INTRADAY PRICE-REVERSAL PATTERNS IN THE CURRENCY FUTURES MARKET: THE IMPACT OF THE INTRODUCTION OF GLOBEX AND THE EURO

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This article assesses the intraday price-reversal patterns of seven major currency futures contracts traded on the Chicago Mercantile Exchange over 1988–2003 after 1-day returns and opening gaps. Significant intraday price-reversal patterns are observed in five of the seven currency futures contracts, following large price changes. Additional tests are conducted in three subperiods (1988–1992, 1993–1998, and 1999–2003) to examine the impact of the introduction of electronic trading on GLOBEX in 1992

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(to assess how a near 24-hour trading session might impact the next-day opening and closing futures prices) and the introduction of the euro in 1999 (to assess its impact on price predictability in other futures markets). It is found that the introduction of the GLOBEX in 1992 significantly reduced pricing errors in currency futures in the second subperiod, making the currency futures markets fairly efficient. However, the introduction of the new currency, the euro, and the disappearance of several European currencies in 1999, resulted in significant price patterns (mostly reversals and some persistence) in most of the currency futures, indicating inefficiencies in the third subperiod. © 2006 Wiley Periodicals, Inc. Jrl Fut Mark 26:1089–1130, 2006

INTRODUCTION AND LITERATURE REVIEW

This study examines the lead[1] contracts of seven currency futures contracts traded on the Chicago Mercantile Exchange (CME): Japanese yen (JY), Australian dollar (AD), British pound (BP), Swiss franc (SF), euro (EC), Canadian dollar (CD), and Mexican peso (ME). Analysis is made of the intraday price movements following price changes between two closing prices (the 1-day return based on closing prices) and between the previous closing price and the current trading day's opening price (the opening gap). The study covers a 16-year period spanning 1988–2003. Significant intraday price reversals or persistence following large 1-day price movements or large opening gaps would be construed as a contradiction of the weak-form market efficiency of the currency futures market.

After the introduction of the GLOBEX electronic trading platform on June 25, 1992 by the CME,[2] trading on these currency futures contracts has gradually become available around the clock and around the globe. The current trading hours of the GLOBEX system are Mondays/Thursdays, Sundays, and holidays from 5:00 P.M. to 4:00 P.M.[3] the following day; nearly 23 hours daily except for Saturdays. With increased trading volume on the GLOBEX system, the roles played by the opening and closing prices determined during the floor session's trading hours should be less essential. In 1999, 11 currencies were united into the euro and trading on the euro was introduced on the

[1]The shift in the number of trades is used to determine the dominant contracts or the lead contracts for all seven futures contracts. The switch usually happens a week before the last day of trading.
[2]On its first day of trading, Japanese yen futures were traded. The British pound, Swiss franc, and Australian and Canadian dollar futures were added to the GLOBEX platform in July 1992. The Mexican peso was added to the GLOBEX platform on May 1995 and the Euro in January 1999.
[3]Friday evening in the United States is Saturday in Europe and markets are closed. All times used in this article are Central Standard Time.

CME.[4] This loss of diversification due to the creation of a new currency could add to market volatility and create possible inefficiencies in the initial stages. This study examines intraday price movements following large price movements in three subperiods, (1988–1992, 1993–1998 and 1999–2003). The purpose is to explore whether there is any predictive pattern displayed by 1-day returns based on closing prices and opening-gap returns when considering intraday price patterns due to the introduction of the on-line (near) 24-hour trading platform, the GLOBEX, and the introduction of the new currency, the euro.

Most studies on intraday price movements have focused on the equity index futures markets. Intraday price reversals following large opening gaps on the S&P 500 index futures contracts traded on the CME and also available on the GLOBEX,[5] have been examined in several articles. Fung, Mok, and Lam (2000) find support for the intraday overreaction theory on the S&P 500 futures contract over a 3-year period (September 1993–June 1996). They attribute the observation of smaller reversals in the U.S. market compared to the Hong Kong market to the introduction of the GLOBEX. Grant, Wolf, and Yu (2005) also find significant intraday price reversals over a 15-year period (November 1987–September 2002), where the diminishing effectiveness of using the opening gaps in predicting intraday price movements of the S&P 500 index futures coincides with their debut on the GLOBEX platform in September 1993. Yu and Rentzler (2004) explore the intraday price movements of the NASDAQ-100 index futures contracts following significant price changes and find persistent intraday price patterns. Fung and Lam (2004) document the existence of overreaction during intraday trading and market closing on Hang Seng Index futures contracts. The pricing error of the index futures relative to its fair value is used to identify investors' overreaction.

Other studies on the futures markets suggest that significant pricing errors and/or high volatility may exist in the opening or closing minutes, which may cause the market to take some predictable paths in the immediate intraday trading (see Daigler, 1997; Ekman, 1992). In addition, Webb and Smith (1994) argue that the existence of higher variance at the open is attributable to the use of the open-outcry auction system

[4]The European Monetary Union consisted of 11 countries in December 1998. They are Belgium, Germany, Spain, France, Ireland, Italy, Luxembourg, The Netherlands, Austria, Portugal, and Finland. Greece joined the European Union as of January 2001.

[5]Equity index futures (such as the S&P) made their debut on the GLOBEX platform in September 1993. Current trading hours of the GLOBEX session: Monday–Thursday 3:30 P.M.–8:15 A.M.; shutdown period from 4:30 P.M. to 5:00 P.M. nightly; Sundays and holidays 5:00 P.M.–8:15 A.M.

without market makers. With increased blurring of the true market opening and closing and a higher volume on the GLOBEX platform, pricing errors associated with market opening and closing should be reduced.

This study focuses on four areas. First, a long history of intraday price movements is used to provide some understanding of how daily opening and closing prices can be used in predicting the intraday price movements in currency futures contracts. Second, the past intraday price movements are separated into extreme positive and extreme negative groups, and the magnitude of the subsequent intraday price movements is examined. When major currencies from three different trading zones are considered, it is found that the Canadian dollar and Mexican peso contracts, both in the North American time zone, have large pricing errors at the open and have strong price-reversal patterns following large opening gaps. Third, regression models are used to construct a test that combines all the currency futures markets together. The source of price reversals is also assessed by considering a magnitude effect. Tests are done to determine whether these markets have a day-of-the-week (Friday) effect whereby traders unwind their positions before the weekend in order to reduce their risk exposure. Fourth, three subperiods are considered: the first representing a period before the introduction of the GLOBEX (1988–1992), then a period directly following the introduction and initial growth of the GLOBEX (1993–1998), and finally a third period associated with the introduction of the euro (1999–2003). Testing is performed to determine whether the influence of opening and closing prices from the traditional floor session on the immediate intraday price movements of currency futures has changed with the introduction of these two new financial innovations.

The remainder of this paper is organized in four sections. The next two sections describe the data and present the intraday event research methodology. The following section reports the empirical results for the entire 16-year sample period and the three subperiods. The findings of this research are summarized in a conclusion.

DATA

Seven currency futures contracts traded on the CME are examined to determine whether the intraday price movements during the floor-trading sessions are influenced by either large 1-day close-to-close returns or large overnight opening gaps determined by closing and opening prices from the floor sessions. Except for euro (EC) futures (January 1999–December 2003)

and Mexican peso (ME) futures contracts (May 1995–December 2003), the sample covers a 16-year period from January 1988 to December 2003. Only data from the floor sessions on all contracts are used in this study and they include the date, time, and price of every transaction with a price change that occurs during each floor session. Transactions with no price change are not included in the original data set, and multiple trades in any minute are kept in chronological order as they are recorded.

All currency futures traded at the CME have expiration dates scheduled on a quarterly cycle: March, June, September, and December, and can be settled with physical delivery. The trading hours for these contracts are from 7:20 A.M. to 2:00 P.M.

The rollover technique is utilized. The shift in the number of trades is used to determine the dominant or *lead* contracts for all seven futures contracts. It is found that the switch usually occurs a week before the last day of trading. For any given trading day, only the lead contract is studied and its opening price for the current day and its two closing prices for the two preceding trading days are used for event-day identification. To facilitate the analysis, the transaction data are converted into minute-by-minute intervals, using only the first price in a given minute, except for the closing quote. Missing minute data are replaced with the previous trade's data.

Two measures of past price movements are used for signaling purposes. First, the *previous 1-day return* (or *1-day return*) is computed with the two closing prices (Close_{t-2} and Close_{t-1}) preceding a trading day t:

$$\text{Previous 1-day return}_t = 100 * [(\text{Close}_{t-1}/\text{Close}_{t-2}) - 1] \qquad (1)$$

The second measure, the *opening-gap return,* is computed with the use of the previous closing price (Close_{t-1}) and the opening price (Open_t) of a trading day t:

$$\text{Opening-gap return}_t = 100 * [(\text{Open}_t/\text{Close}_{t-1}) - 1] \qquad (2)$$

RESEARCH METHODOLOGY

Outlier Tests

To reduce the impact of noise, intraday price movements following large past price movements are considered. Only trading days following either large previous 1-day returns or large opening-gap returns, either positive or negative, are examined.

