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STANFORD UNIVERSITY
FINANCIAL SERVICES RESEARCH INITIATIVE

Risk Management: Problems & Solutions

William H. Beaver
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Editors

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This work could not have been successfully completed without the tireless efforts of Nancy Banks and Ellen O'Connor. Nancy did just about everything except write the chapters. She kept after the authors for their first drafts, coordinated review of the editorial revisions, returned the revised copies to the authors, communicated with the publishers, created the page design and layout, and prepared the entire book in camera-ready form, among numerous other efforts. We are deeply indebted to her. Ellen O'Connor provided invaluable editorial input to ensure consistency among the chapters and to enhance the readability of the entire volume. We also express our gratitude to the members of the FSRI, whose intellectual partnership with us made this possible.

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PREFACE

William Beaver, Professor, Graduate School of Business, Stanford University

George Parker, Professor, Graduate School of Business, Stanford University

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This volume represents a unique combination of essays on the multidimensional aspects of risk management. It is a product of the Financial Services Research Initiative (FSRI), an intellectual partnership formed at Stanford University between members of its faculty and leading financial services organizations.

Because of the importance of risk management to consumers and producers of financial services, the FSRI chose this topic as its inaugural issue. For most of our authors, risks are greater today than they were a generation ago. Risk and risk management now fall under the scrutiny of top management and in the domain of corporate strategy. A review of the popular financial press shows increasing attention to and concern with phenomena as diverse as derivatives, computer models, and technological innovation—all of which simultaneously mitigate against and create new forms of risk. Financial managers may be overwhelmed not only by new risks but also by new ways to manage them. An important objective of this book, then, is to introduce insights and practices that help financial executives conceptualize this complex topic. As many of the authors assert, understanding risk is the first step in managing it.

Like the proverbial elephant surrounded by blindfolded individuals, how you describe risk depends on where you are standing. We have provided various views of risk and of risk management as seen by FSRI academic

The Internal Call Market: A Clean, Well-Lighted Place to Trade

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Introduction[1]

> "The continuous trading market is an aberration from an economic viewpoint and generates a potentially permanent instability favoring fraud and manipulation of the market."
>
> — Maurice Allais, Nobel laureate, Economics

Herodotus tells us that in ancient Babylon, "Once in every year the following course was pursued in every village; whatever maidens were of marriageable age, they used to collect together and bring in a body to one place; around them stood a crowd of men. Then a crier, having made them stand up one by one, offered them for sale, beginning with the most beautiful; and when she had been sold for a large sum, he put up another who was next in beauty. ... They were sold on condition that they should be married." In Herodotus's opinion, this was the wisest of all Babylonian customs.

While the sale of human beings is abhorrent, this anecdote contains an economic lesson. Perhaps what impressed Herodotus was that, by convening an annual market, the Babylonians allowed the supply of and demand for brides to aggregate over time. This increased the expected matching ratio of brides and suitors and avoided the potentially permanent social instability generated by a continuous market. In a continuous market for brides, the supply of young women and demand for them would have varied greatly. On days when many more brides were available than suitors, the most beautiful woman might have fetched a pittance. But when suitors greatly outnumbered brides, prices would have soared and fights would have broken out between successful and thwarted suitors. In a society where the price of a bride varied so widely, a young man saving for marriage would have faced great economic uncertainty.

Like the Babylonians, modern institutional investment funds can benefit from the temporal aggregation of a call market.[2] Imagine a large pension fund that is about to invest $100 million in large capitalization equities. How should it purchase these equities? Will it submit market orders to the New York Stock Exchange (NYSE)?

The motivation for this trade is to establish a long–term investment position; the trade is not prompted by any private information. The fund is concerned with the quality of trade execution, not immediacy. The exchanges offer immediate execution but at a cost of trading with informed traders who "cherry pick" market orders. Specialists fill the trades spurned by informed traders, but they quote a bid–ask spread to protect themselves from those same informed traders. Furthermore, with large trades, the specialists are likely to move the bid–ask spreads before completing the orders to compensate themselves for inventory risk. The floor of the exchange may be one of the worst places for an institution without private information to establish a new investment position. The pension fund would like to trade in a low–cost market with other informationless traders. Such traders come to the market frequently but not continuously. A call market can bring these traders together over time. A call market for composite assets (that is, baskets of securities) is an ideal market for passive institutional traders.[3]

In 1973, when Wells Fargo Bank established the first S&P 500 index fund, institutional investors had no alternatives to trading on the exchanges. Twenty years later they have a multitude. They have developed many techniques for managing risk. By investing in portfolios, they diversify and eliminate the idiosyncratic risks associated with individual stocks. By implementing buy and hold strategies, they diversify temporally and eliminate the risks of active trading in volatile markets. By investing in standardized indexed portfolios, implementing buy and hold strategies, and carefully choosing their trading venues, they minimize trading costs and thereby increase their ratio of expected return to risk. By trading in composite assets, they protect themselves from insiders.

This paper discusses various ways institutional investors control investment risk and trading costs. In particular, it describes the internal call markets of index–fund managers. In an internal market, the buy and sell orders of the index fund participants are first matched with each other.

Only unmatched orders are executed externally (e.g., on an exchange or on a crossing network). Although some of these internal markets are large, they have been ignored in the finance literature. A model of such call markets is presented. The paper is organized into the following topics: (1) recent figures on the growth and size of the indexing industry, trading mechanisms used to manage indexed portfolios, and marketplace alternatives to the traditional exchanges; (2) the internal markets of indexers; and (3) a model of these markets. Some of the mathematical calculations for the model are given in an appendix. Throughout the paper, the primary example of an internal call market is that of Wells Fargo Nikko Investment Advisors (WFNIA). The discussion generalizes to the internal call markets of other index fund managers.

Indexing, Trading Mechanisms and Alternative Marketplaces

Indexing has grown significantly since its introduction in the early 1970s. In 1973, domestic and international index funds offered by U.S. managers held $55 million. By the end of 1992, the indexed assets of U.S. managers stood at $389 billion (Figure 1), or 12% of all tax–exempt assets (Figure 2).[4]

Indexing is not confined to the U.S. At the end of 1992, $91.3 billion were invested in index funds offered by non–U.S. managers.[5]

