Hedge Fund Stuff

SPRING 2001 SEMINAR

Saddlebrook Resort, Wesley Chapel, Florida
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"EMERGING TOPICS

IN FINANCE"

THE INSTITUTE FOR QUANTITATIVE RESEARCH IN FINANCE®
"The Q-Group"®

INSTITUTE FOR QUANTITATIVE RESEARCH IN FINANCE®

SUMMARY

SPRING 2001 SEMINAR
APRIL 1 – APRIL 4, 2001

SADDLEBROOK RESORT
WESLEY CHAPEL, FLORIDA

I. INTRODUCTION, SUMMARY AND CONCLUSIONS

Martin Nowack delivered the opening address at the Spring 2001 Seminar of The Q-Group®, discussing Darwinian evolution of cooperation and fairness.

Under the topic Market Liquidity, Richard Roll presented an analysis of a new and very large data set containing 3.5 billion transaction records, dealing with both liquidity issues and the effects of order imbalances. Ananth Madhavan offered the results of analyzing a large data base of trading costs, relating liquidity, volatility and cost of trading.

Hedge funds were the topic of presentations by Andrew Weisman, who gave an overview of hedge fund activities and offered insights into the returns generating process, by Stephen Brown, who had developed quantitatively based style benchmarks, by Tony Kao, who discussed hedge fund risks, and by Narayan Naik, who derived hedge fund characteristics from time series of returns.

Cyrus Ramezani discussed real options and presented a quantitative analysis correlating the real options in a series of industries with measures of performance.

Stewart Myers presented a concept of financial architecture and discussed what affects the suitability of public ownership and of the conglomerate form.

Jack Treynor offered a quantitative description of the formation of market bubbles, based on rational investor behavior.

Albert Kyle offered a model motivated by the LTCM collapse of 1998 that showed the consequences of the wealth effect of hedge funds.

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1. The Evolution of Fairness

Martin Nowak, Professor of Theoretical Biology at the Institute For Advanced Study, Princeton University, had presented a paper at the Fall 1999 Q-Group® Seminar entitled: "The Evolution of Cooperation" (See Volume 5 of Q-Group® summaries, page 38). In this, the opening address of the Spring 2001 Seminar, he reviewed that previous presentation and extended it beyond "cooperation" to reach "fairness".

As he had done in his previous presentation, Nowak began with three elements of Darwinian evolution: reproduction, mutation, and natural selection (or competition). Although we do not have a complete theory of evolution, we can see that genes develop to genomes, single cells develop to multi-cellular organisms, and individuals form societies, all processes that require cooperation. (Cancer is an example of what happens when cooperation breaks down.)

So cooperation has evolved, and the question is how does cooperation emerge from natural selection?

Our theory says that cooperation among relatives takes place when $r > c/b$, where r is the coefficient of relatedness, c is the cost of cooperation and b is the benefit.

It is relatively easy to understand cooperation among relatives, but what about cooperation among non-relatives? John Maynard Smith developed from Von Neumann and Morgenstern Game Theory an evolutionary game theory whereby successful strategies are spread by natural selection. Nowak used as an example the "prisoners' dilemma," something he had discussed in some detail at the previous presentation. Even though the total benefit to the two prisoners is largest if they cooperate, natural selection seems to force both to act so as to minimize the total benefit to both. To explain how natural selection brings about cooperation, we examine three possibilities. Direct reciprocity is one. I help you because I expect you to help me in the future. One version of this is "tit-for-tat." It turns out that such a rigid rule is too unforgiving to lead to cooperation. But tit-for-tat coupled with random forgiveness can lead to cooperation.

A second possibility is indirect reciprocity. I help you because I expect someone else to help me. In this case it is my reputation that I expect to lead to my reward. Once again, natural selection can lead to cooperation.

Spatial game dynamics is another such evolutionary path.

Finally, Nowak turned to the manner in which natural selection can lead beyond cooperation to fairness. He invited the participants to join in "the ultimatum game." Two players receive $100,000 if they can agree how to split that sum. One of the players must propose the manner of sharing, and the other player either accepts or rejects the proposal. On acceptance, the money is divided. On rejection, neither player receives anything. Nowak posed two questions: As the first player, what division would you propose? As the second player, what proposal would you accept? It turns out that most times the game is played the first player proposes keeping 50% to 70% and the second player accepts a proposal within this range. Why does the first player ask for no more than 70%? Because of the likelihood that the second player will reject such a proposal. Some might see this result to be irrational. Why would the second player reject a free benefit, no matter how small? Once again, natural selection embraces reputation effects so that self-interest is

aligned with fairness. For the second player to reject a low offer involves an immediate cost, but buys a reputation for demanding fair treatment that is likely to lead to better offers in the future.

I. Liquidity

(topic continued on Wednesday)

2. Market Liquidity, Trading Activity, and Order Imbalance

Richard Roll, holder of the Allstate Chair in Finance at the Anderson School of Business Administration, UCLA, distributed two papers by himself, Tarun Chordia, and Avanidhar Subrahmanyam. The first, to be published in the *Journal of Finance*, was entitled: "Market Liquidity and Trading Activity," and the second was: "Order Imbalance, Liquidity, and Market Returns."

Roll began with the first paper and discussed the data underlying the analysis reported in both papers. The data set covered transactions on the New York Stock Exchange for the calendar years 1989–1998, 2779 trading days. Every transaction was time stamped, with price, number of shares, associated bid and ask, and the depth corresponding to each. There were approximately 3.5 billion transaction records. Roll described a number of filters applied to remove apparent errors and anomalous records, affecting less than 0.02% of the records. For each transaction seven variables were defined. These were the *quoted spread*, the *percent quoted spread* (the quoted bid-ask divided by the mid-point of the quote in percent), the *effective spread* (the difference between the execution price and the mid-point of the prevailing bid-ask quote), the *percent effective spread* (the effective spread divided by the mid-point of the prevailing bid-ask quote and expressed as a percent), *depth* (the average of the quoted bid and ask depths), *dollar depth* (the average of the ask depth times ask price and the bid depth times bid price), and the *composite liquidity* (percent quoted spread divided by dollar depth). These data items were averaged over the stocks traded on each trading day. In addition, three variables were calculated: the total share volume each day, the total dollar volume each day, and the total number of transactions each day.

