
A FURTHER INVESTIGATION OF THE LEAD-LAG RELATIONSHIP BETWEEN THE CASH MARKET AND STOCK INDEX FUTURES MARKET WITH THE USE OF BID/ASK QUOTES: THE CASE OF FRANCE

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INTRODUCTION

Much research has investigated the lead-lag relationship of the cash market and the stock index futures market with the use of transaction data. Finnerty and Park (1987), Ng (1987), Kawaller, Koch, and Koch (1987),

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Harris (1989), Stoll and Whaley (1990), and Chan (1992) report that price movements in the futures markets consistently lead the stock index movements, while there is weak evidence that stock index movements lead to futures price changes. This lead-lag relationship between the futures and cash index markets can be attributed to lower transaction costs and less restrictive short selling in the futures market. Chan (1992) suggests that the lead-lag pattern is not well explained by nonsynchronous trading, and that futures prices tend to be better at reflecting marketwide information than cash index prices. Martikainen and Puttonen (1992) suggest that informational interrelationships between futures market returns across countries can be stronger than those between stock markets.¹ Booth, Broussard, and Loistl (1994) and Grunbichler, Longstaff, and Schwartz (1994) also conclude that the German futures market tends to lead the cash market.

Most relevant studies employ transaction data to study the lead-lag relationship between cash and futures markets. This creates nonsynchronous trading problems because the transaction price represents the stale price of the last trade. Because stock index futures contracts are more frequently traded than most individual stocks in the cash market, one is more likely to find futures leading cash with the use of transaction data. On the other hand, bid/ask quotes are executable prices if traders want to buy or sell at the market. As a result, bid/ask prices represent market conditions better than transaction prices. To study the price transmission process between futures and cash, one should look into the lead-lag relationship of bid/ask quotes between cash and futures markets. Because the CME and CBOT do not release bid/ask quotes, most studies on US stock index futures cannot get around the stale-price problem. This study uses a unique data set of French stock transaction prices and bid/ask quotes from the Matif (futures market) and the Paris Bourse (cash market) to further investigate the lead-lag relationship between futures market and cash market. Although the analysis on transaction price data

¹In addition to studies on futures/cash relationships, Manaster and Rendleman (1982), Bhattacharya (1987), and Anthony (1988) report consistent evidence that the option market tends to lead the stock market. They attribute this evidence to lower transaction costs and capital requirements, fewer trading restrictions, and greater actions provided by option trading. However, with the use of transaction data, Stephan and Whaley (1990) show that the stock market leads the option market by 20 minutes, and suggest that the consensus view that options lead stocks may be wrong. Pan, Rim, and Hocking (1991) also document that the currency spot market leads the currency options market by 90 minutes. Freund and Webb (1991) argue that the lead-lag relationship may depend on the type of information. They conjecture that option prices will lead stock prices when firm-specific information becomes available to the market, but marketwide information will first be reflected in stock prices, and then in option prices. In addition, Chan, Chung, and Johnson (1993) argue that the stock market leading the option market is due to technicalities in how the options and stocks are traded.

conforms to previous findings that futures markets lead cash markets, the results with the use of French bid/ask quote-mid-point data suggest that the reverse intermarket price transmission is much stronger.

THE MATIF VERSUS THE BOURSE

It is well known that the French Bourse was originally based on the Napoleonic Code, the outstanding feature of which was the notion that the actual exchange of stocks takes place through intermediaries designated by the state with a monopoly power. This kind of system does little to enhance transparency in an auction market. The Matif, on the other hand, which opened its doors in 1986, was from its inception based on an Anglo-Saxon notion of a continuous open-outcry system with standardized contract orders being filled immediately as long as a counterparty is found. Thus, the presupposition would be greater transparency in the Matif than in the Bourse, with as a consequence futures leading the underlying cash. However, the monopolistic control of state-designated brokers ended on January 1, 1992. From 1986 to 1992, the Paris Bourse shifted from a daily call auction to a computerized limit order market where trading takes place continuously from 10 A.M. to 5 P.M. This is documented by Biais, Hillon and Spatt (1994):

The status of the security's book is updated (almost instantaneously) on traders' screens, each time there is an order arrival, cancellation or execution. Brokers and the most active traders in the market can directly route their orders to the CAC system. Electronic transmission of the orders and updating of the screen usually take less than one second.