Approximately the same number of trading days (5% of all trading days) are allocated to each of four event day groups. These four events are considered to be days following large positive or negative previous 1-day return and days following large positive or negative opening-gap return. The 5th and 95th percentile of all 1-day closing returns and all opening gaps are used as cutoffs to define event days.[6] By using the percentiles from the historical distribution, meaningful comparisons can be made across different subperiods. For simplicity, all four returns or gap filters are rounded to the nearest 10 basis points. These filter sizes are then applied to determine the event days for each of the four event groups.[7]

The intraday cumulative returns (CRs) from the opening price of any given event day t are calculated at 40-minute intervals until the close:

$$\mathrm{CR}_{t,\mathrm{min}} = 100 * [(P_{t,\mathrm{min}}/\mathrm{Open}_t) - 1] \tag{3}$$

where min is the number of minutes after the opening and $P_{t,\mathrm{min}}$ is the first trade price in that minute. Average cumulative returns (ACRs) are calculated for 10 intraday intervals starting at open + 40 minutes (8:00 A.M.), continuing through open + 360 minutes and ending at close (2:00 P.M.), across event day groups as

$$\mathrm{ACR}_{\mathrm{min}} = \frac{1}{T}\sum_{t=1}^{T} \mathrm{CR}_{t,\mathrm{min}} \tag{4}$$

where T is the total number of event days in a group. Significant $\mathrm{ACRs}_{\mathrm{min}}$ can be interpreted as evidence of a violation of the weak-form efficient-market hypothesis.

Similar tests are then applied separately to each of the three subperiods for all currency futures contracts, 1988–1992, 1993–1998, and 1999–2003, except for EC futures (starts January 1999) and ME futures (starts May 1995). Although the extended trading hours on GLOBEX should have no impact on the accuracy of the closing prices in the second subperiod (1993–1998), it is hypothesized that it should reduce the pricing errors of the subsequent opening prices for the floor sessions. As a result, one should observe less significant price patterns following large past price movements. Analysis for the third subperiod (1999–2003) provides evidence on price movements following the introduction of the new European currency, the euro, on January 1, 1999. If the replacement of

[6]5% percentile implies negative events and 95% percentile implies positive events.
[7]Event days and filter sizes will be discussed in detail in a later section.

12 currencies with the new currency, the euro, results in greater volatility, it would also make these markets less efficient.

Regression Tests

Using Full Data Set

In order to test the robustness of the relationship between the intraday futures returns and the previous 1-day and opening-gap returns, six regression models on the 10 intraday intervals are run on the seven currency futures contracts using all data (not just outliers) from January 1988–December 2003.[8] The first regression model shown in Equation (5) examines the relationship between the intraday futures returns and previous 1-day return, the second model [Equation (6)] regresses the futures returns against the opening-gap return, whereas the third model [Equation (7)] examines the joint relationship between the futures returns, the previous 1-day return and the opening-gap return. The last three models [Equations (8)–(10)] present the intercept coefficient ($B_{0,i}$) as the linear function of dummy variables.[9] These regression formulations perform tests that combine all the currency futures markets together. The null hypothesis of weak-form market efficiency would result in all these slope coefficients, $b_{1,i}$ and $b_{2,i}$, being equal to 0. A significant intraday price pattern following previous 1-day returns or opening-gap returns can be interpreted through significant slope coefficients. In particular, significantly negative slope coefficients would support intraday price-reversal patterns and would violate the weak-form efficiency hypothesis.

$$R_{i,t} = b_{0,i} + b_{1,i} * R_{C2C1,t} + \varepsilon_{i,t} \tag{5}$$

$$R_{i,t} = b_{0,i} + b_{1,i} * R_{C1O,t} + \varepsilon_{i,t} \tag{6}$$

$$R_{i,t} = b_{0,i} + b_{1,i} * R_{C2C1,t} + b_{2,i} * R_{C1O,t} + \varepsilon_{i,t} \tag{7}$$

$$R_{i,t} = B_{0,i} + b_{1,i} * R_{C2C1,t} + \varepsilon_{i,t} \tag{8}$$

$$R_{i,t} = B_{0,i} + b_{1,i} * R_{C1O,t} + \varepsilon_{i,t} \tag{9}$$

$$R_{i,t} = B_{0,i} + b_{1,i} * R_{C2C1,t} + b_{2,i} * R_{C1O,t} + \varepsilon_{i,t} \tag{10}$$

[8]The authors wish to thank an anonymous referee for suggesting the use of these tests.
[9]A dummy variable for the British pound is not used, in order to avoid the dummy variable trap.

where t is the day the intraday returns are being considered, and

$$B_0 = (b_0 + b_{0\,\mathrm{JY}} * D_{\mathrm{JY}} + b_{0\,\mathrm{AD}} * D_{\mathrm{AD}} + b_{0\,\mathrm{EC}} * D_{\mathrm{EC}} + b_{0\,\mathrm{SF}} * D_{\mathrm{SF}} + b_{0\,\mathrm{CE}} * D_{\mathrm{CE}} + b_{0\,\mathrm{ME}} * D_{\mathrm{ME}})$$

$R_{i,t} \equiv$ the intraday return of the futures contract measured from the opening to the end of the ith intraday interval of day t,

$R_{\mathrm{C2C1},t} \equiv$ the previous 1-day return of Equation (1),

$R_{\mathrm{C1O},t} \equiv$ the opening-gap return of Equation (2),

$D_{\mathrm{JY}} =$ dummy variable assigned the value of 1 for the Japanese yen and 0 otherwise,

$D_{\mathrm{AD}} =$ dummy variable assigned the value of 1 for the Australian dollar and 0 otherwise,

$D_{\mathrm{SF}} =$ dummy variable assigned the value of 1 for the Swiss franc and 0 otherwise,

$D_{\mathrm{CE}} =$ dummy variable assigned the value of 1 for the Canadian dollar and 0 otherwise,

$D_{\mathrm{EC}} =$ dummy variable assigned the value of 1 for the Euro and 0 otherwise,

$D_{\mathrm{ME}} =$ dummy variable assigned the value of 1 for the Mexican peso and 0 otherwise,

Tests on Three Subperiods: Pre-GLOBEX (1988–1992), Post-GLOBEX (1993–1998) and Euro (1999–2003)

The previous section considered the intraday price patterns of the seven currency futures for the overall period (January 1988–December 2003). To test whether any observed price reversals or persistence have been influenced by the introduction of the GLOBEX and the euro, a similar intraday analysis is conducted on each of five currency futures contracts over three subperiods (ME and EC futures contracts are excluded because of their data limitations.) Results from this section provide insight into the effect of the introduction of GLOBEX and euro on market efficiency and in reducing any predictive power of the two past measures (previous 1-day return and opening-gap return) on currencies futures.

In addition to the data set of the five currency futures contracts, two dummy variables will be used, indicating the post-GLOBEX subperiod (1993–1998) and the post-euro subperiod (1999–2003). The null hypothesis of weak-form efficiency implies that the slope coefficients $B_{1,i}$

in regression Equations (11) and (12) are not significantly different from zero. Significant negative (positive) slope coefficients would signify price reversals (persistence) and a violation of weak-form market efficiency:

$$R_{i,t} = B_{0,i} + B_{1,i} * R_{C2C1,t} + \varepsilon_{i,t} \quad (11)$$

$$R_{i,t} = B_{0,i} + B_{1,i} * R_{C1O,t} + \varepsilon_{i,t} \quad (12)$$

where

$$B_0 = (b_0 + b_{0\,\text{GLOBEX}} * D_{\text{GLOBEX}} + b_{0\,\text{Euro}} * D_{\text{Euro}})$$

$$B_1 = (b_1 + b_{1\,\text{GLOBEX}} * D_{\text{GLOBEX}} + b_{1\,\text{Euro}} * D_{\text{Euro}})$$

D_{GLOBEX} = dummy variable assigned the value 1 in the post-GLOBEX subperiod and 0 otherwise,

D_{Euro} = dummy variable assigned the value 1 in the post-euro subperiod and 0 otherwise.

Magnitude Effect

Previous tests examined intraday price patterns following extreme past price returns in the three subperiods. However, these results may be sensitive to the filter size. To address this, Equations (13) and (14) are tested on each of the seven currency contracts. They take into account the magnitude from the two past price measures: positive past price measure and negative past price measure.