The questions explored in the first paper were:

- How much do liquidity and trading activity vary over time?
- Are there regularities in the time-series of daily liquidity and trading activity? For example, are these variables systematically lower or higher during certain days of the week or around scheduled macroeconomic announcements?
- How does recent market performance influence the ease of trading on a given day?
- What causes daily movements in liquidity and trading activity? Are they induced, for example, by changes in interest rates or in volatility?

In addition to the data described above, from the NYSE records, the research required interest rates, term spreads, quality spreads, daily stock returns (CRSP Index returns), identification of the day of the week on which trading was taking place, and identification of holidays, with dates of announcement of GDP, unemployment and CPI.

Responding to the first question above, Roll showed that the effective spread and the proportional effective

spread had steadily declined in the latter half of the time period studied, with an abrupt decline in both depth and spread around June 1997, when the minimum tick size was reduced from 1/8 to 1/16 on the NYSE. Effective spread was considerably smaller than quoted spread, evidently reflecting within-quote trading.

In response to the second question, there proved to be far more volatility in volume and in transactions than in other variables, including spreads and depths. Spread changes were negatively correlated with depth changes, but there was little correlation between changes in the market-wide quoted and proportional quoted spread and share or dollar volume. Effective spread measures were actually positively correlated with share and dollar volume. Further, the correlations between various spread changes and the number of transactions were also positive.

What was perhaps more interesting was that every series except price exhibited statistically significant negative first order autocorrelation with some evidence of negative second order autocorrelation. Fifth order coefficients were uniformly positive and about half of them significant, indicating the presence of a weekly seasonal (because the trading week is five days). The four spread measures had the largest negative first order autocorrelation coefficient of all variables. The evidence suggested that negative serial correlation is an inherent property of the true time-series process followed by liquidity.

Turning to the third question above, the possible effect of market performance, Roll discussed the importance of the signed concurrent daily return, a measure of recent market history, in the form of a signed 5-day moving average of past returns, and a measure of recent market volatility.

Overall, the evidence can be summarized as follows:

- Quoted spreads, depths, and trading activity respond to short-term interest rates, the term spread, equity market returns, and recent market volatility.

- Depth and the composite measure of liquidity respond to recent market trends.

- Effective spreads respond strongly to equity market returns, recent market trends, and recent market volatility.

- Spreads respond asymmetrically to contemporaneous market movements, increasing much more in down markets than they decrease in up markets.

- There is strong evidence that liquidity and trading activity drop on Fridays relative to other days of the week.

- Tuesday tends to be accompanied by increased trading activity and increased liquidity relative to other days of the week.

- Depth tends to decrease and trading activity tends to increase around major holidays.
- Both depth and trading activity increase prior to announcements of GDP and unemployment rates.

- Impending CPI announcements do not seem to influence either liquidity or trading activity. Evidently, inflation has been relatively easy to predict in the U.S. recently.

The second paper dealt specifically with the effect of order imbalances. For this analysis it was necessary to identify each transaction as either buyer-initiated or seller-initiated, and the authors used the Lee and Ready

algorithm published in 1991. Three order imbalance variables were: OIBNUM (the number of buyer-initiated less the number of seller-initiated trades on a day), OIBSH (the buyer-initiated shares purchased less the seller-initiated shares sold on the day) and OIBDOL (the buyer-initiated dollars paid less the seller-initiated dollars received on the same day). An interesting result was that market order imbalances have significant positive autocorrelations up to five daily lags but the S&P 500 return has no autocorrelation of any significance.

Summarizing the conclusions to be drawn in this second paper, Roll reported:

- Order imbalances are strongly and positively autocorrelated.
- Order imbalances are strongly related to past market returns. There is evidence of aggregate contrarian behavior; signed order imbalances are high following market crashes and low following market increases. Since returns on the S&P500 are virtually uncorrelated, this is evidence that investor actions to correct temporary mispricing are effective and of the appropriate magnitude.
- Changes in market-wide liquidity are strongly and non-linearly related to changes in the market-wide order imbalance. A high order imbalance in either direction is associated with low levels of liquidity.
- Liquidity changes are predictable from market returns, but not from order imbalance. In particular, down market days tend to be followed by days of decreased liquidity. Up market days tend to be followed by days of high liquidity, but the carry-over is weaker.
- There is a strong positive relation between market returns and contemporaneous order imbalance.
- Surprisingly, up-markets tend to be followed by continuations while down-markets tend to be followed by reversals. However, as might be expected, the explanatory power is not very strong. Overall, the evidence suggests that market microstructure effects are quickly absorbed by the market; there is only weak evidence that daily signed market returns can be predicted to any significant degree using past values of liquidity and order imbalances.
- Order imbalances are strongly related to contemporaneous absolute returns after controlling for market volume and market liquidity. This underscores the importance of accounting for order imbalance in addition to volume, as a determinant of return volatility.

II. Hedge Funds

3. Overview of the State-of-the-Art in Hedge Funds

followed by

Dangerous Attractions: Informationless Investing and Hedge Fund Performance Measurement Bias

Andrew Weisman, Chief Investment Officer, Nikko Securities, Co. International, Inc., distributed a paper entitled: "Dangerous Attractions: Informationless Investing and Hedge Fund Performance Measurement Bias."

Weisman began with a discussion of the hedge fund industry, tracing the

evolution from private partnerships making heavy use of speculative tools like leverage and hedging, charging substantial incentive performance fees, aimed at wealthy and/or sophisticated investors, to the present day hedge funds with publicly offered units, and a wide variety of participation forms and investment strategies. He stressed that there is no established classification system by which investors can reasonably compare performances and judge risks.

It is difficult to obtain useful data for hedge funds. There are at least three sources of data collected from the funds, but fund reporting is optional. Some funds have never reported; some report the performance of some portfolios but not all; and it is particularly difficult to learn anything about the performance of funds that have failed and shut down. It is also true that most hedge funds have very short histories.

Turning to his paper, Weisman had undertaken to provide some insights into some of the return generating processes of hedge funds that are probably not well understood by investors. He argued there is an over-reliance on conceptual frameworks and technologies that are appropriate to the traditional investment world but highly inappropriate in the context of hedge funds. More specifically, analyzing the apparent performance records of hedge funds using traditional tools, and applying traditional portfolio optimization models to these performance data may lead to disastrous conclusions. The paper dealt with three specific "informationless" investment strategies. Weisman believes them to be endemic to the hedge fund industry, and indicated that a careful analysis of the published performance results of a hedge fund may indicate or at least suggest the use of informationless strategies, and a potential investor should therefore understand what these strategies are likely to lead to.