In addition, the severe competition between London SEAQ International and the Bourse on French stock trading also imposes pressure to enhance the transparency and efficiency of the Bourse.² A survey on European equities traded on SEAQ by Davis (1993) finds that market-making firms accept customer business in London, but are more likely to close out those positions on a domestic stock exchange. This interlinking ensures an efficient flow of information between the markets, reinforcing price competition.

On the other hand, the Matif uses a traditional open-outcry trading

²All components in CAC40 are also traded on SEAQ International in London, with approximately one-third of the volume on the Paris Bourse. Although the Bourse operates an order-driven system for all stocks, SEAQ International is a quote-driven market, with market makers quoting prices for each stock. See De Jong, Nijman, and Roell (1993) for a comparison of the cost of trading French shares on the Paris Bourse and on SEAQ International.

system during normal trading hours and reports bid/ask/transaction price for each contract appearing on the quotation screen. Bids and offers sent to the trading floor are systematically reported by quote recorders in the pits. In the same way, when a transaction is made, the price of the transaction is displayed on the quotation screen. As documented by Shyy and Lee (1995), DTB (with the use of an automated trading system) leads LIFFE (using open outcry) in the price transmission of Bund futures trading despite the fact that LIFFE has greater trading volume. Similarly, the Paris Bourse is likely to report price information faster than the Matif due to differences in their trading mechanisms.

The rest of this section reviews the major operating differences between the Matif and the Bourse. The Matif contracts share several similarities with the Bourse. Both exchanges utilize market orders, limit orders, fill and kill, and stop loss orders. Neither allows market makers, except for the trading of certain kinds of options such as options on futures where the liquidity is not guaranteed by the market. As for the trading of individual shares and futures contracts on CAC40, neither exchange imposes short-selling restrictions.

One should note also the following salient facts:

1. The Bourse employs an automated order-matching system similar to the one used in Canada. The opening value of the CAC (the first fixing of the day) is determined by the accumulation of orders between 9 A.M. and 10 A.M. In this pre-opening hour, a sequence of call auctions occurs to facilitate the price discovery process. The Matif operates a 24-hour trading system, employing an open-outcry system during normal trading hours. After-hours trading activity is handled on Globex with no trading recess between Globex and the Matif open-outcry.
2. The Bourse has a computerized prioritization system for limit orders based on price priority and time priority. For the Matif, limit orders not serviced immediately are serviced at the next available opportunity through open-outcry floor trading. It is difficult to observe time priority in a floor-trading environment.
3. Market orders on Bourse are executed against the best price. Any excess of market orders on the Bourse that are not completely executed are turned into limit orders at that best price, rather than by walking up (down) the book. On the other hand, market orders on the Matif that are not executed are executed by walking up (down) the book.
4. The Paris Bourse allows for the possibility of placing block orders (limit) that are not fully visible to other traders. These orders are called

hidden orders, with parts of them becoming visible, like a slowly revealed iceberg, as they are serviced. The invisible part of the order retains price priority but not time priority.³ Biais, Hillon, and Spatt (1994) have estimated that one out of eight orders are hidden orders. It is widely believed that hidden orders reduce market transparency, and therefore, reduce the price discovery efficiency of the Bourse.

5. As mentioned before, there is substantial trading of French stocks on the London SEAQ International exchange. Although London has an advantage in attracting larger-sized deals, the trading volume on SEAQ International for the stocks that are components in the CAC40 index is approximately one-third of that on the Paris Bourse. On the other hand, a CAC40 index futures contract is not traded on offshore futures exchange. The competition between SEAQ International and the Paris Bourse may enhance the information efficiency of the French (cash) stock market.
6. For the Matif margin requirements are a minimum of 20,000 francs/contract, revisable as a function of the variation of the index. The Bourse also allows one to speculate on large sums of money by margining with a deposit of approximately 20% of total size. If one compares the margin requirements on the Bourse and the Matif, the Matif has a clear advantage for margin trading.
7. There is very little difference in the taxation of profits on the Bourse or Matif for active traders. Profits are taxed as income for both contracts. For infrequent traders, the tax rate on the Matif is as low as 17% on net income at the end of the year.
8. Although normally the transaction tax ranges from 0.15 to 0.30% in the Bourse, there is no transaction tax for transactions lower than 50,000 francs. Commissions are usually about 0.65% in the Bourse. On the Matif, the commissions are very low, at about 300 francs per contract.