The null hypothesis states that the slope coefficients ($B_{1,i}$) are not significantly different from 0, implying that the direction of the past price measure does not have any effect on future pricing and hence the market is weak-form efficient. The equations examined are

$$R_{i,t} = B_{0,i} + B_{1,i} * R_{C2C1,t} + \varepsilon_{i,t} \quad (13)$$

$$R_{i,t} = B_{0,i} + B_{1,i} * R_{C1O,t} + \varepsilon_{i,t} \quad (14)$$

where

$$B_0 = (b_0 + b_{0\,\text{NEGATIVE}} * D_{\text{NEGATIVE}})$$

$$B_1 = (b_1 + b_{1\,\text{NEGATIVE}} * D_{\text{NEGATIVE}})$$

D_{NEGATIVE} = dummy variable assigned the value of 1 if past return is negative and 0 otherwise.

Day-of-the-Week and Friday Effects

It is hypothesized that because futures trading in the exchange-traded and GLOBEX markets do not trade continuously during the weekend, traders tend to unwind their positions before the weekend to reduce their risk exposure. To test this conjecture, a Friday dummy variable is introduced in regression models (15) and (16). Here the average cumulative returns on each of the seven currency futures are regressed on the past price measures (previous 1-day return or opening-gap return) and a dummy variable.

$$R_{i,t} = B_{0,i} + B_{1,i} * R_{C2C1,t} + \varepsilon_{i,t} \tag{15}$$

$$R_{i,t} = B_{0,i} + B_{1,i} * R_{C1O,t} + \varepsilon_{i,t} \tag{16}$$

where

$$B_0 = (b_0 + b_{0\,\mathrm{FRIDAY}} * D_{\mathrm{FRIDAY}})$$

$$B_1 = (b_1 + b_{1\,\mathrm{FRIDAY}} * D_{\mathrm{FRIDAY}})$$

where

D_{FRIDAY} = dummy variable assigned the value of 1 for Fridays and 0 otherwise.

The null hypotheses of whether the slope coefficients ($B_{1,i}$) are significantly different from zero are tested. In particular, if the coefficients b_1 and $b_{1\,\mathrm{FRIDAY}}$ are significant, it is concluded that the traders tend to alter or unwind their position at the end of the week.

EMPIRICAL RESULTS

Outlier Tests

Event Days

Because the 5th and the 95th percentiles of the past price movements are rounded to 10 basis points, the number of events varies across the four event groups, as shown in Table I, Panel A.[10] The filter sizes for previous 1-day returns range between 1.0% and 1.2%, and between −1.2% and −1.0%, for all futures contracts except for the Canadian dollar (CD; range is between +0.6% and −0.5%). The filter sizes for the opening gaps range

[10]Event days are approximately 5% of the total trading days. For example, in Table I the number of positive-event days are 183 of 4028 (4.54%) and number of negative-event days are 209 of 4028 (5.19%).

TABLE I
Sample Statistics: Number of Qualified Trading Days

Panel A: Determining the filter size(s)

Currency	Period	Number of trading days	Past price movement	Positive filter size (%)	Positive-event days (No.)	Negative filter size (%)	Negative-event days (No.)
JY	1988–2003	4028	Previous 1-day return	1.2	183	−1.1	209
			opening gap	0.9	194	−0.9	173
AD	1988–2003	4020	Previous 1-day return	1.0	204	−1.1	189
			opening gap	0.8	190	−0.9	169
BP	1988–2003	4029	Previous 1-day return	1.0	193	−1.0	195
			opening gap	0.6	230	−0.7	178
SF	1988–2003	4026	Previous 1-day return	1.2	220	−1.2	202
			opening gap	0.8	186	−0.8	218
EC	1999–2003	1250	Previous 1-day return	1.1	62	−1.1	61
			opening gap	0.8	55	−0.8	55
CD	1988–2003	4023	Previous 1-day return	0.6	161	−0.5	234
			opening gap	0.4	139	−0.4	155
ME	1995[a]–2003	2173	Previous 1-day return	1.0	99	−1.0	106
			opening gap	0.5	133	−0.5	100

Panel B: Qualified trading days (filter = the previous 1-day return)

Currency	Period	Number of trading days	Positive event days (No.)	(%)	Negative event days (No.)	(%)
JY	1988–1992	1263	55	4.4	59	4.7
	1993–1998	1514	81	5.4	89	5.9
	1999–2003	1251	47	3.8	61	4.9
AD	1988–1992	1256	56	4.5	59	4.7
	1993–1998	1513	62	4.1	59	3.9
	1999–2003	1251	86	6.9	71	5.7
BP	1988–1992	1265	94	7.4	110	8.7
	1993–1998	1514	62	4.1	49	3.2
	1999–2003	1250	37	3.0	36	2.9
SF	1988–1992	1262	83	6.6	85	6.7
	1993–1998	1514	78	5.2	62	4.1
	1999–2003	1250	59	4.7	55	4.4
EC	1999–2003	1250	62	5.0	61	4.9
CD	1988–1992	1260	23	1.8	55	4.4
	1993–1998	1514	47	3.1	67	4.4
	1999–2003	1249	91	7.3	112	9.0
ME	1995[a]–1998	923	48	5.2	49	5.3
	1999–2003	1250	51	4.1	57	4.6

(*Continued*)

TABLE I
Sample Statistics: Number of Qualified Trading Days (*Continued*)

Panel C: Qualified trading days (filter = the opening gap)

Currency	*Period*	*Number of trading days*	*Positive event days (No.)*	*(%)*	*Negative event days (No.)*	*(%)*
JY	1988–1992	1263	52	4.1	42	3.3
	1993–1998	1514	89	5.9	80	5.3
	1999–2003	1251	53	4.2	51	4.1
AD	1988–1992	1256	48	3.8	46	3.7
	1993–1998	1513	66	4.4	57	3.8
	1999–2003	1251	76	6.1	66	5.3
BP	1988–1992	1265	121	9.6	93	7.4
	1993–1998	1514	58	3.8	53	3.5
	1999–2003	1250	60	4.6	37	4.2
SF	1988–1992	1262	67	5.3	83	6.6
	1993–1998	1514	68	4.5	66	4.4
	1999–2003	1250	51	4.1	69	5.5
EC	1999–2003	1250	55	4.4	55	4.4
CD	1988–1992	1260	35	2.8	46	3.7
	1993–1998	1514	45	3.0	44	2.9
	1999–2003	1249	59	4.7	65	5.2
ME	1995[a]–1998	923	64	6.9	56	6.1
	1999–2003	1250	69	5.5	44	3.5

Note. The objective is to locate a filter size that would result in nearly 5% of all trading days being allocated to the event group. The filter size for the positive event group may differ from the one for the negative event group. We exclude a trading day if its trade volume is less than 10% of its previous trading day's volume.

[a]May 1995.

from 0.6% and 0.9%, both positive and negative, for JY, AD, BP, SF, and EC, but are ±0.5% for ME and ±0.4% for CD. This implies a less volatile market for the Canadian dollar and Mexican peso futures contracts than the other five currency futures.

Table I, Panels B and C, presents the number of qualified trading days and the corresponding percentages relative to the total trading days in each of the three subperiods. For BP and SF futures contracts, the highest percentage of large changes occurs in the first subperiod (1988–1992), for AD, CD, and ME, in the third subperiod (1999–2003) and for JY in the second subperiod (1993–1998).