Figure 1

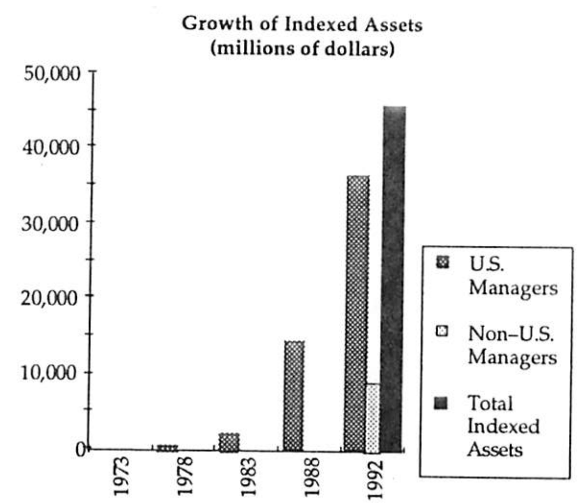
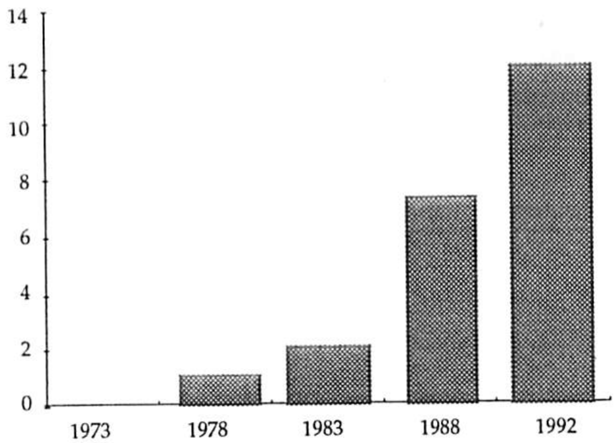


Figure 2

Percentage of Tax–Exempt Assets That Are Indexed



In the early years of indexing, a fund purchasing a complete cross–section of the S&P 500 filled out 500 buy tickets. These were bundled together and delivered to a brokerage firm. The orders were then executed, individually, on the exchange floor and in the over–the–counter market. The process was slow and expensive. Since then, indexing has been a driving force in the development of new trading mechanisms and new marketplaces that serve passive institutional investors. Today, index futures contracts, basis trades, and EFPs (exchange for physical) facilitate the trading of baskets of securities as composite assets. Upstairs block trading, the *rolodex market*, POSIT, Instinet, the NYSE's Crossing Session I, the Arizona Stock Exchange, and the internal call markets of index fund managers offer alternatives to the exchange floor. This section briefly describes each of these.

Composite assets are baskets of securities that can be traded as one asset.[6] Composite assets generally group together securities of a similar investment nature (e.g., high–capitalization stocks or long–term government bonds); thus the securities' essential investment quality is captured while the idiosyncratic risks of individual securities are reduced through diversification. Luskin (1987), Subrahmanyam (1991), and Gorton and Pennacchi (1993) argue that composite assets are well

suited for passive investors. By trading in composite assets, passive investors signal the market that they are not trading on private information. Not only does trading in a composite asset signal a trader's lack of information, but also it offers the uninformed trader some protection from informed traders. For example, an informed trader with private information on IBM would not trade the S&P 500 on this information because it would have little impact on the overall index. Instead she would exploit her information by trading IBM stock or its derivatives. The lower adverse selection risks of trading in composite assets result in lower bid–ask spreads. Thus futures on the S&P 500 index have a much smaller bid–ask spread on average than do the individual underlying stocks.

But the smaller spread on the S&P 500 index futures is not only due to lower adverse selection risks. It also results from the great liquidity in S&P 500 index futures. While trading in composite assets mitigates adverse selection risks, only *standardized* composite assets, such as the S&P 500 index, concentrate liquidity (Grauer and Tiemann 1991). As an example, imagine a market with 1000 equity securities. The participants in this market agree that two composite assets, a high–cap 500 index and a low–cap 500 index, should be traded in this market. They further agree as to which 400 stocks are the largest cap and which 400 are the smallest cap. But they disagree as how to allocate the middle 200 stocks to two indexes. There are then $\binom{200}{100} = 9.0 * 10^{58}$ possible choices of the two composite assets. If each participant attempts to trade a particular choice of composite assets, a trading partner may never appear. Standardized composite assets are needed to obtain the concentration of liquidity found in S&P 500 index futures and in the internal markets of index fund providers.

In 1982, S&P 500 *index futures* were introduced on the Chicago Mercantile Exchange. The average daily trading volume of index futures contracts quickly surpassed the average daily trading volume in the equities underlying the index. Fleming, Ostdiek, and Whaley (1993) estimate that when bid–ask spreads, commissions, and exchange fees are considered, the transaction costs of buying the S&P 500 basket of stocks is 40 times higher than that of buying S&P 500 index futures. Salomon Brothers (1993) calculates the transaction costs of equities to be about 10 times that of futures. The liquidity of the futures market cements the role of the S&P 500 as the investment industry's large–capitalization portfolio standard.

Basis trades are a way for investors, who are restricted from investing in derivative assets, to take advantage of the liquidity of the futures markets. With a basis trade, an investor goes from a cash position to one in equities, or vice versa. The investor obtains futures market prices when they are more favorable than equity market prices without actually trading futures. For example, a pension fund may wish to purchase $100 million of S&P equities. The market impact of this purchase will be greater in the equities market than in the futures market, so a basis trade is arranged with a broker. The pension fund buys futures contracts in the broker's account, and the broker sells equities to the fund. The price of the equities is the average futures price minus an agreed–upon spread, or "basis." The basis is the difference between the futures price and the capitalization–weighted price of the S&P 500 securities minus the broker's implied commission. When the basis trade is complete, the fund owns equities and the broker has a perfectly hedged position: short equities and long futures.

An *EFP* is an exchange of index futures for an indexed basket of securities or vice versa. In 1992, $2.18 billion of S&P 500 EFPs traded on the Chicago Mercantile Exchange. An EFP allows an investor to take advantage of the liquidity in the futures market without changing equity exposure. When might an EFP be used? Suppose a pension fund has recently terminated a money manager. The pension fund does not want the terminated manager to sell the portfolio because he now lacks the incentive to get the best possible prices. The pension fund may bring the portfolio to a transaction management service for restructuring. If the pension fund has chosen to invest in S&P equities, then the part of the portfolio which is not already invested in such equities is sold. The cash proceeds are "equitized," as they are raised, through the purchase of S&P 500 futures contracts. When the pension fund can acquire an S&P 500 portfolio at acceptable transaction costs, the futures are exchanged for equities using an EFP.

Upstairs block trading was one of the first means adopted by institutional investors to cope with the lack of acceptably priced liquidity on the floor of the exchange. In a block trade, an investor wishing to buy or sell a large quantity of a particular security advises a block trader at a brokerage house of the size and desired price of the trade. The block trader finds investors to take the other side of the trade and negotiates a deal with both parties. The trade is then executed at an exchange. By finding and organizing both sides of a large trade, the block trader aggregates order flow that otherwise would not arrive simultaneously on the floor. The block trader earns a commission from both buyers and sellers.