REAL-TIME QUOTES AND DATA COLLECTION

Minute-by-minute bid/ask quotes and transaction prices for the September 1994 CAC index futures contract, cash index, and the individual stocks that are components in the CAC40 index are collected from the Reuter Terminal from August 1 through 31, 1994. All prices reflect the

³The hidden order works like the delay trade in SEAQ that allows the market maker to delay the report of the transaction if the order is bigger than a normal size.

TABLE I
CAC40 Components (Weights for Stocks are as of August 1, 1994)

%	Stock Name	%	Stock Name
1.18	ACCOR	3.35	AIR LIQUIDE
6.61	ALCATEL ALSTBOM	2.79	AXA
0.93	BANCAIRE (CIE)	3.32	B N P
0.90	BOUYGUES	1.34	CANAL PLUS
3.60	CARREFOUR	0.62	CASINO
1.11	C.C.F.	0.84	CR. FONCIER FRCE
1.68	CR. LOCAL FRANCE	0.53	C.G.I.P.
4.15	DANONE	4.71	EAUX (GLE DES)
7.59	ELF-AQUITAINE	0.16	EURO DISNEY SCA
1.52	HAVAS	2.37	LAFARGE COPPEE
0.81	LAGARDERE GROUPE	0.92	LEGRAND
5.15	L.V.M.H.	2.18	LYONNAISE EAUX
1.88	MICHELIN	4.85	OREAL
3.06	PARIBAS	1.36	PERNOD RICARD
3.01	PEUGEOT S.A.	1.17	PROMODES
2.42	RHONE-POULENCA	3.95	SAINT-GOBAIN
0.89	SAINT-LOUIS	0.89	SANCFI
1.65	SCHNEIDER	3.56	SOCIETE GENERALE
3.17	TOTAL B	1.34	TEOMSON-CSF
5.34	SUEZ	3.10	U.A.P.

end of the trading minute as trading activities are simultaneously reported in both the Matif and the Bourse.

This study uses the real-time quotations from the Reuter Terminal through Excel Access, a software product developed jointly by Reuters and Microsoft, which combines the timeliness of market data from the Reuter Terminal with the full functionality of the Microsoft Excel spreadsheet program. The component stocks of the CAC40 index as of August 1, 1994, are shown in Table I.

The following problems incurred in the data-collection procedure should be noted:

1. There were communication breakdowns due to interruptions of the direct communication phone line. Whenever there is a transmission breakdown in the Reuter Terminal, the terminal shows an "IDN COMM FAULT" signal. The data during such periods are deleted from the study.
2. In some (very rare) cases, there are some prices that are completely aberrant, due to human and technical errors. The validity of all data series are checked by filtering out impossible market conditions. For example, the daily high/low prices that are clearly outside the range of possible prices are deleted from our data set.

To examine the consistency of the empirical results, two sample periods are used. The first sample period is from August 1, 1994 to August 18, 1994. There are 3816 observations for each bid/ask/last-price series during the first sample period. The second sample period is from August 19, 1994 to August 23, 1994. There are 3300 observations for each bid/ask/last-price series during the second sample period. Because the open-outcry session of the CAC40 contract in the Matif has the same trading hours as the Bourse, the after-hour Globex trading is not included in the sample period.

CAUSALITY TEST: ERROR-CORRECTION MODEL

To investigate the intermarket relationship between the Matif and the Bourse, Granger causality tests are conducted. A time series, $\{X_t\}$, is said to Granger cause another time series, $\{Y_t\}$, if present Y can be predicted better by using past values of X than by not doing so. The first step in the empirical analysis is to examine the stationarity of the price series. The nonstationarity is tested with the use of the augmented Dickey–Fuller (ADF) test.⁴ The ADF test for all last-price series cannot reject the nonstationary hypothesis at the 0.01 level based on Fuller (1976). On the other hand, all first-differenced series reject the nonstationary hypothesis at the 0.01 level. In addition, a test is conducted to determine whether intermarket comovement exists between each pair of market prices in the Matif and the Bourse. As suggested by Engle and Granger (1987), if Y_t and X_t are co-integrated, then there exists a constant A such that $\varepsilon_t = Y_t - AX_t$ is stationary. As a result,

$$Y_t = a + \beta X_t + \varepsilon_t \quad (1)$$

where Y_t is the price series in the Matif; X_t is the price series in the Bourse. The augmented Dickey–Fuller (ADF) test is used to test the significance of β in the following regression:

$$\Delta \varepsilon_t = a + \beta \varepsilon_{t-1} + \sum_{i=1}^n \phi_i \Delta \varepsilon_{t-i} + v_t \quad (2)$$

where ε_t is the error term from the co-integration equation and v_t is a stationary random error term.

