

S&P 500 listing effect. Indeed, Damodaran and Lim (1991) document an increase in institutional ownership following option listing. On the other hand, recent evidence suggests that the positive listing effect is not nearly as robust as previously thought. Ho and Liu (1997) and Sorescu (1999) document that in the United States, option listing is associated with negative excess returns in the post-1981 period. Moreover, Kabir (1997) documents a negative price response associated with the listing of options in the Netherlands.

Schinski and Long (1995) find evidence from options on OTC firms suggesting that the price response to option listing is driven by changes in liquidity in the underlying asset. Specifically, they found that smaller firms experience an increase in liquidity and a positive excess return at the time of option listing, while larger firms experience a decrease in liquidity and a negative excess return.

Seventh, some authors have studied the impact of options on the underlying stock market by examining cross-market volume/volatility relationships. Poon (1994) finds a structural change in the relationship between stock volume and stock volatility at the time of option listing. Mayhew, Sarin and Shastri (1996) find a positive contemporaneous relationship between option trading volume and underlying stock volatility, but they also find evidence suggesting that option trading improves the quality of the underlying stock market, as measured by bid-ask spreads, the informational component of the spread, and price impact.

Finally, various authors have recognized that option introduction tests may be biased because the listing decision is endogenous.[7] The concern most commonly aired is that option exchanges may list firms that have recently experienced a period of high volatility. If this is true, and if volatility is mean-reverting, we would expect to see a decrease in volatility following option listing, even if the option listing has no effect.

Mayhew and Mihov (1999), however, have argued that the exchanges should not want to list options after transitory volatility shocks. Rather, they should wish to list options in response

[7]For example, Branch and Finnerty (1981), Skinner (1989), Conrad (1989), Nabar and Park (1988), Damodaran and Lim (1991), Fedenia and Grammatikos (1992), Bollen (1998).

to permanent volatility shocks, or perhaps in *anticipation of* increasing volatility. In this case, we would expect to see volatility increase at the time of option listing. To address this issue empirically, Mayhew and Mihov (1999) explicitly model the exchanges' option listing choice. Using a logit model, the characteristics of stocks that were actually selected for option listing are compared with those for others that were eligible but not selected, and a "criterion function" for option listing is estimated. Based on the output of this procedure, a control sample is constructed of stocks that were not selected, but appear to have been good candidates for option listing. Then, the volatility, volume and price effects are investigated for the original sample and the control sample. Contrary to the prior literature, the results indicate that option listing corresponds to an increase in volatility in underlying stocks selected for option listing, when compared with those in the control sample. This result does not hold, however, for the early listings. Also, the results indicate that Sorescu's (1999) finding of a negative price effect after 1981 is considerably weaker than originally reported.

3.6 Other Equity-Based Derivatives

Relatively few authors have addressed the impact of stock index option trading on volatility. Evidence reported by Chatrath, Kamath, Chakornpipat and Ramchander (1995) and Chatrath, Ramchander and Song (1995), however, indicates that trading in the S&P 100 options market has a stabilizing effect on the underlying index. In addition, Lee and Tong (1998) have examined the introduction of individual stock futures in Australia. They find a significant increase in the trading volume of the underlying stock, but no significant volatility effect.

3.7 Expiration Day Effects

Several authors have tested for unusual activity in the underlying markets on days when derivatives expire. Expiration day effects in the United States have been examined by Stoll and Whaley (1986, 1987, 1991), Edwards (1988a), Feinstein and Goetzmann (1988), Herbst and Maberly (1990), Hancock (1991), and Chen and Williams (1994). Evidence from other international index futures markets is reported by Karolyi (1996) for Japan, Stoll and Whaley (1997) for Australia, and Bollen and Whaley (1998) for Hong Kong. Pope and Yadav (1992) report evidence for individual stock options in the U.K.

These papers suggest the following empirical regularities. First, trading volume in the underlying asset is unusually high around expiration dates. Second, although there appear to have been specific instances of price movements on expiration days that appear to have been related to traders unwinding their positions, there is little evidence of a strong, systematic price effect around expiration. Third, during the earlier period of stock index futures trading in the United States, there was some evidence that volatility was abnormally high around "triple witching" hour, but this effect seems to have diminished since 1987, when the expiration of stock index futures and options was moved to the morning.