Large institutional investors avoid the block trader's double commission by contacting each other directly through the *rolodex market*. This is a particularly appealing option for trading an entire basket of stocks, such as the S&P 500. When both buyer and seller are passive investors, they will usually agree to trade at some exogenously determined price (a price obtained from an external source such as an exchange) on the agreed–upon day. The trade will be brought to a broker and executed for a commission of about 1/2 cent per share.

POSIT, a crossing network operated by ITG and BARRA, is available to institutional traders but not to brokers, dealers, or specialists. In a crossing network, investors submit orders to buy or sell stocks at exogenously determined prices. The buy and sell orders are matched and executed without a bid–ask spread (that is, the orders are crossed). On POSIT, orders are crossed twice daily: at approximately 11:30 a.m. and 1:30 p.m. (Eastern Standard Time). Stocks are crossed at prices equal to either the midpoint between the National Market System bid–ask spread or that between the best NASDAQ quotes for a commission of 2¢ per share. In 1992, POSIT crossed $33 billion in equities (over 1.1 billion shares). ITG and BARRA now offer GLOBAL POSIT, a weekly crossing network for international securities. Trades on GLOBAL POSIT are executed at the local market close for a commission of 15 basis points (bp).

Instinet Crossing Services offers four crossing networks: The Crossing Network, Market Match, Yen Equities Network (YEN), and U. K. Crossing Network.[7] The Crossing Network matches buyers and sellers daily after the close. Listed issues trade at their closing price on their primary exchange, and over–the–counter (OTC) issues trade at the midpoint between the closing bid and ask quotes for a commission of 1¢ per share. The Crossing Network offers four tiers: passive traders, semi–passive traders, active traders, and broker/dealer/specialists. Traders in higher tiers can choose not to trade with those in lower tiers. For example, passive traders can stipulate that they wish to trade only with other passive traders and with semi–passive traders, but not with active traders and broker/dealer/specialists. In 1992, The Crossing Network crossed $15 billion in equities. Market Match matches buyers and sellers of U.S. equities each trading day before the NYSE opens. Trades cross at the day's volume–weighted average price. YEN is a weekly crossing network for Japanese equities. Trades are executed at the closing prices of the Tokyo Stock Exchange second session for a commission of 15 bp. The U.K. Crossing Network is a weekly crossing network with trades executed at the midpoint of the ISE (International

Stock Exchange) closing spread for a commission of 12.5 bp. The YEN and the U.K. Crossing Networks, as well as GLOBAL POSIT, are recent services with low but growing volumes.

The NYSE offers *Crossing Session I*, an after–hours crossing market.[8] The NYSE does not charge a fee for Crossing Session I; the session is available only through NYSE member firms, and the commissions they charge their clients are negotiated. The session starts following the regular day session and continues until 5:00 p.m. All trades are executed at the NYSE closing price. Crossing Session I accepts both two–sided and one–sided orders. The majority of orders are two–sided; that is, a buyer and seller have already been matched before the order is submitted. One–sided buy and sell orders are matched on a time–priority basis. In 1992, Crossing Session I's volume was $587 million.

The *Arizona Stock Exchange* (AZX) is an electronic call market that opens once a day after the close of the NYSE. Traders submit limit orders. An electronic, rule–based system determines the price that will best clear the market, and orders are crossed at that price. The AZX, unlike POSIT, The Crossing Network and Crossing Session I, has the potential for price discovery. In theory, traders can submit entire supply and demand schedules which, when matched, determine a market price. Most orders are submitted within 1/8 point of the close, and the exchange serves primarily as a crossing network. For the last nine months of 1992, volume on the AZX was $1.3 billion; for the first eight months of 1993, it was $2.0 billion.

Basis trades, EFPs, block trading, the rolodex market, Instinet, POSIT, NYSE after–hours trading, and the Arizona Stock Exchange all attempt to supply institutional investors with liquidity that is too highly priced on the exchange floor. Each is a useful tool for controlling market impact risk, but each has limitations. Basis trades and EFPs are suitable only in particular circumstances. Upstairs block trades can be "front run"[9] and include the risk of dealing with informed traders. The rolodex market is useful when it works, but it has a low success rate. The NYSE crossing sessions, POSIT, The Crossing Network, and the Arizona Stock Exchange all have relatively low matching ratios.[10] Furthermore, if an institution attempts to buy or sell an entire basket of equities through one of these, the basket is picked over; and the institution is forced to complete the unfilled—and most disadvantageous—parts of the trade on the exchange floor.

Passive institutional investors need a marketplace where great liquidity exists, entire baskets of portfolios can be traded, informed traders are excluded, and costs are minimal. Such a marketplace has developed. It is the internal market of large index fund managers.

Internal Call Markets

Though not discussed in the academic literature, the internal markets of index–fund managers facilitate more trading than the crossing networks. For example, in 1992, more than $44 billion in equities traded in WFNIA's internal market alone. Using fund opening days (the days on which the fund is open for contributions and withdrawals) to implement a call market, index fund managers temporally consolidate the supply and demand of their large customer bases. At WFNIA, this typically results in order–matching rates over of 70% for S&P 500 securities on fund opening days. Trades are crossed at market closing prices. Index fund participants bear no transaction costs for trading in this internal market.[11]

The potential savings are so significant that customers sometimes postpone a contribution to or withdrawal from an index fund until it can be matched in the internal market. Suppose a pension fund anticipates a need for cash at a future date. It wishes to maintain its exposure to equities until that date and still benefit from trading in the internal market. It may direct that its units of the index fund be sold only as internal crosses become available. As units are sold, equivalent index futures positions are purchased. When the time comes for the pension fund to withdraw its cash, the futures are sold. In this way, the cost savings of the internal markets are fully captured while an exposure to equities is maintained.

The cost savings of WFNIA's internal market is an estimated $230 million annually in commissions and bid–ask spread losses alone.[12] When foregone market impact is considered, the total savings on such potentially market–moving, large trades must be much greater.

The present structure of such an internal market results from a decision at the inception of the first S&P index fund. When Wells Fargo began this index fund in 1973, the Wells Fargo pension fund was its only customer. A few months later, Illinois Bell agreed to invest $300 million in the fund on the condition that Wells Fargo would first make an equal matching investment, which it did. However, it realized that if the index fund were run like a mutual fund, Wells Fargo would bear over half the transaction costs associated with the Illinois Bell contribution. This is because a mutual fund accepts cash contributions that are used to purchase stock. Since fundholders own a pro-rated share of the fund, they bear a pro-rated share of all trading costs. Early fund participants share the trading costs of subsequent participants, and, contrary to the spirit of passive investment, buy-and-hold investors are effectively punished for the trading of other investors. Wells Fargo rejected the mutual fund model and determined that investors would bear the costs of transactions made on their behalf but not the costs of transactions made for others. Thus, from an accounting standpoint, incoming investors first buy securities and then contribute them to the fund in exchange for units of the fund. When investors wish to sell their units, securities are sold on their behalf. On fund opening days, some investors buy units of a particular fund while others sell. To the best extent possible, these buy and sell orders are matched with one another. They constitute the largest part of the internal market: unit exchanges.