⁴The test results are not sensitive to lag length used.

If co-integration exists between two series of price data, an error-correction term is added to the causality tests [see Engle and Granger (1987)]. To avoid the problem of heteroscedasticity, a generalized method of moments (GMM) by Hansen (1982) is employed to estimate the parameters in the following Granger causality regression:

$$\Delta Y_t = a + \sum_{i=1}^5 \beta_{yi} \Delta Y_{t-i} + \sum_{i=1}^5 \beta_{xi} \Delta X_{t-i} + \gamma e_{t-1} + e_t \quad (3)$$

where ΔX is the differenced lagged independent variables, ΔY is the differenced lagged dependent variable, and ε is the error term. Y can be affected by X through two different channels. The conventional way to explain Granger causality is to assert that the change in X_{t-1} causes a significant move in Y_t . Another causal channel in the error-correction model is through the residual term from the co-integration equation. Because the price series between the Matif and the Bourse are co-integrated, a diverging X_{t-1} from Y_{t-1} (higher residual in the co-integration equation) will pressure Y_t , moving it closer to X_t . To test the information causality, the Wald test with an asymptotical χ^2 distribution is used to test the null hypothesis: Coefficients for ΔX_{t-1} , ΔX_{t-2} , ΔX_{t-3} , ΔX_{t-4} , ΔX_{t-5} are zero.

If the Granger causality equation is further expressed in the matrix notation as $X = Z\beta + \xi$, where Z is the observation matrix for T observations of regressors; X is the corresponding dependent variable. Hansen (1982) proves that the estimator of β based on OLS is still consistent, but its variance-covariance matrix needs to be modified. The asymptotic distribution of β is expressed by

$$\sqrt{T}(\beta - \hat{\beta}) \sim N(0, \Sigma)$$

where

$$\Sigma = (M_{zz} W^{-1} M_{zz})^{-1} \quad (4)$$

and $M_{zz} = \lim(Z'Z/T)$ and $W = \lim(Z'\xi\xi'Z/T)$. W is unknown. However, the asymptotic distribution of it would remain unaffected if W is replaced by a consistent estimate. It can be verified that, under plausible regularity conditions and assuming that ξ_t has an m th-order moving average representation, W can be consistently estimated as

$$\hat{W} = T^{-1} \sum_{t=1}^T \sum_{k=-m}^m z_t \hat{\xi}_t \hat{\xi}_{t-k}' z_{t-k}' \quad (5)$$

where z_t is the t th row of Z and $\hat{\xi}_t$ is the consistent estimate of ξ_t . W is

sometimes termed the matrix covariogram.⁵ A standard instrumental variables estimator can be employed so as to yield consistent estimates of the coefficients and thus of the stochastic disturbances. These disturbances are substituted into (5) to obtain a consistent estimate of W , which is then employed in (4). Restrictions on β can be tested by the conventional Wald test. In particular, the null hypothesis, $H_0: \beta = \beta_0$, can be tested by the statistic

$$\text{Wald} = (-\beta_0)' Z'ZW^{-1}Z'Z (-\beta_0)$$

which has a limiting χ^2 distribution with a degree of freedom equal to the number of restrictions.

Empirical Results with the Use of the Last Transaction Price

Before testing two time series for integration, it is important to ensure that they each demonstrate the same order of nonstationarity. The ADF test is employed to test the nonstationarity hypothesis for the last transaction price series traded on the Matif and the Bourse. It is found that neither series can reject the nonstationarity hypothesis at the 0.01 level. However, by taking the difference of the price level, all series reject the nonstationarity hypothesis at the 0.01 level.⁶ As a result, it is concluded that the price difference series, not the price level, is stationary. After the stationarity test, the co-integration relationship between the price series on the Matif and the Bourse is investigated. If the Matif series (CAC^F) is regressed against the Bourse series (CAC^C), the estimate of the OLS co-integration regression yields the following results:

$$(1) \text{ Sample Period 1: } CAC_t^F = 0.0018 + 1.0002 CAC_t^C$$

(0.296)
(1198.31)

$$R^2 = 0.997.$$

$$(2) \text{ Sample Period 2: } CAC_t^F = 0.8216 + 0.892 CAC_t^C$$

(62.14)
(515.01)

$$R^2 = 0.987.$$

⁵In practice, a limitation may arise because no guarantee is available that the matrix covariogram is positive definite. One remedy lies in weighing the matrix covariogram with a lag window that displays some measure of decay at a successively higher order [Newey and West (1987)]. The power of the lag windows is selected to be 0.9, which suffices to yield a positive definite matrix covariogram.