Average Cumulative Returns (ACRs in Percent)

Table II presents the average intraday price movements from opening prices for all seven currency futures contracts in the four event groups:

TABLE II
Average Intraday Cumulative Returns (%) Following Large Positive or Negative Past Price Measures

Panel A: Previous 1-day returns

	Large positive previous 1-day returns						
Filter size[a]	*1.20%*	*1.00%*	*1.00%*	*1.20%*	*1.10%*	*0.60%*	*1.00%*
No. event days	*183*	*204*	*193*	*220*	*62*	*161*	*99*
Time intervals (minutes from open)	*JY*	*AD*	*BP*	*SF*	*EC*[b]	*CD*	*ME*[b]
40	0.0139	0.0058	0.0113	0.0282**	−0.0483**	−0.0105	0.0934**
80	0.0011	0.0008	0.0160	0.0307*	−0.0719***	−0.0008	0.0786
120	−0.0094	−0.0071	0.0169	0.0287	−0.0894***	−0.0111	0.0741
160	0.0185	−0.0012	0.0176	0.0306	−0.1019***	−0.0199	0.0571
200	0.0185	−0.0120	−0.0125	0.0310	−0.1321***	−0.0285*	0.0135
240	0.0154	−0.0077	−0.0006	0.0241	−0.1497***	−0.0251	0.0166
280	0.0154	−0.0326	0.0230	0.0155	−0.1512***	−0.0282	0.0445
320	0.0259	−0.0305	0.0171	0.0220	−0.1255***	−0.0376*	0.0251
360	0.0264	−0.0354	0.0401	0.0296	−0.1253***	−0.0312*	−0.0028
Close	0.0608	−0.0486**	0.0639*	0.0536	−0.1109**	−0.0356*	−0.0282
	Large negative previous 1-day returns						
Filter size[a]	*−1.10%*	*−1.10%*	*−1.00%*	*−1.20%*	*−1.10%*	*−0.50%*	*−1.00%*
No. event days	*209*	*189*	*195*	*202*	*61*	*234*	*106*
Time intervals (minutes from open)	*JY*	*AD*	*BP*	*SF*	*EC*[b]	*CD*	*ME*[b]
40	0.0248**	0.0340***	−0.0061	0.0396**	0.0547**	0.0249***	0.0385
80	0.0375**	0.0125	−0.0023	0.0392*	0.0774***	0.0253**	0.0662
120	0.0308*	0.0266	0.0206	0.0706***	0.0711**	0.0331**	0.0959
160	0.0146	0.0286	0.0309	0.0645**	0.0648**	0.0259*	0.0768
200	0.0039	0.0548**	0.0451*	0.0639**	0.0614	0.0330**	0.1581
240	−0.0094	0.0789***	0.0345	0.0615*	0.0817*	0.0387**	0.1724
280	−0.0003	0.1015***	0.0466	0.0579*	0.1009**	0.0408**	0.2396
320	0.0075	0.0994***	0.0486	0.0624*	0.1256**	0.0456**	0.2687*
360	−0.0022	0.1018***	0.0478	0.0594*	0.1362***	0.0609***	0.2289
Close	−0.0117	0.1016***	0.0448	0.0452	0.1311***	0.0598***	0.2436

(*Continued*)

TABLE II
Average Intraday Cumulative Returns (%) Following Large Positive or Negative Past Price Measures (*Continued*)

Panel B: Opening-gap returns

Large positive opening-gap returns

Filter size[b]	*0.90%*	*0.80%*	*1.00%*	*0.80%*	*0.80%*	*0.40%*	*0.50%*
No. event days	*194*	*190*	*230*	*186*	*55*	*139*	*133*
Time intervals (minutes from open)	*JY*	*AD*	*BP*	*SF*	*EC*[b]	*CD*	*ME*[b]
40	0.0036	−0.0174*	−0.0023	−0.0250*	−0.0249	−0.0156	0.0298
80	0.0379*	−0.0427***	0.0044	−0.0065	−0.0457*	−0.0074	0.0239
120	0.0491*	−0.0381**	0.0037	−0.0264	−0.0778*	−0.0262*	−0.0534
160	0.0456*	−0.0462**	−0.0053	−0.0252	−0.0939**	−0.0402**	−0.1507***
200	0.0379	−0.0386*	−0.0022	−0.0495	−0.1316**	−0.0484**	−0.1540***
240	0.0811**	−0.0072	0.0180	−0.0164	−0.1125**	−0.0322	−0.1889***
280	0.0737**	0.0057	0.0265	−0.0011	−0.0984*	−0.0404*	−0.1663***
320	0.0928**	0.0149	0.0284	0.0053	−0.1016**	−0.0431*	−0.1937***
360	0.1130**	0.0019	0.0396	0.0275	−0.0755	−0.0298	−0.1891***
Close	0.1261***	−0.0037	0.0618*	0.0441	−0.0976*	−0.0268	−0.2115***

Large negative opening-gap returns

Filter size[b]	*−0.90%*	*−0.90%*	*−1.00%*	*−0.80%*	*−0.80%*	*−0.40%*	*−0.50%*
No. event days	*173*	*169*	*178*	*218*	*55*	*155*	*100*
Time intervals (minutes from open)	*JY*	*AD*	*BP*	*SF*	*EC*[b]	*CD*	*ME*[b]
40	0.0209	0.0202	0.0317**	0.0631***	0.0021	0.0311**	0.0551
80	0.0282*	0.0193	0.0168	0.0792***	0.0402*	0.0385**	0.1528
120	0.0382*	0.0169	0.0163	0.0766***	0.0348	0.0582***	0.2768**
160	0.0354	0.0222	0.0010	0.0754***	0.0337	0.0667***	0.3529**
200	0.0427	−0.0015	−0.0069	0.0775**	0.0307	0.0719***	0.3853**
240	0.0282	−0.0056	−0.0715*	0.0475	−0.0325	0.0744***	0.4500**
280	0.0146	−0.0129	−0.0593*	0.0561*	−0.0078	0.0730***	0.5111***
320	0.0224	−0.0313	−0.0841**	0.0414	−0.0094	0.0714***	0.4884**
360	0.0330	−0.0350	−0.0760*	0.0298	−0.0308	0.0661**	0.4437**
Close	0.0241	−0.0488	−0.1009**	0.0204	−0.0177	0.0521**	0.4684**

[a]The filter sizes are different across all currencies.
[b]EC (1999–2003) and ME (5/1995–2003).

*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

positive large 1-day returns, negative large 1-day returns, positive large opening-gap returns and negative large opening-gap returns.

Following a large positive previous 1-day return (columns 1–7 in Panel A), slightly significant positive ACRs are observed early in the trading day for SF and ME contracts, and EC contracts exhibit significant price reversals (negative ACRs) all day. For large negative 1-day returns (columns 8–14 in Panel A), significant positive intraday ACRs are observed for four of the seven futures contracts (AD, SF, EC, and CD), indicating price-reversal patterns. Results for JY, BP, and ME contracts indicate no significant price patterns.

Panel B presents ACRs following large positive and negative opening-gap returns, measured from closing previous-day price to current-day opening price. For positive opening-gap returns (columns 1–7 in Panel B), significant negative ACRs are observed (indicating price reversal) all day for AD, EC, CD, and ME contracts, but positive ACRs are observed for JY contracts (indicating persistence). For large negative opening gaps (columns 8–14 in Panel B), significant price reversals are observed for SF, CD, and ME contracts, and at open for BP contracts. Thus, the results in Panel B indicate significant price-reversal patterns in the intraday ACRs after large opening gaps for most currencies.

Results for the Three Subperiods

This section examines each futures contract in the three subperiods, 1988–1992 (pre-GLOBEX), 1993–1998 (post-GLOBEX), and 1999–2003 (post-euro), looking to identify changes in the ACR patterns following the introduction of the GLOBEX in 1992 and the introduction of the euro in 1999. If the introduction and the increased utilization of the GLOBEX platform in 1992 reduce the pricing errors for futures contracts, one should expect to see a decline in significant intraday ACR patterns in the second subperiod relative to the first. However, the loss of diversification with the introduction of the Euro in 1999 could, in general, lead to increased pricing errors in the third subperiod. Results are presented in Table III, Panels A–F.

The Japanese Yen (JY) futures contracts over the three subperiods are examined in Panel A. For large previous 1-day positive returns (columns 1–3), significant positive ACRs (persistence) are observed in the first subperiod, and for large previous 1-day negative returns (columns 4–6), there are slight reversals in the second subperiod. There are no significant reversal or persistence patterns in intraday ACRs following large opening gaps, positive as well as negative, in the first two

TABLE III

Average Intraday Cumulative Returns (%) Following Large Past Price Measures (by Subperiods: 1988–1992, 1993–1998, 1999–2003)