3.8 Lead-Lag Relationships

To the extent that options or futures reduce the transaction cost associated with taking a position in the market, their introduction should be expected to increase the flow of information into the market, and one might expect to see price discovery occurring in the derivative market. A simple way to test for this is to study the lead-lag relationship between price changes (or trading volume) in the underlying and derivative markets.

3.8.1 Lead-Lag Relationship between Stock Indices and Stock Index Futures

The evidence from studies on stock index futures overwhelmingly indicates that index futures lead the reported values of the underlying cash index, with estimates of the lead time ranging from five to forty-five minutes. Many studies also report evidence of a much shorter lead in the opposite direction, with cash markets occasionally leading futures markets by one or two minutes. Authors reporting results for U.S. markets include Kawaller, Koch and Koch (1987, 1993), Herbst, McCormack and West (1987), Stoll and Whaley (1990), Chan, Chan and Karolyi (1991), Chan (1992), Wahab and Lashgari (1993), Ghosh (1993), Fleming, Ostdiek and Whaley (1996), and De Jong and Nijman (1997).

The traditional approach in this literature has been to construct an evenly-spaced time series of cash index and future prices and statistically analyze the lead-lag structure in the two series using bi-directional causality tests, or simply by examining the cross-correlation structure of the two series. Kawaller, Koch and Koch (1987), for example, analyze one-minute time steps on the S&P 500 index for two years, 1984-85, and conclude that S&P 500 futures lead the cash index by 20 to 45 minutes, with the longer lead appearing in the more actively-traded short term futures contracts, but the cash index does not lead the futures market by any more than two minutes. An obvious explanation for this result is that due to asynchronous trading in the underlying stocks, market shocks are registered in the cash index with a distributed lag. Various authors have attempted to correct for infrequent trading. Harris (1989) suggests a method that uses transaction level data on all component stocks. He assumes a simple one-factor generating process with unit loadings for all stocks in the index, then uses a value-weighted least squares procedure on the stocks that trade to estimate current values for stocks that did not trade. Using this procedure, he examines the relationship between the S&P 500 cash and futures in the ten days around the crash of 1987. Based on five-minute time intervals, he finds evidence that a large part, but not all of the extreme movements in the cash-futures basis observed around the crash were due to infrequent trading. After correcting for infrequent trading, he still finds that the futures market was leading the cash market.

Stoll and Whaley (1990) adjust for infrequent trading by passing the cash returns through an ARMA filter. Using 5-minute intervals, they examine the S&P 500 market from April, 1982 through March, 1987, and the MMI futures market from July, 1984 through March, 1987. After attempting to correct for infrequent trading, they still find that futures market leads the cash market by an average of five minutes, but occasionally by more than ten minutes. They confirm that there is also weak evidence for the cash market leading the futures market, but this effect appears to have grown smaller over time.

Chan (1992) confines his attention to the MMI cash index, which is made up of only 20 stocks, and is less subject to infrequent trading than is the S&P 500. He studies the lead-lag relationship between the MMI cash index and MMI futures, and also between the MMI cash index and S&P 500 futures, using five-minute time intervals for two subperiods: August 1984 through June 1985 and January through September 1987. He verifies the usual result that there is strong evidence for the futures market leading the cash market, and weak evidence for the cash market leading the futures. In addition, he studies the lead-lag relation between the MMI index futures and the component stocks, some of which trade more frequently than the futures contract. Here also he finds an asymmetric lead, with futures leading even the most actively traded stocks. Chan (1992) finds no strong evidence that the lead-lag relation between cash and futures is fundamentally different for good vs. bad news, nor does it appear to be related to the level of market activity. He does find, however, that the futures lead is more significant during periods of market-wide movements.

Wahab and Lashgari (1993) note that the previous papers in this literature are misspecified in that they do not explicitly recognize that the cash index and futures follow a cointegrated processes.[8] Accounting for the cointegration of the two series using an error correction model, they still find weak evidence of bidirectional causality in both the S&P 500 and FT-SE 100 markets. It is somewhat difficult to compare their results to other papers in the literature, as their study is based on daily data. Subsequent authors, however, have employed similar error correction models on high frequency data, and have reported results similar to those already established in the literature.