⁶See Table 8.5.2 in Fuller (1976).

TABLE II(a)
GMM Regression for Granger Causality Tests on Transaction Prices of CAC Index between the Matif and the Paris Bourse from August 1, 1994 to August 18, 1994. Parameter Estimates for Lagged Independent Variables (ΔX), Lagged Dependent Variables (ΔY), and an Error Term (ε) are Derived From the Following Regression:

$$\Delta Y_t = \alpha + \sum_{i=1}^5 \beta_{yi} \Delta Y_{t-i} + \sum_{i=1}^5 \beta_{xi} \Delta X_{t-i} + \gamma \varepsilon_{t-1}.$$

T Statistics are in Parentheses. $\chi^2(5)$ Is Used To Test the Null Hypothesis: Coefficients for $\Delta X_{t-1}, \Delta X_{t-2}, \Delta X_{t-3}, \Delta X_{t-4}, \Delta X_{t-5}$ Are Zero. $\chi^2(6)$ Is Used to Test the Null Hypothesis: Coefficients for $\Delta X_{t-1}, \Delta X_{t-2}, \Delta X_{t-3}, \Delta X_{t-4}, \Delta X_{t-5}$, and Error Term Are Zero

CAC ^C GC CAC ^F			CAC ^F GC CAC ^C		
β_{y1}	-0.0076	(-0.34)	β_{y1}	-0.064	(-2.68)
β_{y2}	-0.046	(-1.85)	β_{y2}	-0.068	(-3.25)
β_{y3}	-0.033	(-1.62)	β_{y3}	-0.045	(-2.25)
β_{y4}	-0.020	(-0.98)	β_{y4}	0.003	(0.19)
β_{y5}	-0.025	(-1.23)	β_{y5}	0.006	(0.34)
β_{x1}	0.044	(1.93)	β_{x1}	0.262	(11.12)
β_{x2}	-0.015	(-0.66)	β_{x2}	0.161	(6.56)
β_{x3}	0.021	(1.03)	β_{x3}	0.095	(5.05)
β_{x4}	0.0069	(0.32)	β_{x4}	0.071	(3.96)
β_{x5}	-0.016	(-0.88)	β_{x5}	0.036	(2.40)
γ	-0.029	(-3.39)	γ	-0.069	(-3.73)
$\chi^2(5) = 6.50$			$\chi^2(5) = 125.21^{**}$		
(p value = 0.2600)			(p value = 0.0000)		
$\chi^2(6) = 20.77^{**}$			$\chi^2(6) = 329.07^{**}$		
(p value = 0.0020)			(p value = 0.0000)		

*Significant at the 0.05 level.
**Significant at the 0.01 level.

With the use of the error terms from the previous equations, the t statistics for the β estimates based on eq. (2) are found to be -11.41 and -7.91. The results reject the non-co-integration hypothesis at the 0.01 level. Table II(a) and Table II(b) show the results of Granger causality tests using transaction price data. By testing two pairs of the last price series for Matif/Bourse, the results support the hypothesis that price movements of CAC futures in the Matif Granger cause the price movements in the Bourse at the 0.01 level during both sample periods. However, significant reverse causality from the Bourse to the Matif through first channel (previous cash price affecting futures price) is not significant at the 0.01 level in both sample periods. By adding the error-correction term, the Matif tends to have a price reversal after the spread between cash and futures widens.

Empirical Results with the Use of the Bid/Ask Quote Midpoint

Stale transaction prices and nonsynchronous trading create problems for testing lead-lag relationships between cash and futures. To solve the problem, bid/ask prices are collected for the CAC futures, and all individual stocks that are components in the CAC40 index. Because bid/ask prices are market quotes that are valid for any minute in the sample period, there is no nonsynchronous *quoting* problem in the analysis of using quote midpoint of bid/ask prices.

