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Investigating the Effect of the International Stock Indexes on the United States Stock Index Futures

Zehlha Illhan Ertuna
Old Dominion University

INVESTIGATING THE EFFECT OF THE INTERNATIONAL STOCK INDEXES

ON THE US STOCK INDEX FUTURES

by

Zeliha Ilhan Ertuna
B.S. September 1980, Aegean University
M.B.A. June 1989, Maharishi University of Management

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Approved by:

Mohammad Najand (Director)

Kenneth Yung (Member)

Vinod Agarwal (Member)

ABSTRACT

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Zeliha Ilhan Ertuna
Old Dominion University, 2001
Director: Dr. Mohammad Najand

The futures market is used extensively for price discovery, arbitrage, and hedging. Since their introduction in the 1980's, the stock index futures have also become an active market and a very important research area. Any additional knowledge to understand the underlying effects on the index will help both investors and researchers. In this study, I examine the role of informational flow from the world's major stock markets (British, French, German, Japanese) to the U.S. futures market in terms of forming expectations, and offer new insights regarding the informational efficiency of the futures markets in an international perspective. State space modeling is applied to the relationship between a foreign stock index and the Standard & Poor's futures index. This method tests for the best (in Granger causality sense) relationship among the variables. The results of this study provide first time evidence that there is significant and instantaneous information transmission between the U.S. futures markets and major world spot markets, causality running from foreign spot markets to the U.S. futures markets. The implication of this finding is that the active traders in the U.S. futures markets can improve their trading strategy and gain significant benefits by incorporating pricing behavior of major foreign spot markets.

**I dedicate my dissertation to my mother, Murside Altan Yenisehirlioglu,
for all the love, patience and sacrifices,
and to my husband, Cevat Ertuna, who is the sunshine of my life.**

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CHAPTER I

INTRODUCTION

1.1 Functions and Importance of Futures Markets

Since their introduction in the 1980's, the stock index futures have become a very important research area. The futures market is used extensively for price discovery, arbitrage, and hedging[1].

In terms of hedging, futures are used as risk transfer vehicles. Businesses use them to protect themselves against future changes in security or commodity prices, interest rates or exchange rates. This seems to be the major motive for entering into stock index futures transactions. When the investors are planning a cash market trade, they purchase or sell index futures to insure themselves against adverse price movements, which may happen prior to that cash transaction. By using index futures, they can continue with their usual trading strategies without taking excessive risks.

Futures are also used as a realignment vehicle, when they are traded for arbitrage purposes. When futures contracts are mispriced, arbitrage opportunities arise for adjustments to fair value. Arbitrageurs simultaneously buy and sell futures and the underlying instruments to profit from this kind of price discrepancy between the futures and cash markets.

This dissertation uses The Journal of Futures Markets as a model.

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[1] We should also recognize the fact that, especially after the stock market crash of 1987, among other things such as program trading, stock index futures are blamed for excessive volatility of stock market prices.

Futures markets also serve for trading and speculation. Investors trade in futures markets in the hope of profiting from future price movements. Black (1976) considers the price discovery aspect of the futures as the most important. The difference between the index price and the futures can be considered as an indicator of impending moves in the index. There are numerous studies that show that the price discovery happens more significantly in the futures market than it does in the cash market.

1.2 Objective and the Importance of the Study

The financial literature provides evidence that there is an information flow between the international stock markets. There is also evidence of spillover effects from foreign markets to the local futures market and then another spillover effect from the local futures market to the local spot market. For markets that are exposed to global financial interaction, a significant part of a local futures market can be determined by foreign market behavior. This study investigates this effect of foreign markets on the local futures market. Specifically, we look at the effect of the British, French, German and Japanese (U.S.A.'s main trading partners) spot markets on the U.S. stock index futures.

I believe that extending the current literature to understand the underlying effects on the futures will help the users of the index futures as well as the researchers. Despite its potential importance, there is currently very little research that examines the possible effect of foreign spot markets on the local futures market, specifically on the U.S. futures market.

Major hypotheses to be tested are:

H_{01}: British spot market has no effect on the U.S. futures market.

H_{02}: German spot market has no effect on the U.S. futures market.

H_{03}: French spot market has no effect on the U.S. futures market.

H_{04}: Japanese spot market has no effect on the U.S. futures market.

H_{05}: Major European spot markets have no effect on the U.S. futures market.

H_{06}: Spot markets of the major industrialized nations have no effect on the U.S. futures market.

In studying the U.S. stock index futures, not including the foreign effect may lead to a model misspecification, potentially leading to wrong conclusions in this internationally integrated market. Since traders use the futures market to discover the new equilibrium price of assets when a significant event occurs, it is crucially important to know the underlying effects on the futures market. Traders can gain significant benefits by analyzing pricing behavior in foreign markets. By doing so, they can improve their risk perceptions following changes in these foreign markets. On the other hand, their ability to calculate risk adjustments correctly and to adjust their trading strategies accordingly can be seriously hindered if they assume that spot-futures relationship can be explained entirely by the local market behavior.

CHAPTER II

LITERATURE REVIEW AND ISSUES

2. 1 Informational Flow between Financial Markets

Flow of information between international equity markets had been a topic of interest in finance since the 70s. The main reason for the interest was that if the returns from the equity investments in different nations are not perfectly correlated and the correlation structure is stable, investors can reap gains from international portfolio diversification. Some of these studies support international diversification by showing low correlation among national stock markets [Granger and Morgenstern (1970), Lessard (1975), Panton, Lessig, and Joy (1976), Hilliard (1979)], while others [Agmon (1972), Ripley (1973)] show a co-movement of national stock prices.

Today, with increasing globalization, we see many signs of integration between the world financial markets. Studies are interested with the direction of the information flow and show spot and/or futures prices of one country affecting the spot and/or futures prices of another country, as well as the local interaction of futures and spot markets. We will focus our review on these more recent studies, starting from the late 80's.

There are two questions of importance in this area:

- Is there a co-movement or integration among the national stock prices and if so what is the lead-lag structure?
- Are the relationships among national stock price indexes stable over time? (intertemporal stability)

These issues can be and have been analyzed from many different perspectives:

2.1.1 Informational Flow within National Markets between Futures and Spots

To discover prices, we need to know where to look first. Thus, the price discovery function depends on whether new information is reflected first on the index spot prices or on the futures prices. There are at least three reasons why new information may be disseminated in the futures markets first, and hence, why changes in futures prices are expected to lead the changes on spot prices. First, transaction costs, such as brokerage commissions and margin requirements, are usually lower in the futures markets than in the spot markets[2]. Second, the futures markets are more liquid than the spot markets. Third, futures markets are less restricted than the spot markets[3]. So, not surprisingly, there is strong empirical evidence supporting the notion that informational flow goes from the futures markets to the spot markets.

In the international arena, we also see the sequence of spillover effects from foreign markets to the local futures market and then another spillover effect from the local futures market to the local spot market.

Next, we will look at the empirical evidence of the spot and futures market effects and the interactions of the markets in different countries.

In the U.S. Financial Markets

Early studies concerning the price discovery function of stock index futures were carried out by Zeckhause and Niederhoffer (1983) and Finnerty and Park (1987). Zeckhause and Niederhoffer (1983) examined daily changes in the S&P 500 index and its

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[2] Even though stock prices must be paid within a short-time frame, with futures contracts investor only needs to maintain margin accounts. Also, according to Fleming, Ostdiek and Whaley (1996), trading S&P 500 futures costs about 3% of the cost of trading an equivalent portfolio of index stocks.

nearest future contract. Finnerty and Park (1987) studied the informational link between Major Market Index (MMI) futures and cash market index. In both cases researchers concluded that the direction of the information flow was from futures to spot. However, in both cases, the methodologies used (non-parametric association analysis for the first case and regression analysis for the second) were not sufficient to establish a causal relationship.

Employing a three-stage least-squares regression, Kawaller, Koch, and Koch (1987) investigated intraday price relationship between the S&P 500 futures and index prices. One-minute returns were used from the time period of 1984 – 1985. Kawaller, Koch, and Koch (1987) found that futures prices consistently lead cash market prices by up to 45 minutes. On the other hand, the lead from spot price movements to futures price movements was about one minute. Based on these findings they concluded that the futures markets serve as a vehicle for price discovery.

Using time series analysis, Stoll and Whaley (1990) focused on intraday returns of MMI and S&P 500 stock and futures index and found that the index futures returns lead stock index returns by five to ten minutes, even after controlling for the infrequent trading effect. They also reported a mild positive feedback from the cash market to the futures market, which seemed to have grown smaller as the futures markets have matured. Research period was from 1982 to 1987.

Based on 15-minute returns of S&P 500 index futures and cash market, Cheung and Ng (1990) report that futures lead cash consistently for at least 15 minutes and that

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here is less restriction on short sales in the futures market. (Short sales in the spot market are subject to up-tick rule.)

there is some weak evidence for cash leading the futures. Time period used was April 1982 to June 1987.