Panel A: Japanese yen futures contracts

	Large previous 1-day returns					
	Positive			*Negative*		
Filter size	*1.20%*	*1.20%*	*1.20%*	*−1.10%*	*−1.10%*	*−1.10%*
No. event days	*55*	*81*	*47*	*59*	*89*	*61*
Time intervals (minutes from open)	*1988–1992*	*1993–1998*	*1999–2003*	*1998–1992*	*1993–1998*	*1999–2003*
40	0.0363	0.0056	0.0022	0.0432*	0.0289	0.0008
80	0.0441	−0.0101	−0.0298	0.0265	0.0664**	0.0059
120	0.0381	−0.0248	−0.0384	0.0311	0.0596*	−0.0116
160	0.0798**	−0.0225	0.0177	−0.0009	0.0629*	−0.0410
200	0.0942**	−0.0307	0.0147	0.0163	0.0340	−0.0521
240	0.0742*	−0.0270	0.0195	−0.0125	0.0198	−0.0489
280	0.0762	−0.0074	−0.0166	0.0067	0.0247	−0.0434
320	0.0513	0.0246	−0.0015	0.0198	0.0266	−0.0322
360	0.0359	0.0321	0.0053	0.0106	0.0163	−0.0415
Close	0.1309*	0.0529	−0.0076	−0.0022	0.0040	−0.0438
	Large opening-gaps returns					
	Positive			*Negative*		
Filter size	*0.90%*	*0.90%*	*0.90%*	*−0.90%*	*−0.90%*	*−0.90%*
No. event days	*52*	*89*	*53*	*42*	*80*	*51*
Time intervals (minutes from open)	*1998–1992*	*1993–1998*	*1999–2003*	*1998–1992*	*1993–1998*	*1999–2003*
40	0.0034	−0.0183	0.0406	0.0400	−0.0065	0.0480**
80	0.0250	0.0261	0.0705*	0.0537	−0.0058	0.0607**
120	0.0104	0.0405	0.1016**	0.0494	0.0246	0.0504*
160	0.0412	0.0127	0.1053**	0.0255	0.0267	0.0572*
200	0.0234	0.0272	0.0702	0.0431	0.0492	0.0324
240	0.0491	0.0675	0.1354**	0.0228	0.0479	0.0018
280	0.0494	0.0603	0.1198**	0.0295	0.0095	0.0104
320	0.0442	0.0831	0.1567**	0.0744	0.0128	−0.0054
360	0.0520	0.1220*	0.1576**	0.0834	0.0337	−0.0095
Close	0.1110*	0.1145	0.1604**	0.0612	0.0374	−0.0276

TABLE III
(*Continued*)

Panel B: Australian dollar futures contracts

	Large previous 1-day returns					
	Positive			*Negative*		
Filter size	*1.00%*	*1.00%*	*1.00%*	*−1.10%*	*−1.10%*	*−1.10%*
No. event days	*56*	*62*	*86*	*59*	*59*	*71*
Time intervals (minutes from open)	*1988–1992*	*1993–1998*	*1999–2003*	*1998–1992*	*1993–1998*	*1999–2003*
40	0.0000	0.0118	0.0051	0.0361**	0.0095	0.0528**
80	−0.0113	0.0319	−0.0137	0.0435*	−0.0598**	0.0469*
120	−0.0160	0.0216	−0.0219	0.0310	−0.0427	0.0806**
160	−0.0175	0.0179	−0.0045	0.0338	−0.0265	0.0700**
200	−0.0293	−0.0114	−0.0011	0.0686**	−0.0198	0.1053***
240	−0.0381	−0.0055	0.0106	0.0942***	−0.0139	0.1434***
280	−0.0738**	−0.0250	−0.0113	0.1067**	0.0270	0.1591***
320	−0.0781**	−0.0075	−0.0161	0.1127**	0.0385	0.1389***
360	−0.0996**	−0.0072	−0.0138	0.1481***	0.0274	0.1251**
Close	−0.0967**	−0.0174	−0.0399	0.1626***	0.0059	0.1305**
	Large opening-gaps returns					
	Positive			*Negative*		
Filter size	*0.80%*	*0.80%*	*0.80%*	*−0.90%*	*−0.90%*	*−0.90%*
No. event days	*48*	*66*	*76*	*46*	*57*	*66*
Time intervals (minutes from open)	*1988–1992*	*1993–1998*	*1999–2003*	*1998–1992*	*1993–1998*	*1999–2003*
40	−0.0143	0.0053	−0.0390***	0.0101	−0.0048	0.0487**
80	−0.0095	−0.0531**	−0.0547**	−0.0357	−0.0296	0.0999***
120	0.0042	−0.0512*	−0.0535**	−0.0581	−0.0197	0.1009***
160	0.0245	−0.0506	−0.0870***	−0.0749	−0.0013	0.1102***
200	0.0210	−0.0680*	−0.0508*	−0.0686	−0.0281	0.0683
240	0.0206	−0.0208	−0.0130	−0.0967	−0.0099	0.0617
280	0.0025	−0.0140	0.0247	−0.0859	−0.0205	0.0445
320	0.0137	−0.0077	0.0352	−0.0998	−0.0215	0.0079
360	−0.0020	−0.0056	0.0110	−0.1030	−0.0235	0.0026
Close	0.0385	−0.0376	−0.0010	−0.1263*	−0.0568	0.0122

(*Continued*)

TABLE III

Average Intraday Cumulative Returns (%) Following Large Past Price Measures (by Subperiods: 1988–1992, 1993–1998, 1999–2003) (*Continued*)

Panel C: British pound futures contracts

	Large previous 1-day returns					
	Positive			*Negative*		
Filter size	*1.00%*	*1.00%*	*1.00%*	*−1.00%*	*−1.00%*	*−1.00%*
No. event days	*94*	*62*	*37*	*110*	*49*	*36*
Time intervals (minutes from open)	*1988–1992*	*1993–1998*	*1999–2003*	*1998–1992*	*1993–1998*	*1999–2003*
40	0.0222	0.0440**	−0.0711***	0.0014	−0.0458*	0.0253
80	0.0338	0.0251	−0.0447*	0.0125	−0.0580*	0.0282
120	0.0513*	0.0064	−0.0532	0.0223	−0.0102	0.0574*
160	0.0706**	−0.0162	−0.0603	0.0332	0.0325	0.0216
200	0.0229	−0.0564	−0.0291	0.0418	0.0577	0.0380
240	0.0508	−0.0584	−0.0346	0.0138	0.0606	0.0621
280	0.0588	−0.0278	0.0173	0.0299	0.0547	0.0869*
320	0.0618	−0.0420	0.0024	0.0332	0.0755	0.0591
360	0.0922*	−0.0285	0.0229	0.0334	0.0670	0.0657
Close	0.1385**	−0.0115	0.0008	0.0256	0.0607	0.0817
	Large opening-gaps returns					
	Positive			*Negative*		
Filter size	*1.00%*	*1.00%*	*1.00%*	*−1.00%*	*−1.00%*	*−1.00%*
No. event days	*121*	*58*	*60*	*93*	*53*	*37*
Time intervals (minutes from open)	*1988–1992*	*1993–1998*	*1999–2003*	*1998–1992*	*1993–1998*	*1999–2003*
40	−0.0291**	0.0339*	0.0171	0.0323	0.0376*	0.0282
80	−0.0292	0.0518*	0.0448**	0.0210	−0.0001	0.0375
120	−0.0306	0.0505	0.0302	0.0021	0.0286	0.0498*
160	−0.0393	0.0622*	−0.0009	−0.0071	0.0118	0.0258
200	−0.0364	0.0594	0.0098	−0.0234	0.0162	0.0191
240	0.0032	0.0174	0.0425	−0.1179*	−0.0125	−0.0319
280	0.0121	0.0290	0.0456	−0.1011*	−0.0024	−0.0297
320	0.0063	0.0500	0.0359	−0.1362**	−0.0387	−0.0110
360	0.0212	0.0495	0.0563	−0.1366**	−0.0323	0.0072
Close	0.0577	0.0746	0.0440	−0.1765***	−0.0363	−0.0028

TABLE III
(*Continued*)

Panel D: Swiss franc futures contracts

	Large previous 1-day returns					
	Positive			*Negative*		
Filter size	*1.20%*	*1.20%*	*1.20%*	*−1.20%*	*−1.20%*	*−1.20%*
No. event days	*83*	*78*	*59*	*85*	*62*	*55*
Time intervals (minutes from open)	*1988–1992*	*1993–1998*	*1999–2003*	*1998–1992*	*1993–1998*	*1999–2003*
40	0.0358*	0.0604***	−0.0252*	0.0637**	−0.0340	0.0854***
80	0.0458	0.0521*	−0.0187	0.0519	−0.0291	0.0967***
120	0.0222	0.0729**	−0.0206	0.0978**	0.0035	0.1043**
160	0.0462	0.0857**	−0.0641**	0.0534	0.0164	0.1358***
200	0.0500	0.0971*	−0.0832**	0.0745	0.0045	0.1145**
240	0.0337	0.0966*	−0.0854**	0.0642	−0.0192	0.1485**
280	0.0218	0.0790	−0.0772**	0.0568	−0.0529	0.1844***
320	0.0148	0.1088	−0.0826**	0.0581	−0.0412	0.1859***
360	0.0349	0.0957	−0.0654*	0.0504	−0.0414	0.1870***
Close	0.0835	0.0936	−0.0414	−0.0011	−0.0215	0.1921***
	Large opening-gaps returns					
	Positive			*Negative*		
Filter size	*0.80%*	*0.80%*	*0.80%*	*−0.80%*	*−0.80%*	*−0.80%*
No. event days	*67*	*68*	*51*	*83*	*66*	*69*
Time intervals (minutes from open)	*1988–1992*	*1993–1998*	*1999–2003*	*1998–1992*	*1993–1998*	*1999–2003*
40	−0.0498*	−0.0314	0.0160	0.1062***	0.0684**	0.0062
80	−0.0124	−0.0001	−0.0074	0.1368***	0.0579*	0.0302
120	−0.0233	−0.0265	−0.0304	0.1374***	0.0896**	−0.0090
160	−0.0011	−0.0185	−0.0660	0.1315**	0.0928**	−0.0087
200	−0.0120	−0.0424	−0.1084**	0.1144**	0.1510**	−0.0372
240	0.0433	−0.0119	−0.1007**	0.0755	0.1421**	−0.0766*
280	0.0420	0.0318	−0.1015**	0.0681	0.1557**	−0.0536
320	0.0562	0.0172	−0.0775*	0.0522	0.1081*	−0.0355
360	0.0480	0.0468	−0.0249	0.0618	0.0809	−0.0574
Close	0.1095	0.0534	−0.0541	0.0177	0.0803	−0.0337