The first strategy he discussed is short-volatility investing. This can be described as essentially equivalent to writing insurance policies against low probability events. An example is investing all of the fund's capital at the risk free rate, say 5%, and then at the beginning of every month selling a series of fairly valued calls and puts that expire at the end of the month. The strike prices might be 2.5 standard deviations above and below, respectively, the current market price of some financial instrument. The manager sells a sufficient number of these "strangles" such that in the event the market remains within the 2.5 standard deviation collar, the premiums received will double the risk free rate. The manager is clearly making no use of any judgment other than an expectation that the options are unlikely to be exercised. A Monte Carlo simulation shows that the manager has approximately an 88% chance of outperforming the risk free rate in any year and almost an 86% chance of doubling it. The manager has an almost 50% chance of doubling the risk free rate over any five year period. The expected time to a monthly outcome where the underlying security trades outside the collar by month-end, resulting in a loss of capital, is almost seven years. The strategy then has a high probability of success over a limited future. But as the probability of outperforming the risk free rate increases, the size of the anticipated loss of capital increases at an increasing rate. Weisman showed this graphically. At an 88% chance of outperforming the risk free rate, the corresponding expected loss of capital is approximately 32%. This should not be surprising, since we are assuming that the options are fairly valued, and the "informationless" process of selling options should have a zero expected value, so that an equalizing event is

necessitated, and that event is the loss of 32%. This return generating process is, of course, utterly unlike the process one would expect to underlie long positions in speculative stocks.

The second form of informationless investing is illiquid security investing. If a manager is unable or unwilling to value accurately the fund portfolio on a periodic basis, reported returns will be inaccurate, and the standard deviation in returns will probably be substantially underestimated. The result is that the Sharpe Ratio may appear extremely high (and Weisman pointed out that Sharpe Ratios are much touted by hedge funds).

The third informationless investment technique is St. Petersburg investing. The St. Petersburg Paradox refers to a strategy of making bets on the outcomes of a binomial process such as a coin toss. Upon winning, one bets again with the same unit size. Upon losing, the loser bets two units on the subsequent trial. Another loss leads to doubling up by betting four units. Even though the coin is assumed to be fair the strategy has an infinite expected value. The paradox is that without unlimited funds, the strategy will lead to bankruptcy with a probability of one. The investment analogy is that of a manager increasing leverage as investment losses deplete capital. Weisman showed the results of a randomly generated sample monthly performance history for a manager operating in this way, to show a fairly prolonged period of consistent profitability ending in a complete loss of capital. More specifically a Monte Carlo simulation indicated the expected time to a month-end loss of 50% was approximately four hundred weeks. As in the previous examples, the fund is likely to enjoy a few years of very attractive performance results.

In conclusion, a very attractive apparently superior performance record over a few years for a hedge fund is quite consistent with ultimately disastrous informationless investing strategies. The investor who does not understand this, or is unable to determine just what the hedge fund is doing, is in trouble.

4. Hedge Funds With Style

Stephen Brown, David Loeb Professor of Finance, Stern School of Business, New York University, distributed a paper by himself and William N. Goetzmann entitled: "Hedge Funds With Style."

He began by reiterating the need expressed by Andrew Weisman in the preceding presentation, for style benchmarks. And he suggested quantitatively derived style benchmarks. He had found that differences in investment style contribute about twenty percent of the cross-sectional variability in hedge fund performance. He also explored the meaning of "hedging" to point out that while the pioneer Alfred Winslow Jones had put genuine hedges in place in order to minimize or eliminate market risk, Jones' successors did not hedge in the usual sense. Most current hedge fund strategies are very aggressive and far from the low or zero risk that the word "hedge" suggests.

TASS, a major data service, has classified hedge funds into seventeen different types. This classification is based in large part on manager survey responses and is therefore vulnerable to the manner in which mutual funds describe themselves. It appears that when funds change their self-classification the effect is generally to increase their returns relative to a newly

defined benchmark. Brown went on to describe his Generalized Style Classification (GSC) methodology, which is based on ex post returns of individual funds. Where the number of styles is set at eight, it turns out that class GSC1 corresponds to event driven international, GSC2 to property/fixed income, GSC3 to U.S. equity focus, GSC4 to non-directional/relative value, GSC5 to event driven domestic, GSC6 to international focus, GSC7 to emerging markets, and GSC8 to global macro. This classification scheme seemed to work quite well, with about twenty percent of the cross-sectional variance explained by prior returns-based classifications. This was an improvement over the use of the TASS classifications.

Turning next to the matter of predicting fund performance with style, Brown showed scatter plots of fund returns year by year from 1993 through 1999 as a function of the annual fund return in the previous three years. It turns out that there is very little evidence of persistence in annual hedge fund returns. But members of a style category tend to cluster together.

Next, Brown considered whether hedge fund styles separate managers out in terms of the risk they are willing to bear. For this purpose median value-at-risk for each of eight GSC styles was calculated for 1993-1999. Management styles grouped into three distinct risk classes. The global equity hedge, U.S. equity hedge and global macro styles clustered together in the highest risk class. International and emerging markets were in the intermediate class, and the remainder were in the lowest class.

In conclusion, Brown said:

- There is no well defined "hedge fund" style.
- There are at least 8 distinct styles.
- Styles explain 20% of cross-sectional variation among fund returns.
- Styles also explain differences in risk.
- There is a danger in the use of self-misclassification.
- Appropriate analysis of style, independent of the manager's preference, is crucial.

5. Analyzing Hedge Fund Risks: An Overview

Tony Kao, Managing Director, General Motors Investment Management Corporation, distributed a paper entitled: "Analyzing Hedge Fund Risks."

Kao described the challenge in these terms: One of the emerging applications to active institutional investing is to transfer alpha from hedge funds to a specified asset class. Issues arising from such an approach include: (1) Do these alphas present different distributions from traditional long-only active alphas? and (2) Do these two types of alpha derive from different risk factors? His presentation provided empirical evidence of return sources of long-only versus long/short investing and potential explanations from the standpoint of compensation and investment constraints.

Turning to the classification of hedge funds, he identified first order of return distribution, and second order, or volatility. A third system of classification might be based upon trading strategies or styles, but for this no standards exist. Examining differences between hedge funds and institutional asset accounts helps to

identify the advantages enjoyed by hedge funds and to see where risks unique or especially important to hedge funds may lie.