In another research in this area, Chan, Chan, and Karolyi (1991) applied a bivariate GARCH model to five-minute returns of S&P 500 and MMI futures and cash indexes. Research period was from August 1984 to December 1989. They concluded that the price innovations in either the cash or futures market may be able to predict the arrival of new information in the other market. Looking at the returns, there was a strong lead from futures to cash returns and weak evidence of a lead from cash to futures returns. For the volatilility relations, the pattern of new information flows to the cash and futures markets were more symmetric. Their results showed strong intra-market dependence and persistence in volatility of returns. These results were robust to infrequent trading and other market frictions.

Chan (1992) examined the intraday lead-lag relationship between returns of MM cash index and returns of both MMI and S&P 500 futures. He ran a regression analysis between current returns of the spot MMI and the current, past (three lags) and future (three leads) returns of the futures index adjusting all the t-ratios for coefficients using Hansen's (1982) variance-covariance matrix. Chan concluded that there was strong evidence that the futures lead the cash index and that the lead-lag pattern cannot be totally explained by nonsynchronous trading of stocks, nor by short sale restrictions on the spot market, nor by the differences in the trading activities of spot and futures markets.

Using lead/lag regression analysis, Fleming, Ostdiek, and Whaley (1996) also showed that the S&P 500 futures market leads the underlying spot market. Their intra-

day data covers the period of January - March 1991. Since the trading costs for the index futures is less than the trading costs of index options and the trading costs of index options are less than the trading costs of spot market, based on the trading cost hypothesis, they were expecting the index futures and option returns to lead the stock market returns, and the index futures to lead the index option market. Their results confirmed these hypotheses.

As a summary, empirical evidence from the U.S. markets suggests that the futures price usually leads the stock index movements, leading to an informational role for the futures market.

In the Major World Financial Markets

Abhyankar (1995) investigated the British market by using FTSE (Financial Times Stock Exchange) 100 hourly data for the period 1986 – 1990. Using regression analysis, he concluded that the futures market lead the cash market. The size and the significance of the lead were weaker in the periods after there was a substantial reduction in transactions costs in the London equity market. In a later study, Abhyankar (1998) used linear Granger causality test and intraday data with five-minute intervals to look at the lead-lag relationship for the FTSE 100 spot and futures index again. Using AR(2) filter to purge autocorrelation in the cash index returns, Abhyankar reported that the FTSE-100 index futures returns lead the cash index by about 5-15 minutes, similar to Japanese, German, and U.S. futures markets. However, he noted that if nonlinear effects were accounted for, neither market leads nor lags the other. Using nonlinear causality

test, based on the correlation integral, he showed a strong evidence of a bi-directional nonlinear causal relationship between the futures and cash market returns.

In France, Shyy, Vijayraghavan, and Scott-Quinn (1996) study the CAC index. Using Granger causality test, they look at the minute-by-minute data from a very short time period (August 1994). When they use transaction price data, results show that the CAC futures price leads the CAC cash index. When the mid-quote points of bid/ask prices are used, they only find a reverse causality: cash market leading the futures market. They argue that this may be the more reliable result, since the transaction price represents the stale price of the last trade and thus leads to a nonsynchronous trading problem.

Grunbichler, Longstaff, and Schwartz (1994) studying the German market within an ARMA framework, report that the DAX (Deutsche Aktien Index) index futures lead the cash by 15-20 minutes. One-minute returns were used for the period of November 1990 to September 1991. Booth, Broussard, and Loistl (1994) support these results.

For the Japanese market and based on the data covering the period of September 1988 to September 1991, Chung, Kang, and Rhee (1994) report that the NSA (Nikkei Stock Average) index futures on the Osaka Stock Exchange leads the underlying NSA equity index of the Tokyo Stock Exchange. Their findings show that the lead is not as dominant as it is in the U.S. market and that the cash index also has some predictive ability for futures prices.

Utilizing intra-day data, Min and Najand (1999) look at the lead-lag relationship between the spot and futures markets in Korea and show that the futures market leads the cash market by as long as 30 minutes. Simultaneous equation model is applied to data from May 1996 through October 1996.

Puttonen (1993), using vector error correction model (VEC) of cointegration, also concludes that the Finish futures and option markets informationally dominate the underlying cash market. Daily data is used and the sample period is from May 1988 to the end of 1990. The lead of the derivative markets is two days. This result is based on the data from the whole research period. However, Puttonen (1993) cautions the researchers to be careful in choosing the research periods. According to his research, the lead-lag relationship varies greatly depending on the sub-period under study.

2.1.2. Global Informational Flow Between Spot Markets

Maldonado and Saunders (1981) study the monthly returns for the U.S., Japan, Germany, Canada and the U.K. The time period under study is from 1957 to 1978. Using the Box-Jenkins estimations of the autocorrelation function and spectral analysis, they conclude that the intertemporal relationships between correlation coefficients were unstable and that the correlations were mostly random.

On the other hand, the results of Philippatos, Christofi, and Christofi (1983) supported the existence of intertemporal stability of the correlation coefficients between the major world market indexes. Principal component analysis is applied to monthly stock returns (January 1959 – December 1978), and an interrelation is found among the national stock market indexes of 14 industrial countries (Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Norway, Sweden, the U.K. and the U.S.). International correlations were stable for an investment period of more than two years, while for shorter periods the evidence was not clear. The results also

showed that the national stock market indexes of the fourteen industrial countries were interrelated through a common factor whose effect appeared to be consistent over time.

Ibbotson, Carr, and Robinson (1982) showed a great deal of co-movement between national stock prices and suggested that this could be related to geographical proximity, trade partnership, cultural or economical similarities of the countries.

On the contrary, Schollhammer and Sand (1987) found consistent inter- as well as intra-continental correlations between seven national stock market indexes (France, Germany, Italy, the Netherlands, Switzerland, the U.K. and the U.S.). They applied ARIMA time series analysis to daily data from January 1981 to June 1983. The results showed significant interdependencies of the stock movements among Germany, the Netherlands, Switzerland, the U.K. and the U.S., while in Italy and France, stock price movements seemed to be relatively independent of stock price developments in other countries.

Eun and Shim (1989) studied nine countries (Australia, Canada, France, Germany, Hong Kong, Japan, Switzerland, the U.K. and the U.S.) in terms of their stock market interactions. They applied the VAR model to daily data from those nine markets from January 1980 through December 1985. They concluded that a substantial amount of interdependence exists among national stock markets. For a 20-day horizon, innovations in foreign markets collectively accounted for about 26% of the error variance of a national stock market on the average. Against U.S. innovations, all the European and Asian-Pacific markets responded most strongly with a one-day lag and the responses tapered off rapidly thereafter.

Meric and Meric (1989) test the inter-temporal stability of correlations among national stock market indexes by using Box's M methodology and principal components analysis. Their study used monthly data for 17 countries (Australia, Austria, Belgium, Canada, France, Germany, Hong Kong, Italy, Japan, the Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, the U.K. and the U.S.) and covered the time period of 1973 – 1987. Their results show that the longer the time period (five years or longer) the greater the degree of stability among international stock market relations. Meric and Meric also calculated the degree of dependency of a country's stock market on the stock markets of other countries. Their results showed that the Netherlands was the most dependent stock market in the world. U.S. was slightly less dependent than France, U.K. and Germany, while Japan was the most independent (isolated) of any of these countries.

Hamao, Masulis, and Ng (1990) studied how security price changes in one market influence the opening prices in the next market. They examined the conditional first (and second) moment in common stock prices across Tokyo (Nikkei 225), London (FTSE) and New York (S&P 500) stock markets. They utilized GARCH (1,1)-M model for all three stock return series covering the period of April 1, 1985 to March 31, 1988. Their results showed that from the close-to-open returns there is a significant spillover effect on the conditional mean. They concluded that this finding was consistent with the hypothesis that the international stock markets were integrated.

Jeon and Von Furstenberg (1990), by applying VAR approach to daily stock indexes in Tokyo, Frankfurt, London and New York for the period of January 1986 to

November 1988, concluded that the degree of international co-movements in stock price indexes has increased significantly since the October 1987 crash.

In agreement with this, Arshanapalli and Doukas (1993) also showed that the co-movements among international stock indexes have increased after the October 1987 crash. They looked at the cointegration between the U.S., British, German, French and Japanese stock indexes for the period of January 1980 and May 1990. For the pre-crash period, France, Germany and U.K. stock markets were not related to the U.S. stock market. On the other hand, the results showed that the three major European markets became strongly linked with the U.S. stock market in the post-crash period. The relationship between the U.S., British, German and French stock markets was consistent with cross-border informationally efficient stock markets. The performance of the Japanese stock market showed no links with any of the other markets in the pre- and post-crash periods.