Fleming, Ostdiek and Whaley (1996) examine five-minute return intervals on the S&P 500 futures, S&P 100 call and put options, and the S&P 500 and 100 cash indices for the month of March 1991. They estimate the current cash index levels from the reported level using the ARMA technique employed by Stoll and Whaley (1990), they calculate implied index returns from option prices by inputting lagged implied volatility into a dividend-adjusted binomial tree, and they include an error correction term to account for cointegration. After correcting the cash market for infrequent trading, both S&P 100 options and the S&P 500 futures are found to lead the underlying cash index

[8]See also Ghosh (1993).

by at least one five-minute period. In addition, evidence is found of a much more symmetric lead-lag relationship between futures and options, with the futures market having a marginally more significant lead. Overall, the evidence presented by Fleming, Ostdiek and Whaley (1996) supports the hypothesis that price discovery is directly related to trading costs. Pizzi, Economopoulos and O'Neill (1998) estimate the empirical specification of Wahab and Lashgari (1993) using one-minute time intervals from January to March, 1987, the futures market is found to lead the cash market by more than twenty minutes, and there is also a significant, but considerably shorter lead in the opposite direction.

De Jong and Nijman (1997) analyze the lead-lag relationship between S&P 500 cash and futures using a technique that does not arbitrarily divide the day into five-minute intervals. Examining the last quarter of 1993, their results are roughly in line with the previously known results-the futures lead the cash index by at least ten minutes, but that the cash index leads the futures by at most two minutes.

Most studies in this literature focus exclusively on the lead-lag relationship between returns in cash and derivative markets. Chan, Chan and Karolyi (1991) demonstrate that the interaction between cash and futures markets is more complicated than this. They use a bivariate GARCH framework to analyze more than five years of data from the S&P 500 cash and futures markets, and one year of data on the MMI. They find significant volatility feedback in both directions; that is, trading in either market affects the conditional volatility of subsequent innovations in the other market. This result suggests that we ought to broaden our view of information-based trading beyond the concept of price discovery alone. It also suggests that the other studies on lead-lag relationships, because they do not account for time varying volatility and cross-market volatility feedback, are misspecified.

Research on lead-lag relationships in other international stock index futures markets corroborates the evidence found in the United States. For evidence from the Japanese market, see Tse (1995), Iihara, Kato and Tokunaga (1996), and Chung, Kang and Rhee (1996). For results on the FT-SE 100 market in the U.K., see Wahab and Lashgari (1993), and Abhyankar (1995, 1998). Other international evidence has been reported by Niemeyer (1994) for Sweden; Grunbichler, Longstaff and Schwartz (1994) for Germany; Martikainen, Perttunen and Puttonen (1995) for Finland; Shyy, Vijayraghavan and Scott-Quinn (1996) for France; De Jong and Donders (1997) for the Netherlands; Ferret and Page (1998) for South Africa; and Min and Najand (1999) for Korea.

3.8.2 Lead-Lag Relationship for Stock Options

One approach to testing whether option markets lead stock markets, introduced by Manaster and Rendleman (1982), is to use the observed option prices to calculate Black-Scholes implied stock prices, then test whether deviations between this implied stock price and the observed concurrent stock price can predict future returns on the stock. Based on their examination of daily data on individual stock options from April 1973 to June 1976, Manaster and Rendleman (1982) conclude that option prices do contain information to help predict future stock price changes. Although the quality of their data is relatively poor, their basic result has subsequently been verified by Bhattarcharya (1987), using a very carefully-constructed tick-level data set. Rather than simply testing for statistical relationships, Bhattacharya (1987) measures the profitability of trading strategies, using a methodology which explicitly accounts for bid-ask spreads in both the option and the underlying stock. Although he finds none of the intraday trading strategies generate significantly positive profits, an overnight strategy does appear to be profitable, verifying the result of Manaster and Rendleman (1982) that option markets tend to lead stock markets.

It should be noted that the methodology employed in these two papers tests only whether option prices contain leading information relevant to the stock market, not whether the stock market might also lead the option market. Anthony (1988), using Granger causality tests, finds weak evidence that option market volume leads stock market volume. However, this may be a direct result of hedging activity by option market participants, and does not necessarily imply price discovery in the options market.

Stephan and Whaley (1990) examine three months of tick-level data from both the option and stock markets, comprising the first three months of 1986. Breaking the data into five-minute intervals, they transform observed call price changes into implied stock price changes using a Roll-style American option formula, then regress the implied stock price changes on lagged, contemporaneous, and leading observations of actual stock price changes. Contrary to prior research, they find evidence that the stock market unilaterally leads the option market, by up to fifteen or twenty minutes, and stock trading volume leads option trading volume by slightly longer than that. Chan, Chung and Johnson (1993), however, report that this result vanishes when quote midpoints are used, rather than transaction prices. They argue that the Stephan and Whaley (1990) result is due to infrequent trading, price discreteness, and the fact that a one-tick change in the stock price corresponds to a option price change that is less than one tick. Krinsky and Lee (1997) find that Stephan and Whaley's (1990) result seems to reverse around the time of earnings announcements, with options leading stocks in these periods, but like Chan, Chung and Johnson (1993), they find no significant lead-lag relationship in quote midpoints.