(*Continued*)

TABLE III
Average Intraday Cumulative Returns (%) Following Large Past Price Measures (by Subperiods: 1988–1992, 1993–1998, 1999–2003) (*Continued*)

Panel E: Canadian dollar futures contracts

	Large previous 1-day returns					
	Positive			*Negative*		
Filter size	*0.60%*	*0.60%*	*0.60%*	*−0.50%*	*−0.50%*	*−0.50%*
No. event days	*23*	*47*	*91*	*55*	*67*	*112*
Time intervals (minutes from open)	*1988–1992*	*1993–1998*	*1999–2003*	*1998–1992*	*1993–1998*	*1999–2003*
40	−0.0119	−0.0311*	0.0005	0.0027	0.0283	0.0338***
80	0.0056	−0.0233	0.0092	−0.0110	0.0132	0.0505***
120	0.0319	−0.0660**	0.0064	−0.0132	0.0135	0.0675***
160	0.0451	−0.0850***	−0.0027	−0.0230	0.0006	0.0650**
200	0.0367	−0.0984**	−0.0089	−0.0262	0.0231	0.0679**
240	0.0169	−0.0922**	−0.0009	−0.0365	0.0055	0.0955***
280	0.0140	−0.0996**	−0.0020	−0.0388	0.0180	0.0935***
320	0.0194	−0.1047**	−0.0175	−0.0411	0.0271	0.0992***
360	0.0303	−0.0871**	−0.0179	−0.0271	0.0326	0.1210***
Close	0.0322	−0.0750*	−0.0324	−0.0385	0.0388	0.1207***
	Large opening-gaps returns					
	Positive			*Negative*		
Filter size	*0.40%*	*0.40%*	*0.40%*	*−0.40%*	*−0.40%*	*−0.40%*
No. event days	*35*	*45*	*59*	*46*	*44*	*65*
Time intervals (minutes from open)	*1988–1992*	*1993–1998*	*1999–2003*	*1998–1992*	*1993–1998*	*1999–2003*
40	−0.0186	−0.0360*	0.0019	0.0594***	0.0570**	−0.0065
80	−0.0045	−0.0458*	0.0201	0.0727***	0.0463*	0.0091
120	−0.0173	−0.0968***	0.0224	0.0864***	0.0523**	0.0423*
160	−0.0152	−0.1190***	0.0050	0.1045***	0.0462*	0.0538*
200	−0.0377	−0.1517***	0.0241	0.1254***	0.0688**	0.0361
240	−0.0533**	−0.1123***	0.0413	0.1059***	0.0597*	0.0622*
280	−0.0373	−0.1242***	0.0218	0.0766**	0.0676*	0.0742*
320	−0.0317	−0.1336***	0.0192	0.0711*	0.0801*	0.0658*
360	−0.0174	−0.1196***	0.0312	0.0472	0.0743*	0.0738*
Close	0.0051	−0.1181***	0.0239	0.0197	0.0539	0.0737*

TABLE III
(*Continued*)

Panel F: Mexican peso futures contracts

	Large previous 1-day returns				*Large opening-gaps returns*			
	Positive		*Negative*		*Positive*		*Negative*	
Filter size	*1.00%*	*1.00%*	*−1.00%*	*−1.00%*	*0.50%*	*0.50%*	*−0.50%*	*−0.50%*
No. event days	*48*	*51*	*49*	*57*	*64*	*69*	*56*	*44*
Time intervals (minutes from open)	*5/1995–1998*	*1999–2003*	*5/1995–1998*	*1999–2003*	*5/1995–1998*	*1999–2003*	*5/1995–1998*	*1999–2003*
40	0.1263	0.0626**	0.0897	−0.0056	0.0522	0.0091	−0.0101	0.1380*
80	0.0755	0.0815**	−0.0211	0.1413	0.0760	−0.0244	−0.0480	0.4084**
120	0.0742	0.0740*	0.0360	0.1473	−0.0531	−0.0538	0.1139	0.4841**
160	0.0764	0.0389	−0.0578	0.1926	−0.2088***	−0.0967**	0.1602	0.5983**
200	−0.0291	0.0535	0.0352	0.2638	−0.2138***	−0.0986**	0.2084	0.6103**
240	−0.0367	0.0668	0.0815	0.2506	−0.2370***	−0.1442***	0.2918	0.6514**
280	0.0533	0.0363	0.1473	0.3190*	−0.2097**	−0.1261**	0.4053*	0.6458**
320	0.0351	0.0158	0.2020	0.3260*	−0.2211**	−0.1682***	0.3544	0.6588**
360	−0.0252	0.0183	0.1138	0.3279*	−0.2093**	−0.1703***	0.2959	0.6317**
Close	−0.0731	0.0140	0.1527	0.3217*	−0.2294**	−0.1948**	0.3206	0.6566**

*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

subperiods, but significantly positive ACRs are documented in the third subperiod. It is thus concluded that the introduction of the GLOBEX in 1992 resulted in making the JY futures market efficient. However, the significant patterns that appear after large opening gaps in the third subperiod, following the introduction of the euro in 1999, (post-euro) indicate inefficiencies in yen futures.

For Australian dollar (AD) futures contracts (Panel B), it is found that, following large positive and negative 1-day returns, significant price reversals occur in the first subperiod late in the day but not in the second subperiod. However, in the third subperiod (post 1999), negative 1-day returns result in significant price reversals. For large opening-gap returns, no significant patterns are observed in the pre-GLOBEX and post-GLOBEX subperiods, whereas the euro subperiod depicts significant reversals for both positive and negative opening-gap returns. These results are similar to JY futures contracts, indicating that the introduction of the GLOBEX in 1992 has helped make the AD futures market efficient, but

the introduction of the euro in 1999 has led to inefficiencies in both the JY and AD futures markets.

Results for the British pound (BP) futures contracts appear mostly insignificant (Panel C) and the few significant ACRs in the first subperiod are mostly spurious.

For Swiss franc (SF) futures contracts, significant ACRs are found in the first subperiod (Panel D) for 1-day large negative price changes exhibiting reversals, whereas the significant positive ACRs in the second subperiod indicate persistence. However, in the third subperiod, significant ACR patterns are observed for both positive and negative large 1-day returns. For opening-gap strategies (last six columns in Panel D), significant patterns are not observed in the first and second subperiods for large positive opening-gap returns, but there are significant reversal patterns for negative opening-gap returns. Following the introduction of the euro in 1999, significant inefficiencies are seen in the form of reversals for large positive opening gaps. It is concluded that for SF futures contracts, the introduction of the GLOBEX in 1992 eliminated significant price patterns in two out of four cases, and the introduction of the euro in 1999 led to significant reversals and inefficiencies in three of the four cases.

For Canadian dollar (CD) futures contracts (documented in Panel E), there is a significant reversal pattern in only one out of four cases, following negative opening-gap returns in the first subperiod. However, in the second subperiod, there are significant price reversals for large positive 1-day returns (column 2) and both large positive and negative opening-gap returns (columns 8 and 11). In the third subperiod, significant price reversals are again observed for both the large negative 1-day returns as well as the large negative opening-gap returns. Therefore, the results for CD futures contracts show substantial price-reversal patterns in the second subperiod (three out of four cases), whereas the third subperiod documents inefficiencies in two out of four cases.

For Mexican peso (ME) futures contracts (Panel F), there are only data from 1995 to 2003 and hence the impact of GLOBEX cannot be analyzed. In the 1995–1998 subperiod, significant price reversals are found in only one case (positive opening-gap returns). However, in the post-euro sub-period, significant price patterns are observed in all four cases, three of which exhibit reversals. This leads to the conclusion that, similar to other currency futures markets, the introduction of the euro created an inefficiency in the ME futures market.