Aggarwal and Park (1994) looked at the transmission of information between the U.S. (S&P 500) and the Japanese (Nikkei 225) spot markets and found that the U.S. close-to-open spot returns reflected Japanese open-to-close spot returns, and Japanese close-to-open spot returns reflected the U.S. open-to-close lagged spot returns. Also, the U.S. open-to-close spot returns reflected Japanese open-to-close spot returns, and Japanese open-to-close spot returns reflected the U.S. open-to-close lagged spot returns

Sim and Zurbreugg (1999) used EC-ARCH (an ARCH model incorporating an error correction term) process to investigate the Australian and the Japanese stock markets. Their data covered the period of July 1997 to October 1997. Minute by minute transactions data from the Sydney and Tokyo spot and futures markets are used. Their

results showed that, while the Japanese spot market was not affected by the Australian market, the Australian spot market was affected by both the Japanese spot and futures markets.

2.1.3. Global Informational Flow Between Futures Markets

There is currently very little research done in terms of foreign futures markets affecting the local futures market. Aggarwal and Park's (1994) study examined the daily and overnight transmission of equity prices between the U.S. and Japan, using S&P 500 and Nikkei 225 indexes. Investigating the correlation structure between the Japanese and U.S. spot and futures markets, they found that the U.S. close-to-open futures returns reflected the Japanese open-to-close future returns and Japanese close-to-open futures returns reflected the U.S. open-to-close lagged futures returns. Although, for both cases, there were some overlapping time periods, authors concluded that these findings supported the hypothesis that the U.S. futures open was more likely than the spot open to reflect earlier Japanese returns and the Japanese futures open was more likely than the spot to reflect earlier U.S. returns. The final conclusions were that both futures markets seem to be integrated, and that information seemed to flow both from Japan to the U.S. and vice versa.

Using an EC-ARCH model, Simm and Zurbreugg (1999) also showed that the Japanese futures market affected the Australian futures market. Their results, based on minute by minute data from the period of July 1997 to October 1997, showed that while the futures trader in Australia needed to monitor the effects of the Japanese futures and

spot markets, a trader in the Japanese markets didn't need to worry about the impact of the Australian market.

2.1. 4. Informational Flow between the U.S. Futures and Global Spot Markets

As a means of complimenting and extending the above literature, this research looks at the informational flow from the foreign stock markets to the U.S. futures market. There is evidence that there is a co-movement among global spot markets and a co-movement between the U.S. futures and spot markets, We also have evidence of foreign spot markets effecting the local futures market. Ostermark (1997) showed that the Japanese stock prices have an impact on the Finnish futures index. Simm and Zurbreugg (1999) also show the effect of the Japanese spot market on the Australian futures market. Hence, it is reasonable to suspect that there might be a co-movement between the U.S. futures market and the global spot markets. The objective of this study is to investigate the informational relationship between the spot markets of the major industrialized nations and the U.S. futures market. Based on my research, and to the best of my knowledge, this relationship seems to be unexplored so far.

2.2 Issues

Under this topic I will examine issues that are technical or general in nature and might affect the lead-lag relationship between futures index and cash markets. Some of the issues that are general in nature are developed into a hypothesis and have been subject to empirical tests. Issues that are more technical in nature make up the thorny points of

the research design. Some of the issues of this kind have been remedied satisfactorily and others have been addressed partially.

There is a set of issues that is, to an extent, relevant to this study. Within the framework of international diversification, several researchers examined the source of the variation in the index returns of different countries. Roll (1992) suggests three reasons for the cause of variation in a country's index returns. First is the technical procedures of index construction. Some country indexes are large and well diversified, while others are not. Second is the industrial composition of an index. Third is the real as well as the nominal exchange rate behavior of the local currency denominating an index.

Griffin and Karolyi (1998) report that the returns of the traded-good industries are much more correlated than those nontraded-good industries, implying that the capital markets that contain a high percentage of traded-good industries and similar industry compositions in their indexes may exhibit more integration. Based on the Dow Jones World Stock index data, Griffin and Karolyi (1998) report that the industrial composition of country indexes can only explain around 4% of the variation in the average country index. Due to this result and the similarities between the U.S., British, French, German and Japanese markets, this issue is not considered to be significant enough to be incorporated into this research design.

We know that both nominal and real currency effects exist. Nominal currency effect can be avoided by using returns denominated in a foreign country's local currency. However, since both dollar and local currency returns still contain a currency risk premium (Dumas and Solnik 1995), this solution is not necessarily the ideal one. Nevertheless, it is the most commonly used and the most practical solution.

There are also several studies that investigated the effect of infrequent trading. It has been argued that the observed lead of futures market may be due to the infrequent trading of the underlying stocks in the spot market. Lo and MacKinley (1990) examined the effects of non-synchronous trading and concluded that the infrequent trading induces lag into indexes. Sutcliffe (1997) also suggested that non-synchronicity may lead to a positive serial correlation in value changes of the indexes, even if the underlying stock price changes are random, because of the implicit averaging due to non-synchronicity. On the other hand, Atchison, Butler, and Simonds (1987) showed that only 15% of the positive autocorrelation on the NYSE was due to non-synchronicity. MacKinlay and Ramaswamy's (1988) results based on S&P 500 index also supports the conclusion that there is some additional cause for the autocorrelations other than the non-synchronicity. Harris (1989), using one factor model, and Stoll and Whaley (1990), using ARMA filtering, removed the effects of non-synchronous trading and still found that the futures markets led the spot market. Chan (1992) argued that the remedies implemented by Harris (1989) and Stoll and Whaley (1990) may not be sufficient to eliminate infrequent trading effect, if that effect is not constant. Nevertheless, his results supported Stoll and Whaley (1990) and showed that there was a lead-lag relation between the futures and cash markets, above and beyond nonsynchronous trading. The price leadership of the futures market manifests itself even in the case of highly liquid individual stocks such as IBM [Stoll and Whaley (1990)].

In their study, Fleming, Ostdiek, and Whaley (1996) introduce the trading cost hypothesis. The trading cost hypothesis predicts that the market with the lowest overall trading costs will react most quickly to new information. By analyzing the relationships

among the 5-minute returns for S&P 500 futures, S&P 100 options and for their underlying stock index portfolios, they report that trading costs affect the lead-lag relationship between the markets. The trading costs of the S&P 500 futures is only 20% of the costs of trading index options, and the trading costs of the index options is 17% of those in the cash market. Consistent with the trading cost hypothesis, both the index futures and option returns lead stock market returns, and the index futures tend to lead the index option market. Chan's (1992) finding, that market-wide information disseminates more quickly in futures market than in the cash market can also be considered as a supporting evidence to this hypothesis.

Short-sale constraints also have been offered as an explanation why futures market should lead the spot markets. "No short sale on down-tick" rule, contractual and legal restrictions on shorting by insiders and other regulations may slow the adjustment of prices in the spot markets [Diamond and Verrechia (1987)]. Since there is no restriction in the futures market, based on this hypothesis, futures prices are expected to lead the cash index to a greater degree under bad news. Chan (1992) provided some evidence that the futures market does not lead the cash market only under bad news nor does it have a stronger tendency to lead the spot market under bad news than the good news. This finding suggests that short sale restrictions may not have a strong role in lead-lag structure between the futures and spot markets.

Another issue is the effect of the expiration day. The arbitrage activity could be greatest on expiration day, since program traders would close out earlier positions. This might lead to a different lead-lag relationship on expiration days compared to non-expiration days of the same contract. When they looked into this issue, Kawaller, Koch,

and Koch (1987) found no substantial difference between the expiration day and other trading days.

The intensity of the trading activity in futures and spot markets may also affect the lead-lag structure between the two markets. Admati and Pfleiderer (1988) showed that both informed and liquidity traders prefer thick market. This implies that when trading is high, more information is released. Gurinbichler, Longstaff, and Schwartz (1994) pointed out that if the average time between trades for component stocks was longer than that for the index futures, futures prices would incorporate information more rapidly than cash prices. Stephan and Whaley (1990) provided some evidence from the intraday relation between the stock market and the stock option market that the price discovery and trading activity are related. Chan (1992) analyzed the impact of different intensity of trading activity on the lead-lag relationship between spot index and futures markets and found no compelling evidence that would suggest that the lead-lag relationship may be effected by the relative intensity of trading activity in the cash and futures market.

CHAPTER III

DATA AND METHODOLOGY

3.1 Data

I examine daily data from five markets: Tokyo, Frankfurt, Paris, London and Chicago. The four foreign markets are chosen on the basis of their being major trading partners of the U.S. (U.S. Census Bureau) and having highly developed financial markets. For the Tokyo Stock Exchange, I use the Nikkei 225 Stock Index. This index includes the largest 225 firms in Japan, and it represents about half of the total equity capitalization of the Tokyo Market [Hamao and et al. (1990), Aggarwal and Park (1994)]. It is an equally weighted arithmetic index. Financial Times-Stock Exchange 100 Share (FTSE) Index is used for the London stock market. It represents 73.2% of the equity capitalization of all United Kingdom equities [Sutcliffe (1997)]. It is an equity value weighted arithmetic index. For the German stock index, we used XETRA DAX, which accounts for 65% of the exchange turnover, and for the Paris stock market, I use CAC 40, which represents 63% of the market capitalization [Sutcliffe (1997)]. S&P 500 is an equity value weighted arithmetic index, accounting for about three quarters of the stocks listed on the NYSE. Prices on the nearest futures contracts of S&P 500 futures index are used to represent the U.S. futures market.