First, the first-differenced price series are confirmed to be stationary. Regressing bid/ask quote-midpoint on the Matif series against the Bourse series results in the following estimates for CAC:⁷

$$(1) \text{ Sample Period 1: } CAC_t^F = 0.8716 + 1.087 CAC_t^C$$

$$(66.54) \quad (516.37)$$

$$R^2 = 0.986$$

$$(2) \text{ Sample Period 2: } CAC_t^F = 1.6159 + 0.966 CAC_t^C$$

$$(69.23) \quad (257.00)$$

$$R^2 = 0.953$$

The t statistics for β estimates based on eq. (2) are found to be -11.98 for Sample Period 1 and -8.03 for Sample Period 2. The non-co-integration hypothesis is rejected at the 0.01 level. Tables III(a) and III(b) show the results of the Granger causality test for both sample periods using minute-by-minute bid/ask quote midpoint of CAC futures traded on the Matif and cash index on the Bourse. Surprisingly, the results with the use of bid/ask price series are very different from the previous findings with the use of the last transaction price series. Most importantly, the chi-squared values for the first causal channel from the Bourse to the Matif become significant at the 0.01 level. On the other hand, the Chi-squared values of the first causal channel for the Matif futures affecting the Bourse become insignificant at 0.05 level during both sample periods. (However, the second causal channel of the error term is still significant for the first sample period) During the second sample period, both causal channel, from the Matif to the Bourse are not significant at the 0.05 level. It is also important to note that at least one of the error-term factors

⁷All price series are measured in natural logarithms.

TABLE II(b)

GMM Regression for Granger Causality Tests on Transaction Prices of CAC Index between the Matif and the Paris Bourse from August 19, 1994 to August 31, 1994. Parameter Estimates for Lagged Independent Variables (ΔX), Lagged Dependent Variables (ΔY), and an Error Term (ε) are Derived from the Following Regression:

$$\Delta Y_t = \alpha + \sum_{i=1}^5 \beta_{yt} \Delta Y_{t-i} + \sum_{i=1}^5 \beta_{\varepsilon} \Delta X_{t-i} + \gamma \varepsilon_{t-1}.$$

T Statistics are in Parentheses. $\chi^2(5)$ Is Used To Test the Null Hypothesis: Coefficients for ΔX_{t-1} , ΔX_{t-2} , ΔX_{t-3} , ΔX_{t-4} , ΔX_{t-5} , Are Zero. $\chi^2(6)$ Is Used to Test the Null Hypothesis: Coefficients for ΔX_{t-1} , ΔX_{t-2} , ΔX_{t-3} , ΔX_{t-4} , ΔX_{t-5} , and Error Term Are Zero

CAC ^C GC CAC ^F			CAC ^F GC CAC ^C		
β_{y1}	-0.056	(-2.69)	β_{y1}	-0.024	(-0.86)
β_{y2}	-0.346	(-1.64)	β_{y2}	-0.010	(-0.41)
β_{y3}	-0.047	(-2.10)	β_{y3}	0.003	(0.12)
β_{y4}	-0.025	(-1.24)	β_{y4}	0.028	(0.94)
β_{y5}	-0.005	(-0.28)	β_{y5}	0.011	(0.62)
β_{x1}	0.039	(1.79)	β_{x1}	0.265	(7.58)
β_{x2}	-0.020	(-1.48)	β_{x2}	0.142	(3.83)
β_{x3}	0.025	(2.00)	β_{x3}	0.080	(3.17)
β_{x4}	0.022	(1.99)	β_{x4}	-0.007	(-0.16)
β_{x5}	0.0002	(0.01)	β_{x5}	0.017	(0.52)
γ	-0.008	(-1.93)	γ	-0.039	(-1.60)
$\chi^2(5) = 13.10^*$			$\chi^2(5) = 158.12^{**}$		
(p value = 0.0224)			(p value = 0.0000)		
$\chi^2(6) = 22.74^{**}$			$\chi^2(6) = 268.15^{**}$		
(p value = 0.0008)			(p value = 0.0000)		

*Significant at the 0.05 level.
**Significant at the 0.01 level.