To summarize the results for the subperiods, it is found that the introduction of the GLOBEX in 1992 made the currency futures

contracts JY, AD, and BP more efficient based on past price changes, whereas the SF and CD futures markets exhibit weak-form market inefficiency. Following the introduction of the euro in 1999, several instances of market inefficiency are found in five of the six currency futures contracts, the BP futures contract being the exception.

Regression Tests

Using Full Data Set

Table IV presents the results of regressions, analyzing the relationships between futures returns, past 1-day returns, and opening-gaps returns on individual currency futures contracts. The slope coefficients from regression Equation (5) using previous 1-day returns are shown in the second column in each panel. These slope coefficients are negative and significant for the EC, CD, ME, and SF futures contracts and to a slightly lesser extent for the BP, AD, and JY futures contracts, indicating strong support for significant intraday reversal patterns in the seven currency futures markets. For opening-gap returns [Eq. (6)], shown in the third column in each panel, it is found that the slope coefficients are significant and negative for EC, CD, ME, and SF futures contracts and to a lesser extent for AD and BP futures contracts. The results for Equation (7) support the findings of Equations (5) and (6), lending support to the intraday reversal patterns in the currency futures market.

Next, all the currency futures contracts are combined in order to examine the general relationships between futures returns, past 1-day returns, and opening-gap returns. The results of the three regressions [Equations (8)–(10)] in Table V are similar to Table IV. Here significant reversal patterns are again found for previous 1-day and opening-gap currency futures returns. The results in Tables IV and V lead to the conclusion that the currency futures market is not weak-form efficient.

Tests on Three Subperiods: Pre-GLOBEX (1988–1992), Post-GLOBEX (1993–1998) and Post-Euro (1999–2003)

Table VI presents the results of Equations (11) and (12), which examine the intraday reversal pattern of futures returns on past price returns during the three subperiods. When previous 1-day returns are used as the past measure, columns 4 and 5 show the currency futures markets to be weak-form market efficient in the pre-GLOBEX

TABLE IV

Regression Analysis on Intraday Cumulative Returns Following Two Past Price Measures

Time intervals (minutes from open)	*Panel A: Japanese yen futures contract*				*Panel B: Australian dollar futures contract*				*Panel C: British pound futures contract*				*Panel D: Swiss franc futures contract*			
	Intercept	$R_{C2C1,t}$	$R_{C1O,t}$	*F*	*Intercept*	$R_{C2C1,t}$	$R_{C1O,t}$	*F*	*Intercept*	$R_{C2C1,t}$	$R_{C1O,t}$	*F*	*Intercept*	$R_{C2C1,t}$	$R_{C1O,t}$	*F*
40	0.0094***	−0.0060		2.30	0.0006	−0.0020		0.36	0.0075***	0.0010		0.05	0.0153***	−0.0033		0.49
	0.0094***		−0.0109**	4.46**	0.0006		0.0014	0.12	0.0069**		−0.0225***	11.88***	0.0144***		−0.0237***	11.12***
	0.0093***	−0.0060	−0.0110**	3.42**	0.0006	−0.0020	0.0014	0.24	0.0069**	0.0011	−0.0225***	5.97***	0.0144***	−0.0032	−0.0236***	5.80***
80	0.0078**	−0.0133***		7.01***	0.0024	0.0025		0.30	0.0094***	−0.0006		0.01	0.0176***	−0.0126**		4.62**
	0.0078**		−0.0080	1.46	0.0025		−0.0110*	3.69*	0.0091**		−0.0112	1.71	0.0167***		−0.0256***	8.21***
	0.0077**	−0.0134***	−0.0082	4.27**	0.0024	0.0025	−0.0110*	2.00	0.0091**	−0.0005	−0.0112	0.86	0.0167***	−0.0125**	−0.0256***	6.40***
120	0.0110**	−0.0172***		8.48***	0.0013	−0.0024		0.18	0.0154***	−0.0064		0.94	0.0215***	−0.0219***		10.00***
	0.0109**		−0.0121	2.44	0.0013		−0.0136*	3.72*	0.0147***		−0.0227**	5.09**	0.0200***		−0.0415***	15.39***
	0.0108**	−0.0173***	−0.0124	5.51***	0.0013	−0.0024	−0.0136*	1.95	0.0148***	−0.0063	−0.0226**	3.00*	0.0199***	−0.0218***	−0.0414***	12.68***
160	0.0064	−0.0083		1.51	0.0016	0.0019		0.08	0.0157***	−0.0125		2.58	0.0208***	−0.0228***		7.58***
	0.0063		−0.0130	2.17	0.0017		−0.0227***	7.88***	0.0150***		−0.0240**	4.19**	0.0192***		−0.0419***	10.93***
	0.0062	−0.0084	−0.0131	1.86	0.0016	0.0019	−0.0227***	3.98**	0.0151***	−0.0123	−0.0239**	3.36**	0.0192***	−0.0227***	−0.0418***	9.24***
200	0.0030	−0.0110		2.21	0.0010	−0.0100		1.90	0.0150***	−0.0229***		6.92***	0.0151**	−0.0240**		6.58**
	0.0029		−0.0140	2.08	0.0008		−0.0232**	6.50**	0.0142***		−0.0234*	3.14*	0.0132*		−0.0530***	13.69***
	0.0029	−0.0111	−0.0142	2.17	0.0010	−0.0100	−0.0232**	4.19**	0.0144***	−0.0228***	−0.0231*	4.99***	0.0131*	−0.0239**	−0.0528***	10.11***
240	0.0017	−0.0018		0.05	0.0026	−0.0111		2.02	0.0165***	−0.0180*		3.41*	0.0175**	−0.0223**		4.67**
	0.0018		0.0090	0.73	0.0024		−0.0148	2.30	0.0166***		0.0114	0.59	0.0161**		−0.0369**	5.49**
	0.0018	−0.0017	0.0090	0.39	0.0026	−0.0111	−0.0148	2.16	0.0168***	−0.0181*	0.0116	2.01	0.0161**	−0.0222**	−0.0368**	5.06***
280	0.0006	−0.0083		0.95	0.0040	−0.0185**		4.90**	0.0212***	−0.0170*		2.79*	0.0184**	−0.0224**		4.16**
	0.0008		0.0093	0.69	0.0038		−0.0099	0.88	0.0214***		0.0155	1.00	0.0172**		−0.0314*	3.50*
	0.0007	−0.0082	0.0092	0.81	0.0040	−0.0185**	−0.0098	2.89*	0.0215***	−0.0171*	0.0157	1.91	0.0172**	−0.0223**	−0.0313*	3.82**
320	0.0014	−0.0100		1.25	0.0055	−0.0199**		5.40**	0.0224***	−0.0200*		3.47*	0.0220**	−0.0237**		4.31**
	0.0016		0.0167	2.05	0.0052		−0.0020	0.03	0.0229***		0.0274*	2.84*	0.0211**		−0.0254	2.11
	0.0015	−0.0099	0.0166	1.63	0.0055	−0.0199**	−0.0019	2.71*	0.0231***	−0.0201*	0.0276*	3.19**	0.0210**	−0.0236**	−0.0252	3.20**
360	0.0023	−0.0062		0.45	0.0060	−0.0204**		5.18**	0.0300***	−0.0142		1.65	0.0259***	−0.0234**		4.03**
	0.0026		0.0267**	4.83**	0.0058		−0.0028	0.06	0.0307***		0.0325*	3.79*	0.0255***		−0.0139	0.61
	0.0026	−0.0060	0.0266**	2.63*	0.0060	−0.0204**	−0.0027	2.62*	0.0308***	−0.0143	0.0326*	2.75*	0.0254***	−0.0233**	−0.0137	2.31*
Close	0.0037	0.0024		0.06	0.0108*	−0.0219**		5.48**	0.0337***	−0.0041		0.13	0.0338***	−0.0095		0.63
	0.0041		0.0365***	8.37***	0.0106*		0.0084	0.51	0.0349***		0.0523***	9.31***	0.0337***		−0.0038	0.04
	0.0041	0.0027	0.0365***	4.22**	0.0108*	−0.0219**	0.0084	3.00**	0.0350***	−0.0044	0.0524***	4.73***	0.0337***	−0.0095	−0.0038	0.34