The data covers the time period from November 26, 1990 to February 20, 2001. Foreign stock markets data are obtained from Yahoo Online[4], while the data for the S&P 500 futures index are obtained from Global Financial Data.

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[4] Reuters provides the data for Yahoo Online.

In this research, closing prices of each index is used for number of reasons. Mainly, since the foreign stock markets close before the S&P 500 futures market, it was important to use the closing prices to eliminate the effect of overlapping trading periods. Also, as mentioned in Aggarwal and Parks (1994), research done by using opening values of indexes, may be unreliable due to the fact that these values reflect prior day closing prices for many of the stocks in the indexes.

Tokyo Exchange opens at 9:00 A.M. and closes at 3:00 P.M. local time. London opens at 8:00 A.M. and closes at 4:30 P.M. Frankfurt opens at 9:00 A.M. and since June 2, 2000 closes at 8:00 P.M. (at 5:30 P.M. until then). Paris opens at 9:00 A.M. and closes at 5:30 P.M. Chicago Mercantile Exchange opens at 8:30 A.M. and closes at 3:15 P.M. Since we use the close-to-close prices, the problem of any overlapping trading periods is eliminated. There is no overlap in the trading hours for the Nikkei spot and the S&P 500 futures markets.

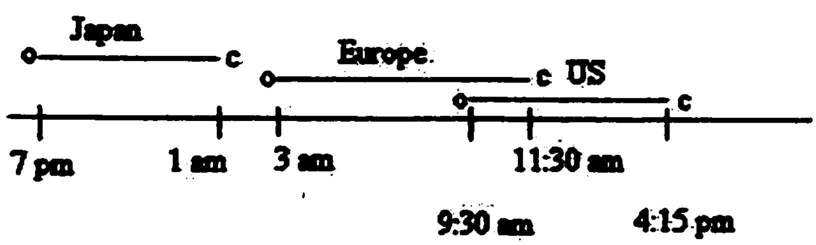

FIGURE 1
Exchange trading hours in U.S. Eastern Standard Time

The problem of nonsynchronous holidays is handled by substituting the most recent entry available for the exchange that was closed [Hamao and et al. (1990), Jeon and Von Furstenberg (1990), Arshanapalli and Doukas (1993)].

Foreign exchange rates are not incorporated and the local currencies are used to calculate the returns. It is argued by different authors that the currency hedging on the forward markets can mitigate pure currency risk, and so it is not necessary to incorporate the foreign exchange changes within domestic prices [Sim and Zurbreugg (1999)].

The natural logarithm of the prices is used to calculate price changes. Continuously compounded price changes are calculated for each index as follows:

$R_t = \text{Ln}\ (P_t/P_{t-1})$

The summary statistics of the data can be seen on Table 2.1

TABLE 2.1

Descriptive Statistics[a]

	DAX 30	CAC 40	FTSE 100	NIKKEI 225	S&P 500 FUTURES
Mean	0.0579	0.0479	0.0395	-0.0225	0.0540
	(0.0178)	(0.0488)	(0.0334)	(.4224)	(0.0065)
Median	0.0535	0.0000	0.0185	0.0000	0.0460
Max	7.2881	6.8306	5.4396	7.6553	5.6173
Min	-9.8709	-7.5753	-4.1399	-7.2340	-7.7621
Std. Dev.	1.2413	1.2361	0.9442	1.4251	1.0075

[a]Descriptive Statistics for daily returns of indexes (Nov. 26, 1990 – Feb. 20, 2001): DAX 30, CAC 40, FTSE 100, NIKKEI 225, and S&P 500 Futures. Significance of mean values is indicated in parenthesis.

3.2 Methodology

3.2.1 Introduction

In this study, state space modeling is applied to investigate the relationship between foreign stock indexes and S&P futures index. The state space model is also called a Markovian representation, or a canonical representation of a multivariate time series process. The state space method is mainly developed in the 1970's, and it tests for the best (in Granger causality sense) relationship between the two variables. State space modeling can be used to determine simultaneously the causal link and the relationship between the two variables. Akaike (1974) shows that any stationary autoregressive moving average (ARMA) process (more generally any multivariate stationary time series) can be expressed in a state space form and any state space process has an ARMA representation.

A lot of commonly used econometric models can be formulated into state space form [Aoki (1990), Lütkepohl (1991), Moryson (1998)] such as:

a. All vector autoregressive moving average models with exogenous regressors (VARMAX)
b. Vector autoregressive models with no moving average parts (VARX), with randomly or systematically varying coefficients,
c. Structural time series models,
d. Multiple regression models with unobservable regressors,
e. Factor analytic models.

The state space time-series procedure has a number of advantages over other similar procedures, main advantage being its application to multivariate systems. In multivariate ARMA models, the model identification is difficult. These models determine the two separate parameters (p and q). Since accurate determination often requires subjective evaluation of models generated by a two-dimensional scan of p and q, it is possible to make errors in determining these parameters. State space model, by directly determining the number of states from the data, avoids this problem.

Time-series model identification methods also involve finding or imposing some restrictions, which will eliminate excess sampling error in the parameter estimates and forecasts. While these restrictions may be helpful at times, at other times they are not appropriate. In a state space model, restrictions are based on the data. Also, these restrictions are capable of characterizing any type of stochastic process. They are imposed not on unstable coefficients of highly collinear regressors, but on the determinants of the dynamic approximation.

Some series share common cycles. State space procedures are able to find these common cycles, and in doing so, allow a smaller specification for number of states and therefore less sampling error in the estimated parameter matrices and the associated covariance matrices. This is a very important characteristic, especially when working with large closely related multivariate systems.

Another characteristic of state space models is that the model choice is sequence-independent: States enter the model in order, which is based on their contribution to the approximated autocovariance sequence. Since other methods attempt to discover the

characteristics of the model that have generated the autocorrelations or impose arbitrary restrictions, the model chosen depends on the order of the preliminary models examined.

Akaike (1976) developed a method that automatically selects an appropriate state space model for the series by using canonical correlation analysis. The state vector contains the necessary information from the present and past values of the series to predict its future values, and is set up to do that with as small a number of elements as possible. Linear combinations of the state variables represent the observed time series.

3.2.2 Theoretical Aspect of State Space Modeling

A General State Space Model (GSSM) is defined by an observation model and a transition model. The assumptions are that (1) the covariate process is non-stochastic, (2) the responses between different endogenous series are conditionally independent, (3) given all the past responses, current responses depend only on the current state and covariates, and (4) the transition model is first order Markovian[5].

The general idea behind a state space model is that an observed multiple time series x_t depends upon a possibly unobserved state z_t which is driven by a stochastic process.

[5] Higher order Markov dependency can be transformed to the first order by augmenting the state vector by its lagged variables.

The observation and state equations are as follows:

$$X_t = Cz_t = [I\ 0 \cdots 0]\begin{bmatrix} X_t \\ X_{t+1|t} \\ \vdots \\ X_{t+k|t} \end{bmatrix} \qquad [1]$$

$$z_{t+1} = Fz_t + G_{t+1} = \begin{bmatrix} 0 & I & 0 & \cdots & 0 \\ 0 & 0 & I & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & I \\ \Phi_p & \Phi_{p-1} & \Phi_{p-2} & \cdots & \Phi_1 \end{bmatrix} z_t + \begin{bmatrix} I \\ \Psi_1 \\ \vdots \\ \Psi_{p-2} \\ \Psi_{p-1} \end{bmatrix} e_{t+1} \qquad [2]$$

where,

x_t is a (r by 1) vector of observable output or endogeneous variables,

z_t is a (s by 1) state vector or the state of nature, whose first r components make up x_t and whose remaining components contain all additional needed information to forecast future values of z_t

F is an (s by s) transition or system matrix,

G is an (s by r) input matrix of the transition equation,

e_t is a (r by 1) vector of system or transition equation errors or noise, with a common variance matrix and mean zero.

Equation [1] is called a measurement or observation equation. The state of nature is generated by equation [2]. Equation [2] is called the transition or system equation, and [1] and [2] make up the general form of a linear state space system.

Following stochastic assumptions are made for the noise process and the initial state:

The initial state z_0 is uncorrelated with e_t for all t and has a distribution with mean μ_{z0} and covariance matrix Σ_{z0}. The input sequence is non-stochastic. If the observed inputs are actually stochastic, the analysis is assumed to be conditional on a given sequence of inputs.

3.2.3 Constructing State Space Model

Since the state space model requires stationarity before the model is constructed, one needs to check the data for stationarity. If the series are nonstationary, one of the ways to make them stationary is by differencing them.