(price differential between cash and futures) in all cases affects the futures return at the 0.05 level. It shows that arbitrage activities will bring the futures price down (up) by selling (buying) futures and buying (selling) cash if the spread (futures–cash) is too high (low). Figure 1 shows that price differentials between cash and futures are not over 0.3% on both sides, and there is no consistent arbitrage opportunity.

These findings show that previous results with the use of U.S. transaction prices could be misleading because of nonsynchronous trading and the stale price problem. Using the bid/ask quote midpoint as an indicator of the current market situation produces totally different results. Another reason that the results of this study show significant reverse causality is that the Bourse employs an automated order-matching system, whereas

TABLE III(a)

GMM Regression for Granger Causality Tests on Bid/Ask Quote-Midpoint of CAC Index Between the Matif and the Paris Bourse from August 1, 1994 to August 18, 1994. Parameter Estimates for Lagged Independent Variables (ΔX), Lagged Dependent Variables (ΔY), and an Error Term (ε) Are Derived from the Following Regression:

$$\Delta Y_t = a + \sum_{i=1}^5 \beta_{yt} \Delta Y_{t-i} + \sum_{i=1}^5 \beta_{xi} \Delta X_{t-i} + \gamma \varepsilon_{t-1}$$

T Statistics Are in Parentheses. $\chi^2(5)$ Is Used to Test the Null Hypothesis: Coefficients for ΔX_{t-1} , ΔX_{t-2} , ΔX_{t-3} , ΔX_{t-4} , ΔX_{t-5} Are Zero. $\chi^2(6)$ Is Used To Test the Null Hypothesis: Coefficients for ΔX_{t-1} , ΔX_{t-2} , ΔX_{t-3} , ΔX_{t-4} , ΔX_{t-5} , and Error Term are Zero

CAC ^C GCCAC ^F			CAC ^F GCCAC ^C		
β_{y1}	-0.562	(-5.24)	β_{y1}	0.164	(6.56)
β_{y2}	-0.434	(-4.13)	β_{y2}	0.036	(1.45)
β_{y3}	-0.318	(-3.29)	β_{y3}	0.075	(3.18)
β_{y4}	-0.204	(-2.67)	β_{y4}	0.003	(0.16)
β_{y5}	-0.106	(-2.23)	β_{y5}	0.015	(0.67)
β_{x1}	0.735	(3.98)	β_{x1}	-0.0002	(-0.05)
β_{x2}	0.286	(2.95)	β_{x2}	0.0025	(0.40)
β_{x3}	0.188	(1.76)	β_{x3}	0.0017	(0.31)
β_{x4}	-0.013	(-0.15)	β_{x4}	0.0016	(0.38)
β_{x5}	0.006	(0.08)	β_{x5}	0.0012	(0.60)
γ	-0.267	(-2.20)	γ	-0.017	(-3.50)
$\chi^2(5) = 21.22^{**}$			$\chi^2(5) = 3.354$		
(p value = 0.0007)			(p value = 0.645)		
$\chi^2(6) = 23.54^{**}$			$\chi^2(6) = 18.51^{**}$		
(p value = 0.0006)			(p value = 0.005)		

*Significant at the 0.05 level.

**Significant at the 0.01 level.

the Matif uses open-outcry floor trading. In an open-outcry system, the bid/ask quotes are reported by exchange observers on the trading floor by watching the trading activities in the pit. Based on conversations with major brokers in London, it is very likely that, in a fast market, the prices reported by an observer are not as updated as the current market. As a result, previous findings in the U.S. (and Germany) that futures lead cash could be due to either stale transaction prices or to the different trading mechanisms employed.

CONCLUSIONS

This article investigates the lead-lag relationship between stock index futures traded on the Matif and the cash index traded on the Paris Bourse.

TABLE III(b)

GMM Regression for Granger Causality Tests on Bid/Ask Quote-Midpoint of CAC Index Between the Matif and the Paris Bourse from August 19, 1994 to August 31, 1994. Parameter Estimates for Lagged Independent Variables (ΔX), Lagged Dependent Variables (ΔY), and an Error Term (ε) Are Derived from the Following Regression:

$$\Delta Y_t = a + \sum_{i=1}^5 \beta_{yt} \Delta Y_{t-i} + \sum_{i=1}^5 \beta_{xt} \Delta X_{t-i} + \gamma \varepsilon_{t-1}$$