It is helpful to understand hedge fund return patterns. Payoffs are similar to option payoffs as in straddles, collars and calls. Hedge funds appear to have higher risk adjusted returns but this raises the question just what risks are actually being taken. Individual funds have low correlation to asset class returns. Correlations across fund categories are very low, but within categories range from .05 (non-directional) to .68 (directional). Within a specific hedge fund, diversification among yield-to-call/put, capital structure arbitrage, multi-class stock arbitrage, paired trade, and special situations is generally quite low.

The return generating process for a hedge fund is complex, so it is difficult to identify systematic risks. Hedge fund risk is a function of leverage, instruments and markets traded, market volatility, strategy diversification within the fund, and liquidity. Kao went on to discuss asymmetric return sensitivities to risk factors in different market environments. Monthly correlations, for example, in fixed income markets are very different in rising and declining interest rate environments.

He identified a number of approaches to risk analysis of hedge funds. These include conventional risk measures, asset class factor analysis, economic/market risk factors, mimicking portfolio/strategy approach, and an integrated risk approach. Discussing each of these in turn, he gave as examples of conventional risk measures the use of standard deviation, drawdowns, and percent of negative months. The Sharpe Ratio, the information ratio, efficiency ratio, appraisal ratio and value-at-risk are further conventional measures. The mimicking portfolio/strategy approach can be especially useful, and Kao offered a number of references on the subject. Finally, he reviewed an integrated risk analytical approach.

He ended his presentation with a series of investment implications.

- Correlation measures can be misleading. One should examine relationships under various market conditions and factor exposures.
- Strategy diversification between funds as well as within funds is important to consistent performance.
- One should distinguish different types of diversification. Some are good, and some are not so good. It is best to assume no diversification benefits under a worst case scenario for value-at-risk.
- It is useful to look for common factors driving both hedge funds and long-only funds.
- How a fund manages its exposures to implied volatilities in extreme cases is the key to consistent performance.
- Optimization requires understanding risk profiles — directionality and volatility exposures.
- Understanding a manager's style drift, changes in leverages, and in concentrated positions is important.

6. Performance Evaluation of Hedge Funds With Option-Based and Buy-and-Hold Strategies

Narayan Naik, Associate Professor of Finance, and Director of the Centre for Research and Education in Hedge Funds, Department of Finance, London

Business School, distributed a paper by himself and Vikas Agarwal, entitled: " Characterizing Hedge Fund Risks with Buy-And-Hold and Option-Based Strategies." He began by posing the question: Given only a series of rates of return for a hedge fund or a group of hedge funds, what can we learn about the characteristics of the funds and in particular the nature of their risks?

A few graphs based on the Hedge Fund Research (HFR) database comparing hedge fund returns with S&P500 Index returns and with quality spreads for bonds suggest that the strategies of a number of classes of hedge funds have produced results similar to those that could be achieved by buying and selling put and call options on stocks, and by taking stock and bond positions. Naik reviewed the reasons why one might expect to come close to replicating the performance of various classes of hedge funds using a set of "Location factors" and one of "Trading Strategy factors." His trading strategy factors were returns on at-the-money and out-of-the-money call and put options on the Russell 3000 Index. The Location factors included returns on thirteen asset classes, including equities, size, book-to-market and momentum factors, bonds and the change in default spread, currencies, commodities, and the return on the CBOE Volatility Index.

The model involved regressing a time series of returns on a hedge fund style index against the set of Location factors and the set of Trading Strategy factors. The two hedge fund strategies were "Event Driven" and "Relative Value Arbitrage". Both of these strategies have been examined in the past, making it possible to compare the results of the current research with what has been found in the past. In other words, it is possible not only to compare the results of the model strategy with the results of the two classes of funds but also to compare them with prior attempts to replicate the two strategies. Naik saw two main advantages in his approach. First he believes it can be universally applied to all hedge fund strategies, and second the approach provides a simple and intuitive way of capturing the important risk exposures of hedge funds.

The returns from Location factors (Buy-and-Hold strategy) are captured by different equity, bond, currency and commodity index returns and by returns to Fama-French's Size and Book-to-Market factors and Carhart's Momentum factor. The returns from Trading Strategy factors are determined from returns on passive strategies that involve buying or writing put or call options on standard asset classes. Monthly net-of-fee returns on Event Driven and Relative Value Arbitrage equally weighted index data from HFR over January 1990 to December 1999 were divided into twenty four-month rolling windows starting from February 1988 and ending in July 1999.

Stepwise regressions were performed, in order to identify the significant factors in the regressions, and it turned out that there were one to four such factors.

Naik first presented a table for the Event Driven strategy. For five two-year periods he showed the alpha of the regression, the adjusted r-squared, and identified the significant factors. For example, for the period January 1990 through December 1991, generally a down stock market, the significant factors were sale of put options on the Russell 3000 index and a short position based upon default spreads. It seemed then, that these factors corresponded to what one might have expected the hedge fund managers to have been doing to profit from a falling market. In this particular example the adjusted r-squared was 0.8. For all five two-year periods the alpha was positive. Naik

commented that this may be due in part and perhaps substantially to selection bias in the calculation of the equally weighted index. Naik also reported that the factors that had proved significant were very similar to the factors found by previous researchers for this hedge fund style.

Naik continued with similar tables for the capital structure arbitrage strategy, the equity hedge strategy, the short strategy, the long strategy, the HFR relative value arbitrage index, the HFR restructuring index, and the HFR hedge (long bias) index. The adjusted r-squareds were generally quite high, although they varied a good deal from time period to time period, and the significant factors seemed intuitively appropriate to the style being considered.

In his presentation, Naik described analysis using index returns. In the full paper he also discussed analysis using individual funds in the Event Driven and Relative Value Arbitrage groups. A large majority of funds showed significant factor loadings on up to five factors. Simple option-based trading strategies played a major role in explaining the variation of return on these hedge funds over time. For the Event Driven strategy a majority of funds showed significant loading on the Fama-French Size factor. For the Relative Value Arbitrage funds, again a majority showed significant loading on the same factor and also on the Value-Growth factor.

Naik also performed out-of-sample tests using the results of a twenty-four month regression to predict fund characteristics in the twenty-fifth month. The results were encouraging.

In his concluding remarks Naik noted the importance of his "Trading Strategy" factors in mimicking the return pattern of hedge funds. The inclusion of option buying/writing strategies captures non-linear risk exposures that are peculiar to these funds. His general approach is applicable across hedge fund strategies and is potentially useful in asset allocation, the construction of an appropriate fund of hedge funds, in risk control and in the design of benchmark and managerial compensation contracts.