There are three steps in constructing state space model:

a. Determining the lag structure of the data fitted to a multivariate autoregressive model,
b. Employing canonical correlation analysis to develop a state space representation of the autoregressive model,
c. Using Kalman filter to construct appropriate likelihood function and consequently to derive parameter estimates for the state space model.

a. Determining the lag order (lag order determination)

(Determining the lag structure of the data fitted to a multivariate autoregressive model.) The lag structure is determined by fitting the data to a series of vector autoregressive models utilizing the Yule-Walker equations. The optimal lag structure minimizes the Yule-Walker equations' prediction error relative to the number of parameters used. Then the order for which AIC is minimized is selected as the number of lags into the past.

b. <u>Selecting State Space Model Form (selection of state vector)</u>

At this stage, canonical correlation analysis is employed to develop a state space representation of the autoregressive model. The lag order obtained from the first step determines the number of autocovariance matrices analyzed in the canonical correlation phase. Canonical correlations of the past with increasing number of steps into the future are computed. Variables that yield large correlations to the state vector are added, and those that yield small correlations are eliminated. Importance of the correlation is judged on the basis of an information criterion from Akaike (1976) called DIC. Positive values for DIC indicate significance.

$$DIC = -n \ln(1-\rho^2_{min}) - \lambda(r(p+1) - q + 1)$$

where,

q = dimension of $\mathbf{f}_t^j$

$\mathbf{f}_t^j$ = a vector formed from the current state vector and the next candidate component

r = the order of the state vector

p = the order of the vector autoregressive process

λ = the multiplier of the degrees of freedom for penalty term

Bartlett's test is another measure that can be used in deciding the dimensions of the state vector. This study utilizes the p-value of Bartlett's test (with chi-square distribution) to check the dimension of the state vector.

c. <u>Estimating the parameters</u>

At this stage Kalman filter is used to construct appropriate likelihood function, and consequently to derive parameter estimates for the state space model through iteration process and prediction error decomposition [Harvey (1989)].

CHAPTER IV

EMPRICAL RESULTS AND DISCUSSIONS

State space modeling can be used to determine simultaneously the causal link (in Granger causality sense) and the relationship between the variables. For this reason, state space modeling is applied first to investigate the relationship between the U.S. stock futures market and four major stock markets (British, German, French, and Japanese) pair-wise. Then the interaction between U.S. stock futures and major European stock markets (British, German, and French as a whole) are analyzed. Finally, information transmissions between all five markets are examined. In the construction stage of the state vectors, feedback mechanisms are allowed. However, considering the speed of transmission in this information age, dimension of state vectors for all analysis is set to two. Most of the time, allowing higher dimensions into the state vector results in non-significant components in the final stage. Current formulation eliminates inclusion of unwarranted dimensions into the system. It is a parsimonious approach, and for all practical purposes, this approach does not deviate significantly from the results obtained automatically using SAS's state space program.

4.1 Information Transmission between the U.S. Futures Market and Major National Stock Markets

4.1.1 German Stock Market

AIC (Akaike's Information Criterion) for the initial autoregressive models that would link U.S. futures and German spot market returns are presented in Table 4.1. Up to 10 lags are considered. The smallest AIC (504.1671) occurs at lag 3. This indicates that a 3-lag model structure might be appropriate. The period covered is from November 26, 1990 to February 20, 2001.

TABLE 4.1

AIC for Autoregressive Models

German Stock Market

Lag	AIC
0	875.7728
1	511.8946
2	509.1830
3	504.1671*
4	508.9298
5	513.6209
6	520.8926
7	518.9536
8	520.6780
9	527.0169
10	530.9326

* Signifies the lag for Yule-Walker equations.

The canonical correlation analysis for the linkage between the U.S. futures and German spot markets is reported in Table 4.2. The first cell of the state vector column indicates that adding $GSCR_{t+1|t}$ (German Spot market Closing price Return at time t+1) to the state vector would yield a canonical correlation of 0.0669.

TABLE 4.2

Canonical Correlation Analysis for the Linkage Between U.S. Futures and German Spot Markets[a]

State Vector	Correlation	DIC	X^2	Df.
$GSCR_t$, $UFCR_t$, $GSCR_{t+1\|t}$	1.0000 1.0000 0.0669	-0.4028	11.5838	6
$GSCR_t$, $UFCR_t$, $GSCR_{t+1\|t}$ $UFCR_{t+1\|t}$	1.0000 1.0000 0.0824 0.0601	-0.6412	9.3498	5
$GSCR_t$, $UFCR_t$, $GSCR_{t+1\|t}$ $GSCR_{t+2\|t}$	1.0000 1.0000 0.0727 0.0586	-1.1098	8.8816	5

[a]Variables are designated by four-letter code. GS = German Spot Market (DAX), UF = U.S. Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})x100$. Daily data covering the period from Nov. 26, 1990 to Feb. 20, 2001. Significance of the correlation is determined by positive values of DIC (another Akaike's information criteria) and Bartlett's χ^2 test.

To decide whether that would justify adding the new variable, and hence, increasing the dimension of the state vector, DIC (another Akaike's information criteria) or Bartlett's chi-square test could be used. Positive DIC values suggest that the new variable could be added to the vector. The null hypothesis for the Bartlett's chi-square test is that the canonical correlation is zero. For $GSCR_{t+1|t}$, the chi-square test statistics is 11.5838. With 6 degrees of freedom, this would indicate a p-value of 0.0719. Hence, the null hypothesis cannot be accepted at the 90% confidence level. Same logic applies to the other variables such as $UFCR_{t+1|t}$ (U.S. Futures market Closing price Return at time t+1) and $UFCR_{t+2|t}$. However, the initial model based on canonical correlation needs to be

refined with Kalman-filter and through recursive maximum likelihood estimates. The final estimate of the state space model is presented in Table 4.3.

TABLE 4.3

State Space Model for the Linkage between U.S. Futures and German Spot Markets[a]

$$\begin{bmatrix} GSCR_{t+1} \\ UFCR_{t+1} \\ GSCR_{t+2|t+1} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ -1.6808^{*} & 6.7396^{*} & -15.7305^{*} \\ -0.6449 & 2.5876 & -6.1428 \end{bmatrix} \begin{bmatrix} GSCR_{t} \\ UFCR_{t} \\ GSCR_{t+1|t} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -0.1067 & 0.4306 \end{bmatrix} \begin{bmatrix} e_{t+1} \\ n_{t+1} \end{bmatrix}$$

[a]Variables are designated by four-letter code. GS = German Spot Market (DAX), UF = U.S. Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})x100$. Daily data covering the period from Nov. 26, 1990 to Feb. 20, 2001. * = Significance of t-test at $p \leq 0.05$ level.

The data in Table 4.3 suggests there is a significant and instantaneous information transmission between the U.S. futures markets and the German stock market ($f_{2,3} = -15.7305$, $p \leq 0.05$). The results also indicate, based on daily data, this relationship is unidirectional and running from the German spot markets to the U.S. futures markets. This result conforms with intuitive expectations. European stock markets open before the U.S. markets and close before the U.S. markets close and both events occur on the same business day. However, these results do not exclude the probable impact of the U.S. futures markets on the German spot markets. The reasoning is twofold. First, to understand the mechanics of the information transmission completely, we need to consider the interaction between the U.S. markets and the European market as a whole. Secondly, that interaction could be detectable perhaps only through a higher frequency data.

The results in this section are in agreement with Jeon and Von Furstenberg (1990) and Arshanapalli and Doukas (1993), whose results show integration among German and U.S. financial markets.

4.1.2 French Stock Market

AIC for the initial autoregressive models that would link U.S. futures and French spot market returns are presented in Table 4.1. The initial autoregressive models suggest a 3-lag structure. At lag 3, AIC (548.7725) is at its minimum.

TABLE 4.4

AIC for Autoregressive Models

French Stock Market

Lag	AIC
0	851.1455
1	555.0592
2	552.1728
3	548.7725*
4	554.0456
5	561.3041
6	560.6639
7	550.6839
8	553.9629
9	557.1142
10	560.9234

*** Signifies the lag for Yule-Walker equations.**

The canonical correlation analysis (Table 4.5) provides a conflicting result on $FSCR_{t+1|t}$ (French Spot market Closing price Return at time t+1): DIC = -0.93894; χ^2_6 =

11.0482, p = 0.087. Based on Bartlett's chi square results, $FSCR_{t+1|t}$ is added to the state vector since it is significant at 90% level.

TABLE 4.5

Canonical Correlation Analysis for the Linkage Between U.S. Futures and French Spot Markets[a]

State Vector	Correlation	DIC	X^2	Df.
$FSCR_t$, $UFCR_t$, $FSCR_{t+1|t}$	1.0000 1.0000 0.0653	-0.9389	11.0482	6
$FSCR_t$, $UFCR_t$, $FSCR_{t+1|t}$ $UFCR_{t+1|t}$	1.0000 1.0000 0.0745 0.0640	0.6263	10.6160	5
$FSCR_t$, $UFCR_t$, $FSCR_{t+1|t}$ $FSCR_{t+2|t}$	1.0000 1.0000 0.0653 0.0598	-0.7205	9.2705	5

[a]Variables are designated by four-letter code. FS = French Spot Market (CAC), UF = U.S. Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})\times100$. Daily data covering the period from Nov. 26, 1990 to Feb. 20, 2001. Significance of the correlation is determined by positive values of DIC (another Akaike's information criteria) and Bartlett's χ^2 test.

The final estimate of state space model is presented in Table 4.6.