In 1987, WFNIA sought and obtained Department of Labor authorization to cross the orders of customers moving between funds provided that the crossing prices were exogenously determined. Like unit exchanges crosses, between-funds are done at market closing prices.

The New York Stock Exchange originally was organized as a call market, but by 1900 it had begun continuous trading.[13] In 1986, the Paris Bourse became the last of the world's major equity exchanges to switch from a periodic call market to continuous trading. Some see the transition of exchanges from call to continuous trading as the natural triumph of a superior market structure. Huang and Stoll (1992) cite the case of the Bourse when advising stock exchanges to "adopt a continuous trading system for active markets." Perhaps this advice should be changed to "adopt a continuous trading system for active traders." Evidence indicates that passive traders may be better served by call markets.

Passive investors have different needs from informed traders. Passive investors make diversified, long-term investments. Since their investment choices are not based on rapidly changing beliefs or short-lived information, they do not need the ability to trade every second of the day—or even every day. While immediacy of trade execution is not important to the passive trader, quality of execution is. Institutional passive investors often make large trades that can temporarily move markets and thereby

reduce anticipated returns. Controlling trading costs and risks is an important part of passive trading. Informed traders, on the other hand, commonly make shorter horizon investments in specific stocks about which they have information. If their information is short lived, they willingly pay larger commissions, bid-ask spreads, and market-impact costs to facilitate immediate trades. With such disparate trading requirements, it is not surprising that passive investors and informed traders are best served by different market structures.

Schwartz (1992) writes, "Thus far, the assumption that participants demand transactional immediacy has gone practically unquestioned. Would some asset managers choose not to pay the price of immediacy if they truly understood the cost of the service and if they had an alternative?" We believe that passive institutional investors have come to understand the cost of continuous trading and that they are not willing to pay it. The world's exchanges may be switching to continuous trading, but many of its institutional investors are leaving the exchanges for the call trading found in crossing networks and the internal markets of index fund managers.

Grossman and Stiglitz (1980) show that, when information is costly, it is optimal for a subset of investors to collect information and for the rest to "free ride" on the information in the price. We contend that, by free riding on the price discovery of others, institutional passive investors may actually improve the quality of price discovery. The non-synchronous arrival on the exchange floor of large orders strains the specialist's ability to provide liquidity. Even when such trades are clearly identified as informationless, the specialist may not be willing to take on large inventory risk for fear that the market will move against her before she has had a chance to trade out of the inventory. Such large, informationless trades may move the market and increase the volatility of prices without revealing more information. They are better executed in a market that aggregates sufficient liquidity to accommodate large, informationless trades.[14] A simple model shows how call markets create liquidity for informationless trades.

A Model of Internal Call Markets

With the growth of crossing networks and of the internal markets of index fund providers, call markets without price discovery have become economically important. Our model is of an internal market provided by the manager of a single index fund. The model applies also to a noncontinuous crossing network in one security.[15] The index fund in our model holds shares in the basket of stocks that comprise the index. This basket of stocks constitutes a single composite asset. On fund openings, participants place orders to buy or sell the composite asset. Buy and sell orders are first matched in the internal market, where there are no trading costs. Unmatched orders are filled on a pro-rated basis in the external market, where there are positive trading costs. We assume that, at fund openings, participants choose investment levels in the composite asset which optimize their utility functions. Participants have liquidity needs that change continuously, so their optimal investment levels also change continuously. However, they must wait until the next fund opening before trading to meet their liquidity needs and returning to optimal investment positions. Thus, participants bear an opportunity cost in waiting for fund openings.

Price discovery plays no role in the model; buy and sell orders are not contingent on some reservation price. Price is assumed to be fixed and exogenously determined. All trading is informationless and motivated solely by liquidity needs.

Other researchers have studied call markets in the context of price discovery. Gresik and Satterthwaite (1989) find that, in an economy where agents have privately known reservation prices, the expected inefficiency of optimally designed market mechanisms decreases almost quadratically as the number of agents increases. Bhattacharaya and Majumdar (1973) derive a bound on how well excess demand can be approximated by a normal distribution; this bound is inversely proportional to the square root of the number of agents in the economy. Our measure of efficiency—one minus the ratio of the expected costs when an internal market is available to the expected costs when it is not—increases as number of market participants grows.

In a partially informed economy, Goldman and Sosin (1979) show that "if sufficient uncertainty surrounds the dissemination of information, frequent transacting may be deleterious to market efficiency." They prove the existence of a unique optimal time interval between market openings. Garbade and Silber (1979) model a market where investors enter at a constant rate and in which clearing occurs periodically. The clearing price is determined by investors' demand functions. Garbade and Silber derive the period between market clearings that minimizes the variances of the difference between the clearing price and the

equilibrium price. They find that this optimal period is inversely proportional to the square root of the entry rate. We look at total cost as a function of the number of fund participants and the time between fund openings. We derive closed-form solutions for the optimal time between fund openings for risk-neutral participants and for a class of risk-averse participants. Like Goldman and Sosin, we find a unique, non-zero optimal period between market openings.

Mendelson (1982) and Harris (1990) model call markets in which traders submit limit orders reflecting their demand curves. In our model, trades are neither motivated by nor contingent on prices.

Cohen, Maier, Schwartz, and Whitcolm (1982) examine two possible structures of a limit-order market that is run in-house by a brokerage firm. Like our model, theirs is of an in-house, or internal, market. In our market, prices are determined exogenously and execution is determined internally. In theirs, customers set prices with limit orders but execution depends on external prices. Their market, unlike ours, is continuous. Cohen, Maier, Schwartz and Whitcolm find, as do we, that the effectiveness of an internal market increases with its size.