III. Real Options

7. Real Options: A Survey of Theory and Applications

Cyrus A. Ramezani, Associate Professor of Finance, College of Business at the California Polytechnic State University, distributed an outline by himself and Alan Jung.

Ramezani began with an overview of real options, describing them, providing a taxonomy, listing the reasons why real options can be valuable, and going on to discuss difficulties in implementation. The value of real options lies in its usefulness as a framework for structuring business decisions. For example, it can be an improvement on discounted cash flow for capital budgeting. While it is relatively easy to conceptualize real options, it is not easy to detect them. The parameters that can be used to value financial options are very hard to quantify for real options. And it may be difficult to translate the value of a real option into observable performance metrics like return on investment, return on equity, and economic value added.

(Jonathan B. Berk presented a paper at the Fall 1998 Q-Group® Seminar entitled: "Valuation and Return Dynamics of New Ventures," in which he described valuation of a project with no current cash flows essentially

undertaking an R&D program with several sources of uncertainty. Real options played a major role in his analysis. This summary can be found in Volume 5 of Q-Group® summaries at page 162.)

Two key ingredients in real option value are management flexibility and uncertainty of investment cash flows. Both flexibility and volatility add to the value of the option. One can then think in terms of a chart with four quadrants, with low option value corresponding to low volatility and limited managerial flexibility and high value corresponding to high volatility and a high level of managerial flexibility. Ramezani suggested low volatility with high flexibility tended to lead to low option value whereas high volatility but low flexibility would probably lead to high option value.

The next step was identifying variables that measure managerial flexibility and those that measure volatility. For measuring managerial flexibility he proposed expenditures on investment activities from the firm's statement of cash flows relative to sales, book value of assets, and market value of assets, as well as research and development expenditures relative to sales or other measures. For uncertainty he proposed volatility of quarterly sales growth, of cash flow growth, and of monthly returns, both in terms of market volatility and idiosyncratic volatility.

For performance measures he proposed economic value added, market value added, Tobin's Q, return on investment, return on equity, and some other basic ratios.

His next step was to make use of COMPUSTAT data for 1998 from which he drew a sample of 2926 firms with "clean" data. He calculated economic value added and market value added, taking other measures from COMPUSTAT's own calculations. He ended with four measures of managerial flexibility: investment cash flow/sales, investment cash flow/book value, investment cash flow/market value, and R&D/sales. And he chose five measures of volatility: volatility of quarterly sales growth, of quarterly cash flows, of monthly returns, risk as measured by beta, and idiosyncratic risk (the residual from applying CAPM). Data were sorted by the median of variables, and companies were allocated to the four quadrants referred to above.

A regression took the form of the performance measure regressed on a vector of the explanatory variables. The results showed that the conditional means of the performance measures were significantly different for each quadrant. The coefficients of control variables were also very different. Statistical tests indicated that a different model is needed for each quadrant. The adjusted r-squared ranged from 0.20 to 0.67. Ramezani presented tables showing the beta risk, the idiosyncratic risk, and the total risk for the HH and LL quadrants.

The main industries in the HH quadrant were mining and oil and gas extraction, chemicals chiefly pharmaceuticals, semiconductor equipment, electronic computers, semiconductors, and communication and software. The main industries in the LL quadrant were construction, food, newspapers and periodicals, plastics materials and synthetic resins, pharmaceutical preparations, primary metals, electronic computers, transportation equipment, and general merchandise stores.

The main industries in the high volatility but low flexibility quadrant were chemicals, communications equipment, semiconductors, apparel, miscellaneous retail, direct mail

advertising, and software. Those in the low volatility but high flexibility quadrant were oil extraction and refining, food, paper, pharmaceuticals, electronic computers, semiconductors, motor vehicles, air transportation, and computer software.

Finally, he concluded that performance measures for firms with valuable real options are significantly higher than those without such options. Equity prices also seemed to reflect the value of real options. Looking forward, he indicated further enhancements to be incorporated in the model include pooling time series/cross sectional data, correcting for heteroskedasticity, expanding the list of explanatory variables, and removing companies that fall fairly close to the intersection of the four quadrants.

8. Financial Architecture

Stewart C. Myers, Gordon Y. Billard Professor of Finance, Sloan School of Management, Massachusetts Institute of Technology, distributed a paper entitled: "Financial Architecture."

Financial architecture, a term proposed by Myers, is something broader than corporate control or corporate governance. It means the entire financial design of a business, including ownership, the legal form of organization, incentives, financing and allocation of risk.

Most of the theory and standard practice of corporate finance has developed with a particular financial architecture in mind. Generally it is that of a public corporation in a country such as the U.S.A. or U.K. with well developed securities markets. But even in those countries there are other distinct and successful architectures.

He introduced his talk by discussing two questions. The first is why some kinds of business firms go public while others do not. The second is why some types of conglomerates are successful while others are not.

What are the reasons for going public? One is access to financing. Another is liquidity for early private investors. Another is the determination of an objective value of a company. Myers pointed out that a related objective may be receiving applause or derision from investors with respect to company activities. Finally, stock can be used to compensate management. The company can pay employees for services that will confer a future benefit.

On the other side, objections to going public include the hassle, the paperwork, and the imposition of regulation. Investors may be poorly informed and perhaps shortsighted. And effective control over management by dispersed outsiders can be difficult.

In considering why high-tech firms go public, it is useful to consider the sequence of events in a business plan for such a company. At stage 1, proving the concept and manufacturing process, the entrepreneur or scientist is essential. The same is true of stage 2 comprising pilot production and sales. In stage 3, where product improvement and manufacturing take place, the entrepreneur is valuable but perhaps not essential. At the full production stage, the entrepreneur is probably helpful but replaceable. At the final stage of follow-on activities the entrepreneur is simply not needed. From the point of view of the entrepreneur or scientist, the incentive to work hard and bear great risks is likely to be the prospect of ultimately going public. The question then is at what point should the firm go public.

The answer is somewhere around stages 2, 3, and 4, that is while the entrepreneur is still important but not essential. This strategy is appropriate for both the entrepreneur and the private investor who carries the firm's financial needs during the early years.