TABLE 4.6

State Space Model for the Linkage between U.S. Futures and French Spot Markets[a]

$$\begin{bmatrix} FSCR_{t+1} \\ UFCR_{t+1} \\ FSCR_{t+2|t+1} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ 0.1155^{*} & -0.5556^{*} & 1.3306^{*} \\ 0.0917^{*} & -0.5337^{*} & 1.1669^{*} \end{bmatrix} \begin{bmatrix} FSCR_t \\ UFCR_t \\ FSCR_{t+1|t} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -0.0633 & 0.3837 \end{bmatrix} \begin{bmatrix} e_{t+1} \\ n_{t+1} \end{bmatrix}$$

[a]Variables are designated by four-letter code. FS = French Spot Market (CAC 40), UF = U.S. Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})\times100$. Daily data covering the period from Nov. 26, 1990 to Feb. 20, 2001. * = Significance of t-test at $p \leq 0.05$ level.

The results in Table 4.6 show that the U.S. futures markets are significantly and instantaneously affected by the French spot markets ($f_{2,3} = 1.3306$, $p \leq 0.05$). The data also suggest that there is an information transmission with a one-day lag from the U.S. futures markets to the French spots markets.

The results are in agreement with Arshanapalli and Doukas (1993) whose results show integration between French and U.S. financial markets.

4.1.3 British Stock Market

For the British Stock markets, the minimum AIC (-865.962) for initial Autoregressive models occurs at lag 8 (Table 4.7).

TABLE 4.7

AIC for Autoregressive Models

British Stock Market

Lag	AIC
0	-582.004
1	-852.231
2	-859.542
3	-864.235
4	-860.617
5	-857.100
6	-853.742
7	-865.471
8	-865.962*
9	-862.048
10	-859.439

*** Signifies the lag for Yule-Walker equations.**

The canonical correlation analysis (Table 4.8) gives conflicting results for $BSCR_{t+1|t}$ (British Spot market Closing price Return at time t+1) in terms of DIC (-0.8776) and chi-square test ($\chi^2_{16} = 31.02607$; $p = 0.0134$). $BSCR_{t+1|t}$ is included in the state vector based on the chi-square results.

TABLE 4.8

Canonical Correlation Analysis for the Linkage Between U.S. Futures and British Spot Markets[a]

State Vector	Correlation	DIC	X^2	Df.
$BSCR_t$, $UFCR_t$, $BSCR_{t+1\|t}$	1.0000 1.0000 0.1094	-0.8776	31.0261	16
$BSCR_t$, $UFCR_t$, $BSCR_{t+1\|t}$ $UFCR_{t+1\|t}$	1.0000 1.0000 0.1380 0.0963	-5.8811	24.0489	15
$BSCR_t$, $UFCR_t$, $BSCR_{t+1\|t}$ $BSCR_{t+2\|t}$	1.0000 1.0000 0.1118 0.0967	-5.6899	24.2395	15

[a]Variables are designated by four-letter code. BS = British Spot Market (FTSE), UF = U.S. Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})\times 100$. Daily data covering the period from Nov. 26, 1990 to Feb. 20, 2001. Significance of the correlation is determined by positive values of DIC (another Akaike's information criteria) and Bartlett's χ^2 test.

The final estimate of state space model is presented in Table 4.9.

TABLE 4.9

State Space Model for the Linkage between U.S. Futures and British Spot Markets[a]

$$\begin{bmatrix} BSCR_{t+1} \\ UFCR_{t+1} \\ BSCR_{t+2|t+1} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ -0.0178 & 0.2994^{*} & -1.2547^{*} \\ 0.0185 & -0.1589^{*} & 0.5664^{*} \end{bmatrix} \begin{bmatrix} BSCR_{t} \\ UFCR_{t} \\ BSCR_{t+1|t} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -0.0427^{*} & 0.2733^{*} \end{bmatrix} \begin{bmatrix} e_{t+1} \\ n_{t+1} \end{bmatrix}$$

[a]Variables are designated by four-letter code. BS = British Spot Market (FTSE 100 index), UF = U.S. Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})\times 100$. Daily data covering the period from Nov. 26, 1990 to Feb. 20, 2001. * = Significance of t-test at $p \leq 0.05$ level.

The data reported in Table 4.9 indicates that the British spot markets do influence the U.S. futures markets ($f_{2,3} = -1.2547$, $p \leq 0.05$). The information transmission is instantaneous and significant, running from the British spot markets to the U.S. futures market. There is also information flow from the U.S. futures market to the British spot market with a one-day lag.

The results in this section are in agreement with the results of Hamao, Masulis, and Ng (1990), Jeon and Von Furstenberg (1990) and Arshanapalli and Doukas (1993) whose results show integration between British and U.S. financial markets.

4.1.4 Japanese Stock Market

The initial autoregressive models for the Japanese stock market suggest a 2-lag structure, since minimum AIC (1656.639) occurs at lag two (Table 4.10).

TABLE 4.10

AIC for Autoregressive Models

Japanese Stock Market

Lag	AIC
0	1857.621
1	1664.647
2	1656.639*
3	1660.672
4	1663.159
5	1666.378
6	1672.048
7	1663.645
8	1668.624
9	1673.355
10	1674.605

*** Signifies the lag for Yule-Walker equations.**

The canonical correlation analysis (Table 4.11) indicates that $JSCR_{t+1|t}$ (Japanese Spot market Closing price Return at time t+1) with DIC = 2.940172; $\chi^2_6 = 14.92284$, p = 0.021, should be added to the state vector.

TABLE 4.11

Canonical Correlation Analysis for the Linkage Between U.S. Futures and Japanese Spot Markets[a]

State Vector	Correlation	DIC	X^2	Df.
$JSCR_t$, $UFCR_t$, $JSCR_{t+1\|t}$	1.0000 1.0000 0.0759	2.9402	14.9228	6
$JSCR_t$, $UFCR_t$, $JSCR_{t+1\|t}$ $UFCR_{t+1\|t}$	1.0000 1.0000 0.0852 0.0506	-3.3604	6.6332	5
$JSCR_t$, $UFCR_t$, $JSCR_{t+1\|t}$ $JSCR_{t+2\|t}$	1.0000 1.0000 0.0762 0.0521	-2.9682	7.0250	5

[a]Variables are designated by four-letter code. JS = Japanese Spot Market (NIKKEI), UF = U.S. Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})\times100$. Daily data covering the period from Nov. 26, 1990 to Feb. 20, 2001. Significance of the correlation is determined by positive values of DIC (another Akaike's information criteria) and Bartlett's χ^2 test.

The final estimate of state space model is presented in Table 4.12.

TABLE 4.12

State Space Model for the Linkage between U.S. Futures and Japanese Spot Markets[a]

$$\begin{bmatrix} JSCR_{t+1} \\ UFCR_{t+1} \\ JSCR_{t+2|t+1} \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ -0.0691^{*} & 0.2834 & -0.8181 \\ 0.0060 & -0.1027 & 0.3308 \end{bmatrix} \begin{bmatrix} JSCR_t \\ UFCR_t \\ JSCR_{t+1|t} \end{bmatrix} + \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ -0.0584^{*} & 0.3812^{*} \end{bmatrix} \begin{bmatrix} e_{t+1} \\ n_{t+1} \end{bmatrix}$$

[a]Variables are designated by four-letter code. JS = Japanese Spot Market (NIKKEI 225 index), UF = U.S. Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})\times100$. Daily data covering the period from Nov. 26, 1990 to Feb. 20, 2001. * = Significance of t-test at $p \leq 0.05$ level.

The final estimates in Table 4.12 suggest there is a significant relationship between the U.S. futures market and Japanese spot markets ($f_{2,1} = -0.0691$, $p \leq 0.05$), with one-day delay on the basis of close-to-close returns. The results point to a unidirectional information flow running from the Japanese spot market to the U.S. futures market. This finding supports the findings of Aggarwal and Parks (1994) in the sense that there is integration between the U.S. and Japanese markets, and the U.S. markets do not play only a leading role in this relationship. It is also in agreement with the results of Hamao, Masulis, and Ng (1990) and Jeon and Von Furstenberg (1990) whose results show an integration among Japanese and U.S. financial markets. In this pair-wise analysis, we do not see any information flow from the U.S. futures market to the Japanese spot market.

4.2 Information Transmission between the U.S. Futures Market and Major European Stock Markets

The relationship between the U.S. futures market and the three major European Spots market as a whole is also investigated. Table 4.13 shows that the initial autoregressive models covering three European spot markets and the U.S. futures markets suggest a 2-lag structure (minimum AIC = -2214.52).

TABLE 4.13

AIC for Autoregressive Models

European Spot Markets

Lag	AIC
0	-1687.20
1	-2196.45
2	-2214.52*
3	-2214.18
4	-2207.44
5	-2193.61
6	-2185.01
7	-2192.68
8	-2174.82
9	-2170.39
10	-2148.86

* Signifies the lag for Yule-Walker equations.