Our model is from one fund opening at $t = 0$ to the next fund opening at $t = T$. There are N index fund participants. (A prototypical participant would be a pension fund.) At $t = 0$, each participant determines and makes an optimal investment in the index fund. Each participant has an exogenously driven liquidity process, $L_{i,t}$, that follows a Wiener process with mean zero and variance $\sigma^2 t$. The liquidity processes are independent of each other (and can be thought of as the flow of money into and out of a pension fund). When that flow is positive, cash reserves build up which the participants want to invest in the index fund. When the cashflow is negative, the participants want to sell shares of the index fund to meet cash needs. By waiting to trade at fund openings, participants incur an opportunity cost. For example, a participant's borrowing interest rate may be higher than her risk-free lending rate, and her risk-adjusted expected return from the fund may lie between them. When she has an inflow of cash, she would like to invest it immediately in the index fund; but she must settle for the lower return from lending the cash while she waits for a fund opening. As another example, the manager of a pension fund has guidelines regarding the amount of cash held by the fund. If too much cash (or too much borrowing) accumulates in the fund, he violates the guidelines and appears to be managing poorly. In waiting for the opportunity to rebalance at a fund opening, he bears a cost. The model assumes that the opportunity cost is proportional to the absolute value of L_t by a factor of C_2.[16]

At $t=T$, each participant trades $L_{i,T}$ to return to his optimal holding in the index fund.[17] His trading needs are first matched internally with those of other participants. Unmatched orders are traded externally. We assume that demands crossed in the internal market incur no trading costs. External trading costs are proportional to the amount traded and are the same for buying and selling. The cost of external trading is a constant, C_1, times the absolute value of the unmatched portion of the liquidity needs.

Thus, participants have two different types of costs: opportunity costs and external trading costs.

If the fund has only one participant, $(N=1)$, all trades will be external and expected trading costs are:

$$C_1 \cdot E(|L_T|) = C_1 \cdot \sigma\sqrt{\frac{2T}{\pi}}. \tag{1}$$

When $N>1$, the expected trading costs per participant are the expected net trading needs after each participant's orders have been matched with each other, times the external trading cost constant, divided by the number of participants:

$$\frac{C_1}{N} \cdot E\left(\left|\sum_{i=1}^{N} L_{i,T}\right|\right) = C_1 \cdot \sigma\sqrt{\frac{2T}{N\cdot\pi}} \tag{2}$$

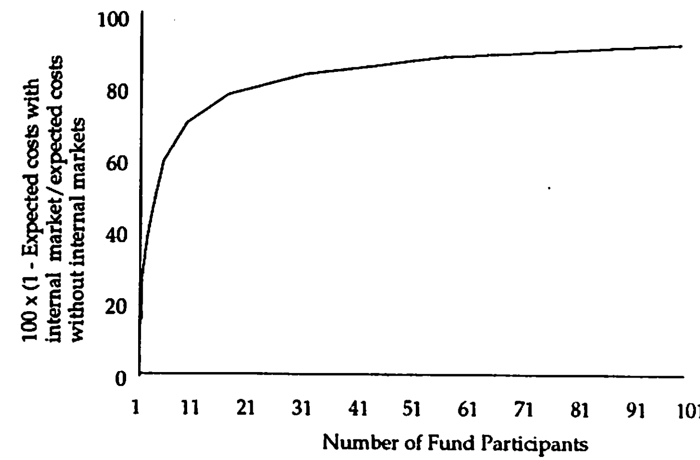
We compare the expected trading costs of internal market participants, for whom only unmatched orders are traded externally, to the expected trading costs of investors who have no internal market and must trade all orders externally. One minus the ratio of these expectations measures the cost savings of the internal market.[18]

$$1-\frac{E[\text{Trading costs with internal market}]}{[\text{Trading costs without internal market}]} = 1-\frac{1}{\sqrt{N}}. \tag{3}$$

Multiplied by 100, this measure can be expressed as a percentage.

Figure 3

Expected Savings of Internal Market



As the time between openings of the market increases, the amount of trading at any one opening increases with the square root of time. While this is a one–period model, we assume that participants remain in the fund period after period. Of primary interest to a participant is the expected amount of trading (external) per unit of time (e.g., one year) rather than the expected amount of trading at any one opening. Expected trading per unit of time is a decreasing function of period length, T:

$$E\left(\frac{trading}{T}\right) = \sigma\sqrt{\frac{2}{\pi\cdot T\cdot N}}. \tag{4}$$

Though the expected trading and expected trading costs per unit of time decrease asymptotically to 0 as the time between fund openings increases, fund participants cannot wait forever to trade. To find the optimal period between fund openings, participants must balance the lower trading costs of longer periods with increasing opportunity costs.

To derive the optimal period between fund openings, we first consider risk–neutral participants wishing to minimize expected total costs. Then we examine a class of risk–averse participants wishing to minimize risk–adjusted total costs.

Let $Q_1(N,T,\sigma)$ be a participant's external trading costs:

$$E[Q_1,(N,T,\sigma)] = C_1 \cdot \sigma \sqrt{\frac{2T}{\pi \cdot N}}. \tag{5}$$

Let $F_1(N,T,\sigma) = \frac{Q_1(N,T,\sigma)}{T}$, be a participant's trading costs per unit of time. Then

$$E[F_1(N,T,\sigma)] = \frac{k_1}{\sqrt{T}}, \text{ where } k_1 = C_1 \sigma \cdot \sqrt{\frac{2}{\pi \cdot N}}. \tag{6}$$

Opportunity costs are assumed to be proportional to the absolute value of L_t. (Compounding of opportunity costs is ignored.) The instantaneous opportunity cost is $C_2|L_t|dt$. Let

$$Q_2(T,\sigma) = \int_0^T C_2|L_t|dt$$

be a participant's cumulative opportunity costs over the non–trading period. Then

$$E[Q_2(T,\sigma)] = \frac{2C_2\sigma}{3}\sqrt{\frac{2}{\pi}} \cdot T^{\frac{3}{2}}. \tag{7}$$

Let $F_2(T,\sigma) = \frac{Q_2(T,\sigma)}{T}$ be a participant's cumulative opportunity costs per unit of time. Then

$$E[F_2(T,\sigma)] = k_2\sqrt{T}, \text{ where } k_2 = \frac{2C_2\sigma}{3}\sqrt{\frac{2}{\pi}}, \tag{8}$$

is the expected opportunity cost per unit of time.

To find the optimal period between fund openings, T^*, the expected total cost function $E[F_{total}] = E[F_1] + E[F_2]$ is differentiated with respect to T and set equal to zero:

$$T^* = \frac{k_1}{k_2} = \frac{3C_1}{2C_2\sqrt{N}} \tag{9}$$

For risk–neutral participants, T^* is unaffected by the rate of diffusion in the liquidity process (σ). T^* is decreasing as opportunity costs (C_2) go up, decreasing as the number of participants in the fund (N) grows, and increasing as external trading costs (C_1) increase. Consistent with these last two findings are the observations that (1) WFNIA's S&P 500 index funds (which have many participants and lower trading costs) open weekly; (2) intermediate capitalization equity index funds (which have fewer participants and higher external trading costs) open every other week; and (3) the Russell 1000 and Russell 3000 index funds (which have yet higher external trading costs) open monthly.[19] Similarly, POSIT and The Crossing Network offer domestic equity crossing sessions once or twice daily; these sessions have high volume and low trading costs. But GLOBAL POSIT, YEN, and the U. K. Crossing Network offer international crossing sessions only once a week; these sessions have lower volume and higher trading costs than their domestic counterparts. Our model predicts that as volume builds on GLOBAL POSIT, YEN and the U. K. Crossing Network (or as trading costs drop), crossing sessions will be held more frequently.