Myers took a further example: biotech start-ups. For these companies, assets are intangible, and there is high uncertainty at the early stages of development. It is difficult for outside investors to evaluate performance or prevent waste or capture of resources. Investment requirements are substantial, nevertheless, biotechs go public "early." Why is this so? Investors in the IPO are patient and can diversify. The payoff to insiders depends on the price of shares. There is a very large upside potential if the R&D succeeds. And if it succeeds, the value of the product is reachable by outside investors, the interests of insiders and investors are aligned, and dispersed ownership limits investor power. Especially if the product is a patented FDA approved drug, investors are protected from theft, transfer or expropriation.

A management consulting company, on the other hand, has assets that are almost entirely human capital. Assets are not reachable by outside investors. Outside investors could not evaluate performance or prevent waste or capture of resources. Investment requirements are small, and management consulting companies are almost privately held. Myers commented that those that have gone public have generally not been successful. The key idea here is that a combination of human capital and financial capital needs set the stage for public financing.

Turning to the matter of conglomerates in the United States, Myers suggested that the advantages claimed for this form of business are internal diversification and reduction in risk, superior management, and increased shareholder value from growth in earnings per share. Why then have most conglomerates not been successful? Top management may have added value in some cases, but continuing synergies were rare. Diversification for risk reduction does not add value. U.S. conglomerates already had relatively easy access to capital markets, so there was little need for internal capital markets. Furthermore, internal capital markets often misallocate capital. It is impossible to observe the market values of divisions within a conglomerate, and therefore difficult to set incentives for division managers.

At the same time, there have been some successful U.S. conglomerates. These include private investment companies and partnerships, for example those engaged in venture capital, merchant banking, and LBO firms. But these are *temporary* conglomerates, their strategy is to buy, fix and improve, and sell. They do not "buy and manage."

Outside the United States, however, conglomerates are quite common. Myers suggested among the reasons: size may give access to financial markets in foreign countries, and especially to international markets. Size and political power may be particularly important in "managed" economies. Family enterprises are important in some countries, and conglomerates may be essentially family owned. Companies in smaller countries may need scale to attract professional management and scale may require diversification. In some countries conglomerates may provide the clout to protect entrepreneurs from political interference.

The key ideas here are that there are many different financial architectures that are adapted to the nature of the business and local conditions. The particular financial architecture should depend on scale and nature of assets. On whether the assets are tangible or intangible. On the significance of assets in place versus growth opportunities. On whether the assets are reachable by financial investors. On the nature of business risk. And on human capital investment versus capital financed by outside investors. Once again, the choice has to do with the relative roles of human and financial capital.

9. The Canonical Market Bubble

Jack L. Treynor, President, Treynor Capital Management, Inc., distributed a paper entitled: "The Canonical Market Bubble." His presentation was a sequel to the presentation he had given at the Spring 1997 Q-Group® meeting, under the title "Bulls, Bears and Market Bubbles." (The summary can found in Volume 5 of Q-Group® summaries at page 154.) In that presentation he had offered a model for market bubbles, assuming that investors held only one of two possible opinions with respect to where the market was going. In the present paper he has taken what he believes to be a more realistic assumption: that value opinions will be distributed, with most investors clustered in the middle and relatively few in the tails (that is at very high and very low expected prices). His initial question was whether a bubble can develop in a market where opinions are continuously distributed, but still rational in the sense of being unaffected by a feedback process.

The model he offered was based on the following propositions:

- Equilibrium market level depends on investors' opinions and their wealth.
- When the market level rises, wealth shifts from pessimists to optimists. When the market level falls, wealth shifts from optimists to pessimists.
- If the wealth shifts are big enough, the new equilibrium will engender further wealth shifts.
- The size of wealth shifts depends on the size of the disagreement in opinions. In a two-opinion market, the key to the precondition for a bubble is the difference.

We assume that in any point in time the distribution of wealth depends only on the market level, and not on the path to that level. We assume that investors do not change their opinions x. We assume they make active bets proportional to their disagreement with the market price p, and their wealth, and inversely proportional to their estimate of the error variance in their opinions σ^2. The path independent wealth function is $f(x,p)$. The fraction of their wealth they will bet is then $\left(\frac{x-p}{\sigma^2}\right)$.

Investors gain or lose when the market level changes according to: $\frac{df}{dp}=\left(\frac{x-p}{\sigma^2}\right)f(x,p)$.

This differential equation leads to $\ln f=\frac{1}{\sigma^2}\left(xp-\frac{p^2}{2}\right)-\frac{K}{2\sigma^2}$ where K is any constant of integration.

$$\text{Hence,}\quad \ln f=-\frac{1}{2\sigma^2}\left(p^2-2xp+k\right),$$

and $f(x,p)=e^{\frac{-\left(p^2-2xp+K\right)}{2\sigma^2}}$

Next, in order for active long positions to offset active short positions, the equilibrium price $\hat{p}$ must satisfy $\int\left(\frac{x-\hat{p}}{\sigma^2}\right)f(x,p)dx=0$.

It follows that, at equilibrium:

$$\int xf(x,p)dx = \hat{p}\int f(x,p)dx$$

$$\hat{p} = \int xf(x,p)dx.$$

Now when the perceived market level p changes, the equilibrium price $\hat{p}$ also changes, so we have: $\frac{\partial \hat{p}}{\partial p} = \int x\frac{\partial f}{\partial p}dx.$

Using our differential equation in $f(x,p)$ we have:

$$\frac{\partial \hat{p}}{\partial p} = \int x\left(\frac{x-p}{\sigma^2}\right)f(x,p)dx$$

$$= \frac{1}{\sigma^2}\left[\left(\hat{\sigma}^2 + \hat{p}^2\right) - p\hat{p}\right] \approx \frac{\hat{\sigma}^2}{\sigma^2},$$

for small changes in p. Here $\hat{\sigma}^2$ is the true error variance of investor opinions, while σ^2 is the error variance perceived by investors.

The relation between the two error variances is the key to whether a given change in price will elicit a still bigger price change towards equilibrium in the same direction. Treynor noted that the harder the market is to value — that is, the less concrete the sources of its prosperity — the easier it is for active investors to have systematically biased opinions about the accuracy of their appraisals, and therefore produce $\sigma^2 < \hat{\sigma}^2$, and $\frac{\partial \hat{p}}{\partial p} > 1$.

It turns out then that the ratio of the error variance is a key measure. It is a measure of investors' hubris regarding their errors. It also governs the size of active investors' positions and hence the size of the wealth transfers when the market level changes. *It is the precondition for a bubble.*

The canonical model does not require investors to change their opinions. Indeed, we have assumed they do not change them. The model does require them to make bets that are proportional to their wealth, and to disagree. Unless one were to insist that mere disagreement is necessarily irrational, this model is based on rational behavior. But in the model the equilibrium corresponding to a give set of investor expectations is not unique: the same expectations —and even the same initial wealth endowments— can ultimately result in many different equilibrium market levels. Changes in the market level can be non-random, even if expectations are rational.