T Statistics Are in Parentheses. $\chi^2(5)$ Is Used to Test the Null Hypothesis: Coefficients for ΔX_{t-1} , ΔX_{t-2} , ΔX_{t-3} , ΔX_{t-4} , ΔX_{t-5} Are Zero. $\chi^2(6)$ Is Used To Test the Null Hypothesis: Coefficients for ΔX_{t-1} , ΔX_{t-2} , ΔX_{t-3} , ΔX_{t-4} , ΔX_{t-5} , and Error Term are Zero

CAC ^C GCCAC ^F			CAC ^F GCCAC ^C		
β_{y1}	-0.380	(-8.41)	β_{y1}	0.0685	(2.12)
β_{y2}	-0.544	(-5.55)	β_{y2}	-0.0007	(-0.02)
β_{y3}	-0.402	(-3.95)	β_{y3}	0.0259	(1.33)
β_{y4}	-0.266	(-2.98)	β_{y4}	-0.0004	(-0.01)
β_{y5}	-0.138	(-2.33)	β_{y5}	-0.024	(-1.03)
β_{x1}	0.436	(4.24)	β_{x1}	0.0033	(0.79)
β_{x2}	0.490	(2.63)	β_{x2}	0.0067	(1.46)
β_{x3}	0.462	(2.02)	β_{x3}	0.0069	(1.30)
β_{x4}	-0.028	(-0.15)	β_{x4}	0.0063	(1.66)
β_{x5}	0.195	(0.68)	β_{x5}	0.0035	(1.82)
γ	-0.168	(-2.25)	γ	-0.0019	(-0.90)
$\chi^2(5) = 30.64^{**}$			$\chi^2(5) = 8.13$		
(p value = 0.0000)			(p value = 0.14)		
$\chi^2(6) = 59.47^{**}$			$\chi^2(6) = 8.93$		
(p value = 0.0000)			(p value = 0.17)		

*Significant at the 0.05 level.
**Significant at the 0.01 level.

By the application of an error-Correction model [Engle and Granger (1987)] to the minute-by-minute transaction price data, it is found that the CAC futures price leads the CAC cash index. However, because the transaction price represents the stale price of the last trade, this test cannot solve the nonsynchronous trading problem. As a result, the mid-quote points of bid/ask prices are used to repeat the test. It is found that the lead-lag relationship from futures to cash vanishes, and reverse causality from cash to futures becomes significant. These findings suggest that previous results showing futures leading cash may be primarily due to (a) market nonsynchronous trading and stale price problems and (b) differences in trading mechanisms used in cash or futures markets.

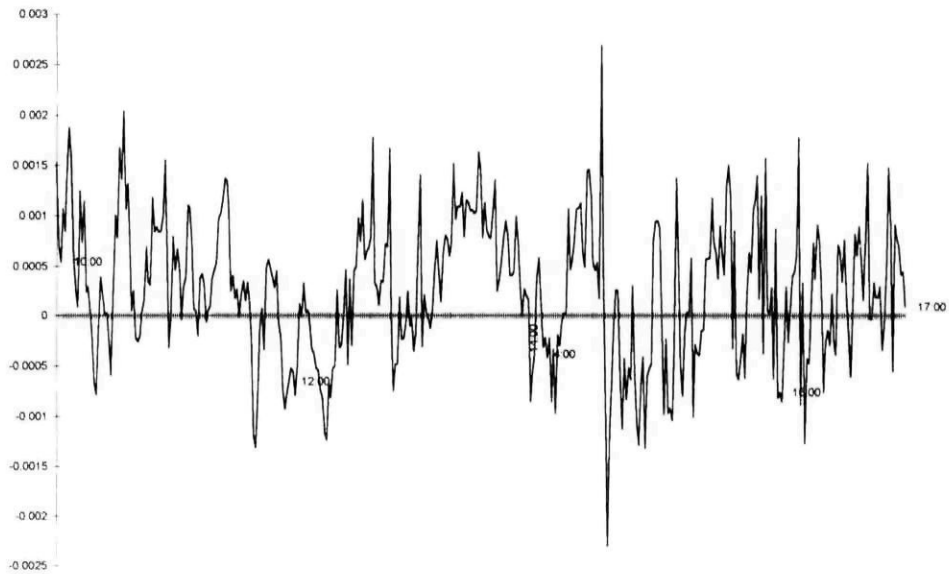


FIGURE 1

Arbitrage profit return from buying cash and selling futures (August 27, 1994).

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