Figure 4

Expected Trading Costs per Unit of Time

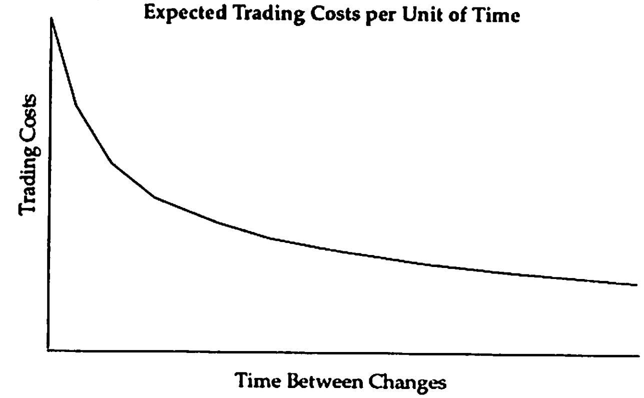


Figure 5

Expected Opportunity Cost per Unit of Time

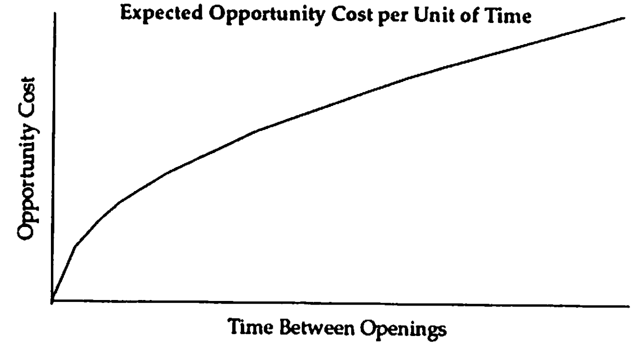
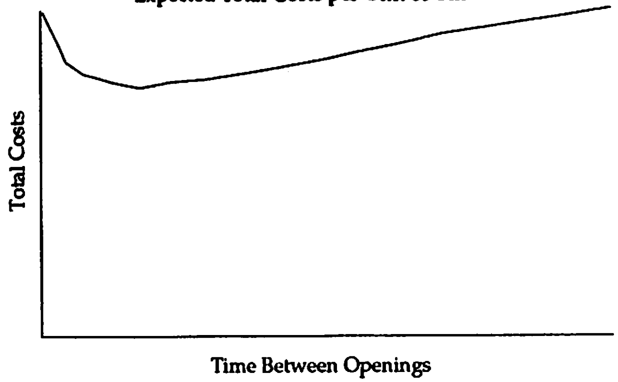


Figure 6

Expected Total Costs per Unit of Time



Next, consider a class of risk–averse participants wishing to minimize risk–adjusted total costs. Each participant wishes to minimize the function,

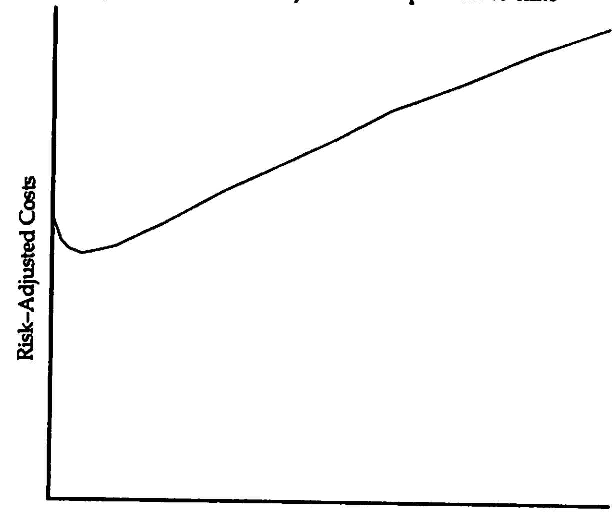
$$V = \frac{E(Q_1)}{T} + \frac{E(Q_2)}{T} + \frac{VAR(Q_1)}{T \cdot \rho} + \frac{\int_0^T E(C_2|L_2|)^2 dt}{T \cdot \upsilon}, \quad (10)$$

where Q_1 and Q_2 are defined as before, and ρ and υ are the same for each participant.[20] To find the optimal period between fund openings, T^*, V is differentiated with respect to T and set equal to 0. (This is done in the appendix.)

For risk–averse participants, unlike risk–neutral participants, T^* changes as the rate of diffusion in the liquidity process (σ) changes; the direction of change depends on other parameter values. As in the risk–neutral case, T^* decreases as opportunity costs (C_2) go up and as the number of participants in the fund (N) grows. It increases as external trading costs (C_1) increase. T^* increases as the measures of risk tolerance, ρ and υ, increase.

Figure 7

Expected Total Risk–Adjusted Costs per Unit of Time



The model assumes that the liquidity processes for all fund participants have zero drift, i.e., at the beginning of a period, participants do not know whether they are more likely to be buyers or sellers at the end of the period. Relaxing this assumption, we allow for participants who plan to increase or decrease their investment level over the next period in addition to meeting their normal liquidity needs. This can be represented by assigning each participant's liquidity process a randomly determined drift component $\mu_1 \sim N(0, \sigma_\mu)$. The drift components are independent and are identically distributed. At the beginning of the period, each participant knows his own drift component but not those of other participants. More important, the index fund provider does not know the individual drift components; he only knows their distributions. The fund provider must determine the fund opening period that is optimal for the participants.

From the fund provider's point of view, each participant's liquidity process now has two random components: the drift component and the diffusion component. As before, the diffusion component, $L_{\sigma,t}$, is distributed $N(0, \sigma^2 \cdot t)$. The drift component, $L_{\mu,t}, = \mu \cdot t$, is distributed $N(0, \sigma_\mu{}^2 \cdot t)$. Thus, from the fund provider's point of view at $t = 0$, the total liquidity

$L_t = L_{\mu,t} + L_{\sigma,t}$ is distributed $N\left(0,\left(\sigma^2+\sigma_\mu^2\right)\cdot t\right)$, at any $t,(0<=t<=T)$. Although the individual liquidity processes are not $\left(0,\sigma^2+\sigma_\mu{}^2\right)$ Wiener processes, the fund provider can nevertheless substitute $\left(\sigma^2+\sigma_\mu{}^2\right)\cdot t$ for the variance of the liquidity process in the previous calculations of T^*. As noted above for risk-neutral investors (but not for risk-averse investors), the optimal period between fund openings will be unaffected by the increased variance of the liquidity process.