The canonical correlation analysis (Table 4.14) indicates that $BSCR_{t+1|t}$ (DIC = 4.4004; χ^2_{16} = 36.2878, p = 0.003) and $FSCR_{t+1|t}$ (DIC = 3.7961; χ^2_{15} = 33.6981, p = 0.004) should be added to the state vector. Although the results of canonical correlation analysis does not suggest inclusion of $GSCR_{t+1|t}$ (DIC = -8.2560; χ^2_{14} = 19.69057, p = 0.14), that state vector is included in the model for two reasons. First, in the pair wise analysis with the U.S. futures market, that state vector is significant. Second, it would be reasonable to keep that state vector in the model as a control vector.

TABLE 4.14

Canonical Correlation Analysis for the Linkage Between U.S. Futures and European Spot Markets[a]

State Vector	Correlation	DIC	X^2	Df.
$BSCR_t$, $FSCR_t$,	1.0000 1.0000	4.4004	36.2878	16
$GSCR_t$, $UFCR_t$,	1.0000 1.0000			
$BSCR_{t+1\|t}$	0.1182			
$BSCR_t$, $FSCR_t$,	1.0000 1.0000	3.7961	33.6981	15
$GSCR_t$, $UFCR_t$,	1.0000 1.0000			
$BSCR_{t+1\|t}$, $FSCR_{t+1\|t}$	0.1238 0.1139			
$BSCR_t$, $FSCR_t$,	1.0000 1.0000	-8.2560	19.6906	14
$GSCR_t$, $UFCR_t$,	1.0000 1.0000			
$BSCR_{t+1\|t}$, $FSCR_{t+1\|t}$,	0.1310 0.1149			
$GSCR_{t+1\|t}$	0.0872			
$BSCR_t$, $FSCR_t$,	1.0000 1.0000	-11.7879	14.1764	13
$GSCR_t$, $UFCR_t$,	1.0000 1.0000			
$BSCR_{t+1\|t}$, $FSCR_{t+1\|t}$,	0.1338 0.1151			
$GSCR_{t+1\|t}$, $UFCR_{t+1\|t}$	0.1070 0.0740			
$BSCR_t$, $FSCR_t$,	1.0000 1.0000	-8.8828	17.0742	13
$GSCR_t$, $UFCR_t$,	1.0000 1.0000			
$BSCR_{t+1\|t}$, $FSCR_{t+1\|t}$,	0.1376 0.1186			
$GSCR_{t+1\|t}$, $BSCR_{t+2\|t}$	0.1037 0.0812			
$BSCR_t$, $FSCR_t$,	1.0000 1.0000	-15.1905	10.7823	13
$GSCR_t$, $UFCR_t$,	1.0000 1.0000			
$BSCR_{t+1\|t}$, $FSCR_{t+1\|t}$,	0.1331 0.1153			
$GSCR_{t+1\|t}$, $FSCR_{t+2\|t}$	0.1094 0.0646			
$BSCR_t$, $FSCR_t$,	1.0000 1.0000	-8.4100	17.5458	13
$GSCR_t$, $UFCR_t$,	1.0000 1.0000			
$BSCR_{t+1\|t}$, $FSCR_{t+1\|t}$,	0.1341 0.1153			
$GSCR_{t+1\|t}$, $GSCR_{t+2\|t}$	0.0904 0.0823			

[a]Variables are designated by four-letter code. BS = British Spot Market (FTSE), FS = French Spot Market (CAC), GS = German Spot Market (DAX), UF = U.S. Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})\times 100$. Daily data covering the period from Nov. 26, 1990 to Feb. 20, 2001. Significance of the correlation is determined by positive values of DIC (another Akaike's information criteria) and Bartlett's χ^2 test.

The final estimate of state space model in Table 4.15 points out some interesting interactions. First, the data indicates significant instantaneous information transmission between the U.S. futures market and the British ($f_{4,5} = -4.5751$, $p \leq 0.05$), French ($f_{4,6}$ =

7.0000, $p \leq 0.05$), and German ($f_{4,7} = -6.4474$, $p \leq 0.05$) spot markets. Also, data suggests that each of the European markets is influenced by the information flow from the U.S. futures market to their own spot markets with a one-day lag.

TABLE 4.15

State Space Model for the Linkage between U.S. Futures and European Spot Markets[a]

$$
\begin{bmatrix} BSCR_{t+1} \\ FSCR_{t+1} \\ GSCR_{t+1} \\ UFCR_{t+1} \\ BSCR_{t+2\psi+1} \\ FSCR_{t+2\psi+1} \\ GSCR_{t+2\psi+1} \end{bmatrix}
=
\begin{bmatrix}
0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0.4306^{*} & 0.8768^{*} & -1.0971^{*} & 1.1728^{*} & -4.5751^{*} & 7.0000^{*} & -6.4474^{*} \\
0.3296^{*} & 0.7048^{*} & -0.9260^{*} & 1.0183^{*} & -3.3992^{*} & 5.4667^{*} & -5.3977^{*} \\
-0.0273 & 0.1926^{*} & -0.1389^{*} & -0.2025^{*} & 0.9968^{*} & 0.3375^{*} & -0.7211^{*} \\
-0.2216^{*} & -0.2180^{*} & 0.4179^{*} & -0.8533^{*} & 3.2458^{*} & -2.8307^{*} & 2.3478^{*}
\end{bmatrix}
\begin{bmatrix} BSCR_{t} \\ FSCR_{t} \\ GSCR_{t} \\ UFCR_{t} \\ BSCR_{t+\psi} \\ FSCR_{t+\psi} \\ GSCR_{t+\psi} \end{bmatrix}
+
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1 \\
0.0052 & -0.0248 & -0.0579^{*} & 0.2937^{*} \\
0.0224 & -0.0265 & -0.0757^{*} & 0.3903^{*} \\
0.0821^{*} & 0.1186^{*} & -0.2034^{*} & 0.4034^{*}
\end{bmatrix}
\begin{bmatrix} e_{t+1} \\ n_{t+1} \\ u_{t+1} \\ v_{t+1} \end{bmatrix}
$$

[a]Variables are designated by four-letter code. GS = German Spot Market (DAX), FS = French Spot Market (CAC 40 index), BS = British Spot Market (FTSE 100 index), UF = US Futures Market (S&P 500 Futures Index), C = Close, R = log Returns computed by $\ln(P_t/P_{t-1})\times 100$. Daily data covering the period from November 26, 1990 to February 20, 2001. * = Significance of t-test at $p \le 0.05$ level.

4.3 Information Transmission between the U.S. Futures Market and Major World Stock Markets

The initial autoregressive models for the relationship between the U.S. futures market and the four major world stock markets (Table 4.16) suggest a 2-lag structure (minimum AIC = –723.502 at lag 2).

TABLE 4.16

AIC for Autoregressive Models

World Stock Markets

Lag	AIC
0	-65.5444
1	-719.049
2	-723.502*
3	-710.377
4	-697.009
5	-679.621
6	-655.472
7	-657.863
8	-631.451
9	-618.081
10	-584.499

*** Signifies the lag for Yule-Walker equations.**

The canonical correlation analysis (Table 4.17) indicates that $BSCR_{t+1|t}$ (DIC = 4.9522; χ^2_{10} = 24.90398, $p < 0.01$) and $FSCR_{t+1|t}$ (DIC = 4.8164; χ^2_9 = 22.77666, $p < 0.01$) should be part of the state vector. Although $GSCR_{t+1|t}$ (DIC = -4.2145; χ^2_8 = 11.76729, $p = 0.1619$) and $JSCR_{t+1|t}$ (DIC = -12.2163; χ^2_7 = 1.781274, $p = 0.9709$) are not suggested by two selection criterion, both are included for the following reasons: (1) results in section 4.2 Table 4.15 indicate that the German market plays a significant role

in the information transmission between the U.S. futures and European spot markets, and (2) the Japanese stock market is significant in pair-wise with the U.S. futures market and should be part of the state vector at least as a control vector.

The final estimates of the model are presented in Table 4.18. The empirical findings point to a significant and instantaneous information flow from the U.S. futures markets to all four major world spot markets. Data also suggests that the British and Japanese spot markets are influenced by the information flow from the U.S. futures market with a one-day delay.

Findings of this study are in tune with the research previously done in related areas. The finance literature provides empirical evidence that there is a global informational flow between major spot markets [Hamao, Masulis, and Ng (1990), Jeon and Von Furstenberg (1990) and Aggarwal and Park (1994)]. There is also evidence that the U.S. futures markets lead the U.S. spot markets [Stoll and Whaley (1990), Cheung and Ng (1990) and Fleming, Ostdiek and Whaley (1996)]. The intuitive conclusion from the two points above is the exact result of this study. Furthermore, the findings of this study support the findings of Ostermark (1997) and Simm and Zurbreugg (1990) in the sense that there is informational linkage between the global spot markets and local futures markets.