Diltz and Kim (1996) examine the lead-lag relationship between stocks and options using an error correction model that recognizes that the observed stock price and the option-implied stock price are cointegrated. Using data for eight firms for the calendar year 1988, they find evidence both for the stock market leading the option market and the option market leading the stock market. O'Connor (1999) also estimates an error-correction model, using the TORQ database to examine 19 firms during November and December, 1990. He finds that the stock market tends to lead the option market, and that the lead time is cross-sectionally related to various measures of option liquidity and trading costs.

Finucane (1999) estimates the relationship between observed option price changes and lagged and leading stock price changes using a methodology that avoids arbitrary divisions of the trading day into fixed-length intervals. He constructs his data set in event time, and he defines price changes as changes in bid-ask quote midpoints. He models the option price change as a linear function of two lagging and two leading stock price changes, and estimates the model using the Generalized Method of Moments. Examining data from November and December 1990 on ten firms, he finds evidence that stock price changes lead option price changes, but also that option price changes lead stock price changes. In order to investigate the maximum lead time, he repeats the estimation on carefully selected subsamples. For example, to determine whether the stock market leads the option market by at least two minutes, he would repeat the analysis on the subset of observations for which the second quote prior to the option price change occurred at least two minutes earlier. He concludes that stock prices lead option prices by no more than six minutes, and option prices lead stock prices by no more than three minutes.

Easley, O'Hara and Srinivas (1998) take a slightly different approach—they test whether option market volume leads stock price changes. Their analysis is based on two months of data, October and November 1990, on fifty firms. Dividing the trading day into five-minute intervals, they regress stock price changes on lagged option volume, and vice versa. Using conventional measures of option volume, they find no significant effect. However, they do find that "signed" option volume does help predict future stock price changes. Signed volume is calculated by first classifying trades as buyer- or seller-initiated according to their location within the prevailing bid-ask spread, then lumping long call volume together with short put volume, and short call volume with long put volume.

Chan, Chung and Fong (1999) further examine the joint dynamics of signed trading volume and returns in the stock and option markets. Using tick-level stock and options data for fourteen firms for the first quarter of 1995, they calculate signed volume and quote-midpoint returns for five-minute intervals. They then specify a vector autoregression of stock returns, call option returns, put option returns, stock signed volume, call option signed volume, and put option signed volume. They estimate the model by performing a separate ordinary least squares regression for each of these variables on the lagged values of all six variables. They find that stock returns lead call and put returns by at least three lags (fifteen minutes), and option returns lead stock returns by only one lag (five mintues). They also find that signed stock volume leads stock and option returns by one lag, but contrary to the results reported by Easley, O'Hara and Srinivas (1998), signed option volume does not lead stock returns.

Cao, Chen and Griffin (1999) document abnormal trading activity in option markets prior to takeover announcements, for a sample of 78 events between 1986 and 1994. Consistent with the notion that informed traders trade in the options market, they find that abnormal returns at the time of the announcement are cross-sectionally related with abnormal call option volume, but not with abnormal stock volume, in the pre-announcement period. In addition, these authors find that prior to takeover announcements, volume tends to increase for nearly all types of options, regardless of whether they are calls or puts, in-the-money or out-of-the-money, short-term or long-term, actively traded or inactively traded. Interestingly, this is true for both buyer- and seller-initiated volume. However, there tends to be a larger increase in buyer-initiated volume than seller-initiated volume for calls, with the opposite being true for puts. This reinforces the conclusion that at least part of this volume represents informed trading. Finally, Cao, Chen and Griffin (1999) test the performance of trading strategies based on moving-average trading-volume triggers. They find that strategies based on abnormal option volume tend to be profitable, while those based on abnormal stock volume do not, supporting the conclusion that option market activity, forecasts price movements.[9]

4 Where Do We Go From Here?

The past decade has seen rapid development of the scope and scale of derivative markets. Among the main developments are:

- A large increase in the size of the OTC market for interest rate, exchange rate, and stock index derivatives;
- Increasing complexity of contracts, such as exotic options and other structured products;

[9] Also see Nofsinger and Prucyk (1999), who perform a similar study based on option trading around scheduled macroeconomic news announcements.