Our model simplifies the reality of an index fund provider's internal market. It makes no provision for new participants entering the market. In the last 20 years, indexing has grown steadily. On average, more money has flowed into rather than out of funds. With such a positive trend incorporated into the model, transaction costs savings will still increase as fund participants grow, but the increase will be slower. So too, if the model's participants have positively correlated liquidity processes, transaction costs savings will increase more slowly as a function of N.

In the model, participants meet their liquidity needs by trading in only one composite asset. In reality, participants may invest in several index funds and choose among them to meet liquidity demands. This too lowers the savings of transaction costs. The low matching rates on POSIT, The Crossing Network, and the Arizona Stock Exchange may be partially due to the fragmentation of liquidity among the many securities traded in these markets.

Conclusion

The marketplace constantly evolves to meet the needs of its many participants. Twenty years ago, Wells Fargo introduced the first S&P 500 index fund to meet the needs of institutional investors who wished to make long-term, well-diversified investments at a low cost. The growth of indexing has been accompanied by the growth of index fund managers' internal markets. Trading within these markets is done without bid-ask spread, commissions, or market impact; it is virtually free of transaction costs. We have seen how these internal markets achieve cost savings by bringing together many investors, aggregating liquidity through call trading, and concentrating trading on composite assets. Composite assets, like the internal markets, have evolved with indexing. Composite assets diversify away idiosyncratic risk, protect investors from traders with inside information, and facilitate low-cost trading in the internal markets of index fund managers. They are excellent vehicles for long-term investment strategies, and the internal markets are an ideal place to trade them.

Appendix

To calculate equation (3) we observe that $\left|\sum_{i=1}^{N} L_{i,T}\right|$ and $\left|L_{i,T}\right|$ have half-normal distributions:

$$1-\frac{E[\text{Trading costs with internal market}]}{E[\text{Trading costs without internal market}]}=$$

$$1-\frac{C_1 E\left[\left|\sum_{i=1}^{N} L_{i,T}\right|\right]}{C_1 E\left[\left|\sum_{i=1}^{N} L_{i,t}\right|\right]}= \tag{11}$$

$$1-\frac{NC_1\sigma\sqrt{\frac{2T}{N\cdot\pi}}}{NC_1\sigma\sqrt{\frac{2T}{\pi}}}=1-\frac{1}{\sqrt{N}}$$

To derive equation (7), we integrate the expected instantaneous opportunity costs from 0 to T:

$$E\left[Q_2(T,\sigma)\right]=\int_0^T\int_{-\infty}^{\infty}\frac{C_2\cdot|L_t|}{\sqrt{2\pi\sigma^2 t}}e^{-\frac{L_t^2}{2\sigma^2 t}}dL_t dt=$$

$$C_2\cdot\int_0^T\sigma\sqrt{\frac{2t}{\pi}}dt\ . \tag{12}$$

$$=\frac{2C_2\sigma}{3}\sqrt{\frac{2}{\pi}}\cdot T^{\frac{3}{2}}$$

To find the optimal period between fund openings, T^*, the expected total cost function $E[F_{total}]=E[F_1]+E[F_2]$ is differentiated with respect to T and set equal to zero.

$$E[F_{total}(N,T,\sigma)]=\frac{k_1}{\sqrt{T}}+k_2\cdot\sqrt{T} \tag{13}$$

$$\frac{dE[F_{total}(N,T,\sigma)]}{dT}=\frac{-k_1}{2}\cdot T^{-\frac{3}{2}}+\frac{k_2}{2}T^{-\frac{1}{2}}=0 \tag{14}$$

and since $T>0$,

$$T^*=\frac{k_1}{k_2}=\frac{3C_1}{2C_2\sqrt{N}} \tag{15}$$

To solve for T^* in the risk–averse case, we first calculate

$$V=\frac{E(Q_1)}{T}+\frac{E(Q_2)}{T}+\frac{VAR(Q_1)}{T\cdot\rho}+\frac{\int_0^T E(C_2L_2)^2\,dt}{T\cdot\rho}. \tag{10}$$

The first two terms of (12) are known from the risk–neutral case. To derive the third term of equation (12), $\frac{VAR(Q_1)}{T\cdot\rho}$, we use the expectation of the half–normal distributions of $\left|\sum_{i=1}^{N}L_{i,T}\right|$ and $|L_{i,T}|$, to calculate $var(Q_1)$:

$$\frac{VAR(Q_1)}{T\cdot\rho}=\frac{1}{T\cdot\rho}\left[E\left(\frac{C_1\left|\sum_N L_T\right|}{N}\right)^2-\left[E\left(\frac{C_1\left|\sum_N L_T\right|}{N}\right)\right]^2\right]=$$

$$\frac{1}{T\cdot\rho}\left[\frac{C_1^2\sigma^2T}{N}-\frac{2C_1^2\sigma^2T}{\pi\cdot N}\right]= \tag{16}$$

$$\frac{C_1^2\sigma^2}{N\cdot\rho}\left(1-\frac{2}{\pi}\right)=k_3$$

To calculate the fourth term in equation (12), $\frac{\int_0^T E(C_2|L_2|)^2\,dt}{T\cdot\rho}$, we integrate the expected instantaneous opportunity cost from 0 to T:

$$\frac{\int_0^T E(C_2|L_2|)^2\,dt}{T\cdot\rho}=\frac{1}{T\cdot\rho}\cdot\int_0^T\int_{-\infty}^{\infty}C_2^2\frac{L_t^2}{\sqrt{2\pi\sigma^2 t}}e^{-\frac{L_t^2}{2\sigma^2 t}}dL_t\,dt$$

$$=\frac{C_2^2}{T\cdot\rho}\cdot\int_0^T\sigma^2 t\,dt \tag{17}$$

$$=k_4T,\ \text{where } k_4=\frac{C_2^2\sigma^2}{2\rho}$$

Thus

$$V=\frac{k_1}{\sqrt{T}}+k_2\cdot\sqrt{T}+k_3+k_4T. \tag{18}$$

Differentiating with respect to T, and setting equal to 0, we get:

$$\frac{dV}{dT}=\frac{-k_1}{2}\cdot T^{-\frac{3}{2}}+\frac{k_2}{2}T^{-\frac{1}{2}}+k_4=0 \tag{19}$$

Bearing in mind that $T^*>0$, (13) can be solved for T^*, the optimal time between fund openings for the given class of risk averse investors:

$$T^*=\frac{b^2}{3c^2}+2^{1/3}$$

$$\left(b^4+6abc^2\right)\Big/3c^2\left(2b^6+18ab^3c^2+27a^2c^4+3^{3/2}c^3\sqrt{4a^3b^3+27a^4c^2}\right)^{1/3} \tag{20}$$

$$+\left(2b^6+18ab^3c^4+3^{3/2}c^3\sqrt{4a^3b^3+27a^4c^2}\right)^{1/3}\Big/3\cdot\sqrt[3]{2}\,c^2$$

where $a=\frac{-k_1}{2}$, $b=\frac{k_2}{2}$,,and $c=k_4$.