Interesting questions are who buys? and who sells? as the price changes.

If investors obey our betting rule, the position h of an active investor with opinion x is:

$$h = f(x,p)\left(\frac{x-p}{\sigma^2}\right)$$

Then, when the market level changes, the investor will trade

$$\frac{dh}{dp} = \left(\frac{x-p}{\sigma^2}\right)\frac{df}{dp} - \frac{1}{\sigma^2}f(x,p).$$

As before, the gain or loss incurred is $\frac{df}{dp} = f(x,p)\left(\frac{x-p}{\sigma^2}\right).$

Substituting $\frac{\partial f}{\partial p}$ in the expression for $\frac{\partial h}{\partial p}$, we have

$$\frac{dh}{dp} = \left[\left(\frac{x-p}{\sigma^2}\right)^2 - \frac{1}{\sigma^2}\right]f(x,p).$$

At the boundary between buyer and seller, we have $\frac{\partial h}{\partial p}=0$, hence

$$(x-p)^2 = \sigma^2,$$

$$x - p = \pm\sigma,$$

$$x = p \pm \sigma.$$

We see that the effect of a market level change on extreme investors is dominated by its impact on their wealth, whereas the effect on moderate investors is dominated by its impact on their degree of disagreement. When, for example, the market level rises, the extreme bull responds to increasing wealth by lengthening his position. The extreme bear responds to declining wealth by reducing his short position. Both respond by buying. The moderate bull responds to the reduction in disagreement with the market level by shortening his long position. The moderate bear responds to the increase in disagreement by increasing his short position. Both respond by selling.

Treynor next asked: Who wins? Who loses?

At the beginning of the bubble, we had

$$\ln f(x,p) = -\frac{1}{2}\left(\frac{x-p_1}{\sigma}\right)^2,$$

$$(x-p_1)^2 = -2\sigma^2 \ln f(x,p).$$

Skipping some derivations, and assuming that the integration constant K = x^2, we have:

$$(x-p_2)^2 = -2\sigma^2 \ln f(x,p_1) - \frac{(p_2-p_1)(p_2+p_1-2x)}{2\sigma^2}$$

$$f(x,p_2) = f(x,p_1)e^{\frac{\left[x-\frac{p_2+p_1}{2}\right](p_2-p_1)}{\sigma^2}}.$$

The distribution of *people* —of investors— is almost certainly bell shaped. If they do indeed tend to be steadfast in their opinions during the progress of a bubble, then, as the distribution of wealth moves upward —i.e., toward more optimistic appraisals — away from the bell of the *people* distribution and toward one of the tails. It is moving away from the mass of investor opinions and toward opinions that are both 1) more extreme, and 2) less populated

In the absence of a bubble, wealth accrues to investors who have guessed right. So investors who have guessed right enjoy more economic clout than investors who have guessed wrong. But in a bubble the wealth, hence the clout, ends up with investors who merely hold extreme opinions. Can we be comfortable with the economic signals provided by such a market?

IV. Liquidity (continued)

10. Liquidity, Volatility and Trading Costs Across Countries and Over Time

Ananth Madhavan, Managing Director of Research, ITG, Inc., distributed a paper by himself, Ian Domowitz and Jack Glen entitled: "Liquidity, Volatility and Equity Trading Costs Across Countries and Over Time."

By way of introduction, Madhavan observed that execution costs can substantially reduce or even eliminate portfolio alphas, and he provided an example. Dimensional Fund Advisors 9-10 fund is a passive index fund of stocks in the smallest 9th and 10th deciles of New York Stock Exchange traded stocks. Although apparently an index fund, the fund has achieved mean returns of something over 200 basis points above the index return, with less volatility. Research by Keim, reported by Madhavan, indicated that the fund's trading strategy added about 204 basis points.

In the first part of his presentation, Madhavan undertook to examine the magnitude of equity trading costs across countries and over time. In the second part he set out to analyze the determinants of costs, the interaction of

costs, liquidity and turnover, and to discuss the implications for international portfolio management and diversification.

With respect to the costs themselves, he relied on global trade data from Elkins/McSherry, Inc., covering 135 investing institutions and brokers, over 42 countries, for active trading strategies only. Macroeconomic data came from IFC, the World Bank and local markets. Explicit costs include such things as commissions, fees and taxes. Implicit costs consist of price impact. Price impact is calculated by Elkins/McSherry with reference to a benchmark taken as the mean of the day's open, close, high and low prices.

There is a large variation in trading costs from 22 basis points in the Netherlands to 184 basis points in Venezuela. The mean cost is 60 basis points which can be compared with custody and management fees of approximately 35 basis points. Explicit costs are about 2/3 of the total except in North America. The correlation between explicit and implicit costs is positive, ranging from .09 to .31. A number of graphs illustrated the relative importance of explicit and implicit costs in North American markets and in a number of regional markets. Costs have been falling over the past five years and implicit costs have been falling three times faster than explicit costs. Adoption of automated systems, primarily in emerging markets (where costs are very high) have helped to bring costs down. In developed markets, automation has reduced implicit costs. Further influences are competitive pressures from new markets, increasing competition for order flow, and a shift in investment strategies to find liquidity and minimize costs.

Turning to the determinants of costs, Madhavan began with correlation analysis. He confirmed that implicit costs are inversely related to market capitalization, and positively related to volatility. Explicit costs are not correlated with the variables he had explored: turnover, market capitalization, volatility, automation, and emerging markets.

The two-way comparisons suffer from a number of limitations. They ignore interaction among key variables. The joint interaction of turnover, volatility and costs is particularly important. Madhavan had therefore developed a panel-data model to investigate dynamic relations among these key variables both across countries and through time. Volatility is taken as exogenous, influencing trading costs and turnover and ultimately returns, while trading costs themselves influence turnover and hence returns.

Summarizing results set out in tables, he reported that lower trading costs substantially increase turnover as does higher volatility. Higher market capitalization leads to reduced volatility, reduced cost and reduced turnover. Higher volatility increases cost but reduces turnover, with a net increase in returns of about 5%. Turning to effects on diversification, there are important difference between optimal portfolios ignoring transaction costs and those allowing for transaction costs.