- Introduction of many new international derivatives exchanges trading interest rate and currency futures, stock index futures, index options and stock options;
- Development of new classes of derivative markets, including contracts based on credit markets, electricity, catastrophic losses, and weather;
- Noteworthy losses such as those at Barings, Proctor and Gambol, and Orange County have put into question the adequacy of existing risk management and internal monitoring techniques.

Given these developments, it is perhaps more important than ever to understand the relationships between spot and derivative markets, and the potential effects of introducing new derivative contracts. These developments have given us not only a motivation, but also the means to expand our research focus to a broader set of issues—new questions have been raised, and new data are available to address them.

4.1 Increased Size of the OTC Market

The last decade has witnessed tremendous growth of the over-the counter derivatives market. To illustrate, in 1987, the total notional value outstanding on interest rate and currency swaps as reported by the International Swaps and Derivatives Association, was about $865 Billion. By June, 1999, that number had increased to over $52 Trillion.

Although notional value is not a measure of risk exposure, this large increase certainly indicates a marked increase in the risk management activities of corporations and banks. How does the development of a large, highly-liquid markets for transferring interest rate risk impact the economy? If firms can effectively hedge interest rate and currency risk, how does this feed back into their real investment decisions? Do active forward and swap markets have any impact on equilibrium real interest rates? Does an active interest rate swap market improve the quality of the markets for treasuries or corporate bonds? How important is an active currency swap market in encouraging foreign investment? Given active interest rate and currency swaps, how much pressure is placed on the central banks to collaborate with each other? To what extent do forward and swap markets affect systemic risk?

4.2 Increased Complexity of Contracts

In conjunction with the rapid growth of the OTC derivatives market, we have seen rapid innovation in customized second- and third-generation derivative products. A wide variety of exotic derivatives are currently traded, with colorful names like caps, floors, collars, swaptions, lookbacks, binaries, knockouts, knockins, corridors, trigger forwards, Hokey-Cokeys, soft barriers, choosers, forward starts, exchanges, rainbows, quantos, Bermudans, Asians, touches, walls, ladders, cliquets, and shouts, to name a few.

Some of the theoretical research described in section 2, above, indicates that we might expect different kinds of deriviatives to have different effects on the underlying asset. For example, the introduction of options may be different from the introduction of futures. How do exotic options affect the underlying markets? In particular, George Soros and others have suggested that contracts with *discontinuous* payoffs, such as knockouts and binary options, can be destabilizing. The logic is as follows. Suppose that large traders can use their influence in the market to manipulate prices a small amount, but it is costly for them to do so. For standard options, a small amount of market manipulation can only generate a small payoff, and it would not be worth the cost. For options with discontinuous payoffs, it may be that a small manipulation can generate a huge payoff. To illustrate, suppose that a large institution has a knockin option that will only generate a payoff if the underlying reaches a certain level. When the underlying is close the barrier, there is an incentive for the institution to try to manipulate the price so that it breaches the barrier and kicks in the option. Does this type of manipulation occur in practice? If so, how much?

4.3 Globalization of Derivative Markets

In the early 1980s, we witnessed the onslaught of markets for financial derivatives in a handful of developed nations. In the late 1980s and early 1990s, the fever spread to Hong Kong, Japan, Brazil, and most of Western Europe. In the latter half of the 1990s, index futures and other financial derivatives spread to emerging and transition economies—Hungary, Israel, Malaysia, Korea, Russia, Poland, Venezuela and Greece, among others. It appears that this trend will continue as we enter the new millennium. Long-term plans are underway to introduce derivatives exchanges in many other nations, with formal arrangements already underway in India, Turkey, Mexico, Czech Republic, Slovakia and Indonesia, among others.

The widespread adoption of derivatives in emerging markets raises some interesting questions. How should regulators in developing countries decide when to permit derivatives trading? How can exchanges in emerging markets predict whether new contracts will be successful? Is an active over-the-counter market a necessary precursor to successful exchange-traded contracts? Have derivative markets played a significant role in attracting foreign investment? Is there a significant risk of default for exchange-traded derivatives in emerging markets? What is the optimal design of a futures and options clearinghouse in the presence of high volatility, hyperinflation, or sovereign risk? In a country with high corruption and poor enforcement of contracts, does the introduction of derivatives just provide another opportunity for market manipulation, or can a well-functioning derivatives market help curb market manipulation in the underlying market? What are the tradeoffs between domestic vs. off-shore derivatives trading? Given an active off-shore futures market, it is possible for a country to enforce limits on foreign stock ownership?