Notes

[1] We wish to thank Truman Clark, Jonathan Tiemann, and Klaus Toft for very helpful conversations and comments. We also wish to thank Eric Clothier, Patricia Dunn, Blake Grossman, Bertrand Jacquillat, Hayne Leland, Donald Luskin, Jim Ross, Mark Rubinstein, Jeff Skelton and Kathy Sonderby for their comments. All errors are ours.

[2] In a call market, trading in a particular commodity takes place only at specific times when the market for that commodity is "called."

[3] Passive traders and investors make long-term buy and hold investments. Their trades are motivated by liquidity needs—not by private information—and are termed "informationless." Trades made on the basis of private information are informed trades.

[4] Assets indexed by U.S. managers are from a Rogers Casey survey of index fund providers. These figures are understated because not all index fund providers responded to the survey and because indexed assets managed internally by pensions funds are not included in totals. These totals are the numerator for the percentage of tax-exempt assets indexed. The denominator is the total U.S. tax-exempt assets from "The Money Market Directory of Pension Funds and their Investment Managers 1993" (Money Market Directories, Inc.: Charlottesville, VA). This includes all tax-exempt funds with assets over $1 million.

[5] Intersec Research.

[6] Two exchange-traded composite assets, Standard and Poor's Depository Receipts (SPY) and Index Super Units (ZIU), have recently been introduced on the American Stock Exchange. For discussions of a variety of composite asset alternatives, see Rubinstein (1989) and Harris (1990 JFM).

[7] Instinet Corporation also runs the Instinet Real Time Trading System, an anonymous, negotiated, electronic trading system.

[8] The NYSE also offers Crossing Session II for aggregate-priced multi-stock orders. All Crossing Session II orders are two-sided. Orders must be trades of at least 15 listed stocks with a value of at least $1 million. No order matching is done in Crossing Session II. Rather, previously agreed-upon trades are executed.

[9] A block trade is front run when the broker, or some other trader who is aware of the pending trade, makes a trade before the block trade to profit from the price impact of the block trade. It is generally illegal for a broker to front run a customer.

[10] The Crossing Network and AZX report share matching rates of 7% and 5%, respectively. These rates are not automatically comparable to each other or to matching rates on other crossing networks or exchanges. For both The Crossing Network and AZX, matching ratios are higher for liquid and high capitalization stocks, for unconstrained orders, and for orders matched than for shares matched. This is because large orders are completely filled less often than small orders. POSIT does not keep data on unfilled orders or on matching rates. Matching rates are not relevant for Crossing Session I since the majority of orders are two sided.

[11] Transaction costs include commissions, bid-ask spread, and risk of market impact. Fund participants pay usual investment management fees but (at WFNIA) there are no additional charges when they trade in the internal market.

[12] For domestic stocks, this estimate assumes commissions of 4¢ per share, 1/2 bid-offer spread of 23 bp for S&P 500 stocks, 90 bp for extended market stocks, and 168 bp for low-cap stocks; for international stocks an average of 101 bp in costs are assumed.

[13] The NYSE still opens daily trading with a call market.

[14] While removing large informationless trades may have benefits in a specialist-based exchange, removing all informationless trades would not be beneficial and could even result in no trading. Black (1991) suggests that an exchange should address the needs of its informationless traders so that they do not migrate to other trading venues.

[15] We assume that the transaction costs in the internal market are zero. To model crossing networks, a cost function should be added for internally crossed trades.

[16] The authors wish to thank Klaus Toft for discussions helpful to developing of the model.

[17] Hereafter, the subscript i in $L_{i,t}$ will be suppressed when it is possible to do so without ambiguity.

[18] Because C_1 appears in both the numerator and denominator of the ratio, we are in effect calculating

$$1-E\left[\left|\sum_{i=1}^{N} L_{i,T}\right|\right] \Big/ E\left[\sum_{i=1}^{N}\left|L_{i,T}\right|\right].$$

This is not the same as the expected matching rate, which is:

$$1-E\left[\left|\sum_{i=1}^{N} L_{i,T}\right| \Big/ \sum_{i=1}^{N}\left|L_{i,T}\right|\right].$$

The two are, however, approximately equal. Numerical estimation shows that

$$E\left[\left|\sum_{i=1}^{N} L_{i,T}\right| \Big/ \sum_{i=1}^{N}\left|L_{i,T}\right|\right] \approx \frac{1}{\sqrt{N}},$$

and that for $N > 10$, the approximation is within one per cent.

[19] While the majority of WFNIA's S&P 500 index funds open weekly, a few open daily.

[20] Implicit in the choice of risk-adjusted cost function is an assumption that the crossing rate and the realized opportunity costs are not correlated. For large N, the assumption is a good approximation; for very small N it is not.

The term ρ is a measure of a participant's tolerance for variation in transaction costs. The fourth term of

$$V, \int_0^T E\left(C_2\left|L_2\right|\right)^2 dt \Big/ T \cdot \upsilon,$$

emphasizes a participant's aversion to large temporary liquidity imbalances. (For example, a four-week period with three weeks of zero-liquidity imbalance and one week of $400,000 imbalance would be less desirable than a four-week period with a constant imbalance of $100,000.) The term υ measures a participant's tolerance for such temporary imbalances. An alternative risk-adjusted cost function would be to replace the fourth term of V with

$$\operatorname{var}\left(\int_0^T C_2\left|L_t\right| dt\right) \Big/ T \cdot \upsilon.$$

Such a specification emphasizes a participant's aversion to variation in cumulative opportunity costs.

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The Future of Futures

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Introduction

This chapter describes the evolution of the financial infrastructure into the next century. We argue that derivative instruments are one of the foundations of this new infrastructure. We focus on the significant and expanding role that derivatives will play in reducing the frictions involved in providing financial services. This reduction in frictions will enable investors to do business more efficiently and profitably. Moreover, it will reduce the cost of capital to firms.

After an overview of recent developments in financial innovation and change, we discuss the ability of derivative instruments to reduce frictions. Derivatives break cashflows into finer gradients and thus provide investors and issuers with the particular cashflows they desire. We view derivatives as elemental building blocks in creating tailor–made investments that provide payoff patterns to match investors' demand. This customizing ability of derivatives is the basis for the evolution of the financial infrastructure. Subsequent sections of the paper address issues relating to this evolution from the viewpoints of financial institutions, regulators, and academic researchers.

Background

Over the last ten to fifteen years, we have witnessed an explosive growth in financial innovation and new financial products. For example, ten years ago, automatic teller machines were rarely used to facilitate transactions processing. Almost all entities now accept credit cards in