TABLE 4.17

Canonical Correlation Analysis for the Linkage Between U.S. Futures and World Spot Markets[a]

State Vector	Correlation	DIC	X^2	Df.
$BSCR_t$, $FSCR_t$	1.0000 1.0000	4.9522	24.9040	10
$GSCR_t$, $JSCR_t$	1.0000 1.0000			
$UFCR_t$, $BSCR_{t+1\|t}$	1.0000 0.0980			
$BSCR_t$, $FSCR_t$	1.0000 1.0000	4.8164	22.7767	9
$GSCR_t$, $JSCR_t$	1.0000 1.0000			
$UFCR_t$, $BSCR_{t+1\|t}$	1.0000 0.0982			
$FSCR_{t+1\|t}$	0.0937			
$BSCR_t$, $FSCR_t$	1.0000 1.0000	-4.2145	11.7673	8
$GSCR_t$, $JSCR_t$	1.0000 1.0000			
$UFCR_t$, $BSCR_{t+1\|t}$	1.0000 0.1020			
$FSCR_{t+1\|t}$, $GSCR_{t+1\|t}$	0.0982 0.0674			
$BSCR_t$, $FSCR_t$	1.0000 1.0000	-12.2163	1.7813	7
$GSCR_t$, $JSCR_t$	1.0000 1.0000			
$UFCR_t$, $BSCR_{t+1\|t}$	1.0000 0.1056			
$FSCR_{t+1\|t}$, $GSCR_{t+1\|t}$	0.0991 0.0690			
$JSCR_{t+1\|t}$	0.0263			
$BSCR_t$, $FSCR_t$	1.0000 1.0000	-11.1528	0.8463	6
$GSCR_t$, $JSCR_t$	1.0000 1.0000			
$UFCR_t$, $BSCR_{t+1\|t}$	1.0000 0.1062			
$FSCR_{t+1\|t}$, $GSCR_{t+1\|t}$	0.1056 0.0911			
$JSCR_{t+1\|t}$, $UFCR_{t+1\|t}$	0.0639 0.0181			
$BSCR_t$, $FSCR_t$	1.0000 1.0000	-10.9014	1.0973	6
$GSCR_t$, $JSCR_t$	1.0000 1.0000			
$UFCR_t$, $BSCR_{t+1\|t}$	1.0000 0.1124			
$FSCR_{t+1\|t}$, $GSCR_{t+1\|t}$	0.1011 0.0840			
$JSCR_{t+1\|t}$, $BSCR_{t+2\|t}$	0.0684 0.0206			
$BSCR_t$, $FSCR_t$	1.0000 1.0000	-10.9237	1.0750	6
$GSCR_t$, $JSCR_t$	1.0000 1.0000			
$UFCR_t$, $BSCR_{t+1\|t}$	1.0000 0.1084			
$FSCR_{t+1\|t}$, $GSCR_{t+1\|t}$	0.1005 0.0867			
$JSCR_{t+1\|t}$, $FSCR_{t+2\|t}$	0.0437 0.0204			
$BSCR_t$, $FSCR_t$	1.0000 1.0000	-10.4176	1.5805	6
$GSCR_t$, $JSCR_t$	1.0000 1.0000			
$UFCR_t$, $BSCR_{t+1\|t}$	1.0000 0.1071			
$FSCR_{t+1\|t}$, $GSCR_{t+1\|t}$	0.0995 0.0779			
$JSCR_{t+1\|t}$, $GSCR_{t+2\|t}$	0.0586 0.0247			

TABLE 4.17

Continued

State Vector	Correlation	DIC	X^2	Df.
$BSCR_t$, $FSCR_t$	1.0000 1.0000	-10.4223	1.5758	6
$GSCR_t$, $JSCR_t$	1.0000 1.0000			
$UFCR_t$, $BSCR_{t+1\|t}$	1.0000 0.1074			
$FSCR_{t+1\|t}$, $GSCR_{t+1\|t}$	0.0999 0.0762			
$JSCR_{t+1\|t}$, $JSCR_{t+2\|t}$	0.0587 0.0247			

[a]Variables are designated by four-letter code. BS = British Spot Market (FTSE), FS = French Spot Market (CAC), GS = German Spot Market (DAX), JS = Japanese Spot Market (NIKKEI), UF = U.S. Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})x100$. Daily data covering the period from Nov. 26, 1990 to Feb. 20, 2001. Significance of the correlation is determined by positive values of DIC (another Akaike's information criteria) and Bartlett's χ^2 test.

TABLE 4.18

State Space Model for Linkage between the U.S. Futures and World Spot Markets[a]

$$
\begin{bmatrix} BSCR_{t+1} \\ FSCR_{t+1} \\ GSCR_{t+1} \\ JSCR_{t+1} \\ UFCR_{t+1} \\ BSCR_{t+2\psi+1} \\ FSCR_{t+2\psi+1} \\ GSCR_{t+2\psi+1} \\ JSCR_{t+2\psi+1} \end{bmatrix}
=
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0.4139^{*} & 0.4383^{*} & -0.0527 & -0.1696^{*} & 0.3201^{*} & 1.4936^{*} & 1.5396^{*} & -1.0298^{*} & -3.0567^{*} \\
0.2285^{*} & 0.2636^{*} & 0.0240 & -0.0862^{*} & 0.1635^{*} & 1.7672^{*} & 0.5480^{*} & -0.3737^{*} & -2.3110^{*} \\
-0.0220 & 0.1778^{*} & -0.1621^{*} & -0.0130 & -0.0848 & 0.3709 & 0.4437 & -0.6602^{*} & 0.0266 \\
-0.0290 & 0.1769^{*} & -0.0313 & 0.0068 & -0.1589 & 1.0391^{*} & 0.2333 & -0.3773 & -0.4069 \\
0.1574^{*} & 0.2113^{*} & -0.0608 & -0.0659^{*} & 0.1280^{*} & 1.1864^{*} & 0.6376^{*} & -0.5723^{*} & -1.3453^{*}
\end{bmatrix}
\begin{bmatrix} BSCR_{t} \\ FSCR_{t} \\ GSCR_{t} \\ JSCR_{t} \\ UFCR_{t} \\ BSCR_{t+1\psi} \\ FSCR_{t+1\psi} \\ GSCR_{t+1\psi} \\ JSCR_{t+1\psi} \end{bmatrix}
+
$$

$$
+
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 \\
0.0065 & -0.0181 & -0.0634 & -0.0563 & 0.2987 \\
0.0377 & -0.0233 & -0.0768 & -0.0656 & 0.3915 \\
0.0900 & 0.1302 & -0.2026 & -0.0875 & 0.4046 \\
0.1115 & 0.0659 & -0.0030 & -0.0774 & 0.3257
\end{bmatrix}
\begin{bmatrix} e_{t+1} \\ n_{t+1} \\ u_{t+1} \\ v_{t+1} \\ w_{t+1} \end{bmatrix}
$$

[a]Variables are designated by four-letter code. GS = German Spot Market (DAX), FS = French Spot Market (CAC 40 index), BS = British Spot Market (FTSE 100 index), JS = Japanese Spot Market (NIKKEI 225 index), UF = US Futures Market (S&P 500 Futures Index), C = Close R = log Returns computed by $\ln(P_t/P_{t-1})\times 100$. Daily data covering the period from November 26, 1990 to February 20, 2001. * = Significance of t-test at $p \leq 0.05$ level.

CHAPTER V

CONCLUSION

Using state space modeling, this work examines the causal link (in Granger sense) between the U.S. futures markets (S&P 500 index) and four major world spot markets (German XETRA DAX stock index, French CAC 40 index, British FTSE 100 index, and Japanese NIKKEI 225 index). The major finding of this study is that there is significant instantaneous information transfer and price discovery between the U.S. futures markets and four major world spot markets. This study provides, for the first time, evidence that in this relationship the causality is running from major foreign spot markets to the U.S. futures markets. The implication of this finding is that the active traders in the U.S. futures markets may improve their trading strategy and gain significant benefits (in terms of pricing or in terms of risk assessment) from incorporating the pricing behavior of major foreign spot markets.

Empirical evidence provided by this study indicates that academic research in the futures markets should incorporate the impact of foreign spot markets to prevent any model misspecification.

A possible extension of this study would be the interaction of international futures markets. Another extension of this study would be the volatility spillover effect from U.S. futures market to the foreign spot markets.

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VITA

ZELIHA ILHAN ERTUNA

Bilkent Universitesi
Dogu Lojmanlari C – 10
Bilkent – 06533 Ankara
Turkey
E–mail: zertuna@odu.edu

EDUCATION

Old Dominion University, Business and Public Administration Dept.,
Finance/International Business Ph.D. Program 1995 - Present (ABD)

University of Memphis, Fogelman College of Business &
Economics, M.S. in Finance 1995

Maharishi International University, College of Business
Master of Business Administration, 1989

University of Ege, College of Science, Turkey
Bachelor of Science in Chemistry, 1980

EXPERIENCE

Old Dominion University, Finance Department
Adjunct Faculty/Teaching Assistant 1995 - 2000
Courses Taught at Undergraduate Level:
Financial Management
Teletechnet Courses Taught at Undergraduate Level:
Financial Management

University of Memphis, Finance Department
Instructor/ Graduate Assistant 1990 - 1994
Courses Taught at Undergraduate Level:
Financial Management

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