4.4 New Classes of Derivatives

The introduction of derivatives on new underlying assets (or in general, on new state variables) presents interesting new challenges and opportunities to study the relationship between cash and spot markets. For example, with the introduction of electricity derivatives, we have an underlying asset that trades, but, essentially, cannot be stored. In addition, the demand for electricity is quite volatile, and the supply is subject to large unpredictable shocks (for example, when a generator fails). As a result, this market is susceptible to "short squeezes" that cannot be cured through regulation. As a result, the existence of forward contracts in this market has led to extreme price spikes.

The introduction of credit derivatives, which have payoffs that are based on some aggregate measure of defaults, may have interesting implications for the structure of the financial sector.

Other interesting products have been introduced. For example, "catastrophe insurance options" are based on the total insured catastrophic losses in certain regions of the country. These options may have some impact on the insurance industry.

Volatility derivatives are cash-settled contracts with payoffs related to some measure of the volatility of cash markets. For example, a contract might be based on the CBOE's VIX volatility index, which represents the volatility implicit in the prices of near-term at-the-money S&P 100 index options. Alternatively, a contract might be based on the realized volatility of a certain index or interest rate over a particular time period. The introduction of volatility options might make it easier for equity trading desks to control their model risk, or "vega risk." In equilibrium, would this have any effect on the underlying market, or perhaps on the standard options?

The introduction of weather derivatives affords us an interesting "control sample" for testing whether the introduction of derivatives affect the underlying markets. These are cash-settled contracts where the payoff is calculated on the basis of realized rainfall or temperatures in a particular city. It is quite difficult to make the case that the introduction of precipitation options impacts the volatility of rainfall, or to attribute global warming to the introduction of temperature futures. Nevertheless, these derivatives may have an indirect impact on other markets through their effect on the behavior of energy firms or farmers.

4.5 Large Losses

In late 1994, the Orange County Investment Pool lost $1.7 Billion, largely as a result of levered interest rate positions acheived through derivative securities. The instruments used to achieve this position were not highly complex or hard to understand. Neverthess, a lack of sufficient oversight permitted the manager of the pool to take risks that were clearly beyond what was appropriate. This is just one of many prominent examples of unacceptably large losses in derivatives markets due to inadequate monitoring or oversight.

In the past few years, a great deal of effort has been spent trying to develop alternative techniques for measuring the risk of large losses and effectively controlling this risk. There is much left to be done, however. Derivative securities may have a greater potential to disrupt an economy where financial institutions have poor internal risk management controls, and are ill-prepared to deal with catastrophic losses. How, then, does a trading firm decide that its internal controls are adequate? In the face of poor internal controls, how can a firm evaluate the credit risk of its trading partners?

5 Summary

In summary, a great many papers, both theoretical and empirical, have addressed the question of how speculation in general, and derivative securities in particular, impact the underlying asset markets. The theoretical research has revealed that there are many different aspects of the relationship between cash and derivative markets. Although many models predict that derivatives should have a stabilizing effect, this result normally requires restrictive assumptions. At the end of the day, the theoretical literature gives ambiguous predictions about the effects of derivatives markets.

As for the empirical literature, research has uncovered several stylized facts, most of which suggest that derivatives tend to help stabilize prices and improve liquidity in the underlying market, and that some price discovery occurs in derivative markets. It should be noted, however, that there are also many studies that come to the conclusion that derivatives have had no significant impact on cash markets. In addition, this research has concentrated primarily on exchange-traded derivatives in developed countries. Selected papers have been written about particular developing markets here and there, but it is difficult to derive firm conclusions.

We are in a period of vast growth of derivative markets. We see this growth both in OTC markets and on exchanges, in developed and developing nations, in the introduction of new types of contracts, and in the extension of derivatives to new underying markets. Now, more than ever, we need to fully understand the relationship between derivative and cash markets. Which results from the developing markets may be applied to emerging markets? Which results from index futures can be applied to electricity futures? Which results from stock options can be applied to currency knockouts? Despite the hundreds of papers already written in this field, the rapid growth of derivative markets continues to provide us with new, important and interesting questions.

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