Finally, Madhavan discussed how one might deal with transaction costs. Monitoring costs is important, and Madhavan elaborated on monitoring. Trading less aggressively and reducing turnover can reduce costs. Accommodating to lack of liquidity can also help.

In conclusion he said:

- Equity trading costs vary widely and are economically significant

- It is crucial to understand interaction of volatility, costs, and turnover
- In a global context, costs may dramatically affect the benefits from international diversification
- One can improve investment performance by focusing on measurement, analysis and control of trading costs.

11. Contagion as a Wealth Effect

Albert Kyle, Associate Professor of Finance, Fuqua School of Business Administration, Duke University, distributed a paper by himself and Wei Xiong entitled: "Contagion as a Wealth Effect."

Much of the motivation for the research came from the Long Term Capital Management (LTCM) crisis of the summer of 1998. At that time LTCM, numerous hedge funds, banks, and securities firms all tried simultaneously to reduce exposure to a variety of financial instruments, including Russian bonds, Brazilian stocks, U.S. mortgages, spreads between on-the-run and off-the-run government securities and spreads between swaps and U.S. Treasuries. During this financial crisis financial intermediaries suffered losses as prices moved against their positions. Market depth and liquidity decreased simultaneously in several markets. The volatility of prices increased simultaneously in several markets. And correlation of price changes of seemingly independent positions of financial intermediaries increased. Commentators used "contagion" to describe the rapid spread from one market to another of these phenomena.

The purpose of the research was to explain contagion with a theoretical model in which increased risk aversion is based on a wealth effect of financial intermediaries. Convergence traders (hedge funds) are assumed to trade in markets for two risky assets. They are perfectly competitive traders who speculate that the transitory effect of noise trading on asset prices will induce temporary deviation of prices from their long-term mean. We assume that noise traders operate in one of the two markets. Noise trading demands liquidity from time to time, which the hedge funds can provide to their advantage. Noise traders also trade on incorrect information, providing further opportunities. A third class of traders in both markets is made up of long-term investors. They are prudent but not fully rational. They follow a robust long-term investment strategy holding risky assets in both markets proportionally to the spread between asset prices and fundamental values. Convergence traders, of course, aggressively exploit short-term opportunities. They are assumed to have logarithmic utility. This utility implies a trading strategy in which both the expected trading profits and the percentage variance of the portfolio equal the short-term (instantaneous) squared Sharpe Ratio in the market. Logarithmic utility also implies a risk management strategy which prevents wealth from dropping to zero through dynamic portfolio rebalancing.

Kyle noted that in addition to the wealth effect motivating convergence traders to reduce positions due to reduced wealth, they have an opposite incentive, a substitution effect, to add to positions because these positions become more profitable as noise trading pushes prices further out of line. Usually, the wealth effect is smaller than the substitution effect and convergence traders respond to noise trading shocks by taking the other side in a manner which reduces volatility and adds to liquidity. In some extreme cases, however, when convergence traders

have unusually large positions, the wealth effect dominates the substitution effect and convergence traders respond to noise-trading shocks by liquidating positions. This is what exacerbates price volatility and consumes some of the liquidity provided by long-term investors.

The model assumes that traders in the financial markets exchange a safe asset with a constant interest rate for the two risky assets. In the context of convergence trading, each of these two risky assets can be thought of as a spread position between other assets. It is assumed that the cash flows of these two assets are observable, mean-reverting stochastic processes with constant instantaneous volatilities, constant rates of mean reversion, known long-term means, and also that the two cash flow processes are independent. The fundamental values of the two risky assets are defined as their expected payoffs to a risk neutral investor discounted at the risk free rate of interest. It can be shown that the risk neutral marked-to-market profits on the two assets follow Brownian motions with constant volatility and an equilibrium depends on the fundamental cash flow process only through the parameters of the volatilities.

The equilibrium prices for the two risky assets arise from trading by the three different types of market participants. Long-term investors always provide liquidity to the market. When prices fall below fundamental values in either market, long-term investors will buy. And when the price falls further, long-term investors will buy more. Long-term investors have no wealth effects. Implicitly, they are assumed to have deep pockets. The liquidity provided by long-term investors provides an exit strategy for convergence traders during crises.

Convergence traders are subject to large wealth fluctuations when they are leveraged. Their wealth effect is therefore an important variable in determining their asset demand. With logarithmic utility, convergence traders have decreasing absolute risk aversion. As their wealth gets close to zero, these traders become infinitely risk averse. To prevent their wealth from going negative, convergence traders will use the liquidity provided by long-term investors to liquidate their risky positions as their wealth decreases. Without these long-term investors, there can be no equilibrium with only convergence traders and noise traders.

In the model there are three sources of uncertainty: the fundamental shock in asset A, the fundamental shock in asset B, and the noise trading shock in asset A. There are two state variables: the level of noise trading and the aggregate wealth of convergence traders. Due to the logarithmic utility, the total wealth of all convergence traders can be aggregated to represent their total risk-bearing capacity.

Kyle reported his results. Stochastic volatility is highest when noise traders are big sellers and convergence traders' capital is depleted (as in a crisis) but not too small. Stochastic correlation is highest when volatility is highest. Convergence trader positions have positively correlated returns. Expected returns are most favorable when convergence traders' wealth is low and noise trading is far from its mean. Noise traders are inelastic demanders of liquidity and long-term investors always supply liquidity. Convergence traders usually supply market liquidity but demand liquidity in crisis scenarios.

The model has important implications for risk management. The key insight is that in equilibrium the risks are endogenously determined by

the trading of all market participants, and it may be dangerous to treat risks as exogenous in risk management. First, risk managers should recognize the wealth effect of convergence traders who use a short-term trading strategy. Second, risk managers should appreciate the importance of market liquidity provided by long-term investors in periods of crisis. Third, risk managers should realize that correlation between assets tends to deviate from historical values and rise during crises in such a way that portfolio losses occur in all positions simultaneously. Failure to recognize these factors can result in under-estimation of volatility and correlation between asset prices, especially when the wealth amplification effect is severe.

Since market-created risks, such as contagion and volatility amplification by the convergence traders' wealth effect, are only evident in extreme scenarios, studying historical data of asset returns and volatility tends to overlook or underestimate these risks, unless extremely long series of data are used. Even if very long series of data are available, the potential changes in the structure of the market can make it hopeless to determine these extreme risks from historical data. The model suggests that risk managers calculate their optimal risky positions after considering the capitalization and positions of other traders in the market.

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