Time intervals (minutes from open)	Panel E: Euro futures contract				Panel F: Canadian dollar futures contract				Panel G: Mexican peso futures contract			
	Intercept	$R_{C2C1,t}$	$R_{C1O,t}$	*F*	*Intercept*	$R_{C2C1,t}$	$R_{C1O,t}$	*F*	*Intercept*	$R_{C2C1,t}$	$R_{C1O,t}$	*F*
40	0.0085*	−0.0251***		11.98***	0.0055***	−0.0229***		20.75***	0.0036	−0.0024		0.08
	0.0078		−0.0107	1.10	0.0054***		−0.0296***	16.41***	0.0042		−0.0223*	3.39*
	0.0081	−0.0248***	−0.0089	6.37***	0.0055***	−0.0223***	−0.0285***	18.08***	0.0042	0.0004	−0.0224*	1.69
80	0.0139**	−0.0374***		15.20***	0.0044*	−0.0217***		10.63***	0.0067	−0.0182		2.27
	0.0123*		−0.0291**	4.68**	0.0044*		−0.0528***	30.14***	0.0135		−0.2301***	186.61***
	0.0128*	−0.0364***	−0.0265**	9.58***	0.0045*	−0.0205***	−0.0519***	19.89***	0.0131	0.0109	−0.2330***	93.73***
120	0.0282***	−0.0544***		19.80***	0.0028	−0.0295***		14.60***	0.0064	−0.0680***		22.40***
	0.0256***		−0.0493***	8.25***	0.0027		−0.0857***	59.34***	0.0162*		−0.3855***	400.91***
	0.0263***	−0.0527***	−0.0455***	13.51***	0.0029	−0.0276***	−0.0844***	36.24***	0.0169*	−0.0204	−0.3802***	201.72***
160	0.0206**	−0.0628***		18.13***	−0.0018	−0.0268***		9.25***	0.0053	−0.0622***		15.71***
	0.0175*		−0.0596***	8.30***	−0.0018		−0.1082***	72.70***	0.0183*		−0.4746***	537.64***
	0.0183*	−0.0608***	−0.0553***	12.71***	−0.0017	−0.0244***	−0.1071***	40.31***	0.0184*	−0.0029	−0.4739***	268.72***
200	0.0141	−0.0648***		15.55***	−0.0025	−0.0381***		14.85***	0.0107	−0.1004***		35.42***
	0.0103		−0.0753***	10.72***	−0.0026		−0.1276***	80.48***	0.0230**		−0.5009***	508.18***
	0.0110	−0.0622***	−0.0708***	12.62***	−0.0024	−0.0353***	−0.1260***	46.85***	0.0242**	−0.0390**	−0.4906***	257.86***
240	0.0251**	−0.0723***		16.25***	−0.0015	−0.0393***		13.78***	0.0078	−0.1083***		36.89***
	0.0218*		−0.0605**	5.77**	−0.0016		−0.1127***	54.39***	0.0208*		−0.5340***	518.82***
	0.0227*	−0.0703***	−0.0555**	10.60***	−0.0014	−0.0368***	−0.1110***	33.39***	0.0222*	−0.0429***	−0.5227***	263.53***
280	0.0256**	−0.0765***		16.52***	−0.0004	−0.0427***		14.84***	0.0195	−0.1237***		42.84***
	0.0222*		−0.0618**	5.46**	−0.0005		−0.1179***	54.44***	0.0329***		−0.5643***	512.54***
	0.0231*	−0.0745***	−0.0565**	10.59***	−0.0003	−0.0401***	−0.1161***	33.92***	0.0347***	−0.0550***	−0.5498***	262.30***
320	0.0314**	−0.0775***		16.50***	0.0009	−0.0488***		18.21***	0.0222	−0.1365***		46.68***
	0.0279**		−0.0645**	5.81**	0.0008		−0.1130***	46.83***	0.0352***		−0.5697***	456.97***
	0.0288**	−0.0753***	−0.0592**	10.74***	0.0010	−0.0463***	−0.1108***	31.79***	0.0374***	−0.0675***	−0.5519***	236.34***
360	0.0383***	−0.0811***		17.25***	0.0033	−0.0543***		21.40***	0.0163	−0.1329***		39.74***
	0.0356***		−0.0475*	3.00*	0.0032		−0.1099***	41.80***	0.0283**		−0.5350***	348.42***
	0.0365***	−0.0796***	−0.0418	9.81***	0.0034	−0.0519***	−0.1074***	30.86***	0.0306**	−0.0682***	−0.5170***	180.85***
Close	0.0480***	−0.0804***		16.13***	0.0041	−0.0499***		16.90***	0.0126	−0.1389***		40.89***
	0.0451***		−0.0514*	3.35*	0.0040		−0.0988***	31.58***	0.0246*		−0.5435***	336.98***
	0.0460***	−0.0788***	−0.0458	9.42***	0.0042	−0.0477***	−0.0965***	23.63***	0.0271*	−0.0733***	−0.5242***	175.67***

Note. Simple regression are conducted on each of the 10 intraday intervals. Intraday cumulative returns are regressed against the past price measure (previous 1-day return ($R_{C2C1,t}$) or opening-gap return ($R_{C1O,t}$). Equation (5): $R_{i,t} = b_{0,i} + b_{1,i}(R_{C2C1,t}) + \varepsilon_{i,t}$. Equation (6): $R_{i,t} = b_{0,i} + b_{1,i}(R_{C1O,t}) + \varepsilon_{i,t}$. Equation (7): $R_{i,t} = b_{0,i} + b_{1,i}(R_{C2C1,t}) + b_{2,i}(R_{C1O,t}) + \varepsilon_{i,t}$.

*Significant at 10% level.

**Significant at 5% level.

***Significant at 1% level.

TABLE V

Multiple Regression Analysis on Intraday Cumulative Returns Following Two Past Price Measures from 1988–2003

Panel A: $R_{i,t} = B_{0,i} + b_{1,i} * (R_{C2C1,t}) + \varepsilon_{i,t}$

Time intervals (minutes from open)	$B_{0,i}$: *Linear function of the intercept coefficients*								
	b_0	$b_{0\,JY}$	$b_{0\,AD}$	$b_{0\,EC}$	$b_{0\,SF}$	$b_{0\,CD}$	$b_{0\,ME}$	b_1	F
40	0.0075***	0.0019	−0.0069*	0.0008	0.0077*	−0.0022	−0.0039	−0.0051***	3.24***
80	0.0095**	−0.0017	−0.0069	0.0042	0.0081	−0.0051	−0.0031	−0.0108***	4.26***
120	0.0155***	−0.0046	−0.0140**	0.0124	0.0060	−0.0128**	−0.0110	−0.0226***	11.45***
160	0.0158***	−0.0095	−0.0139*	0.0045	0.0050	−0.0176**	−0.0122	−0.0208***	7.71***
200	0.0151***	−0.0122	−0.0139*	−0.0013	0.0000	−0.0177**	−0.0073	−0.0304***	10.77***
240	0.0166***	−0.0150*	−0.0138	0.0081	0.0009	−0.0182**	−0.0121	−0.0287***	8.73***
280	0.0213***	−0.0208**	−0.0171*	0.0039	−0.0030	−0.0218**	−0.0055	−0.0335***	10.36***
320	0.0226***	−0.0214**	−0.0169*	0.0084	−0.0006	−0.0218**	−0.0045	−0.0366***	11.44***
360	0.0302***	−0.0281***	−0.0240**	0.0077	−0.0043	−0.0270***	−0.0180	−0.0350***	10.64***
Close	0.0339***	−0.0304***	−0.0230**	0.0136	−0.0002	−0.0299***	−0.0259**	−0.0289***	8.57***

Panel B: $R_{i,t} = B_{0,i} + b_{1,i} * (R_{C1O,t}) + \varepsilon_{i,t}$

Time intervals (minutes from open)	$B_{0,i}$: *Linear function of the intercept coefficients*								
	b_0	$b_{0\,JY}$	$b_{0\,AD}$	$b_{0\,EC}$	$b_{0\,SF}$	$b_{0\,CD}$	$b_{0\,ME}$	b_1	F
40	0.0071**	0.0022	−0.0065	0.0005	0.0076*	−0.0018	−0.0032	−0.0144***	6.67***
80	0.0084**	−0.0010	−0.0059	0.0035	0.0078	−0.0041	−0.0012	−0.0393***	20.41***
120	0.0137***	−0.0033	−0.0123*	0.0113	0.0054	−0.0109*	−0.0079	−0.0647***	39.20***
160	0.0137***	−0.0081	−0.0120	0.0031	0.0042	−0.0155**	−0.0084	−0.0782***	42.46***
200	0.0127**	−0.0105	−0.0118	−0.0028	−0.0007	−0.0153*	−0.0033	−0.0852***	39.91***
240	0.0145**	−0.0136	−0.0120	0.0068	0.0003	−0.0162*	−0.0088	−0.0718***	24.67***
280	0.0192***	−0.0193**	−0.0153	0.0026	−0.0035	−0.0197**	−0.0024	−0.0726***	22.69***
320	0.0206***	−0.0199**	−0.0153	0.0073	−0.0011	−0.0198**	−0.0018	−0.0668***	18.19***
360	0.0285***	−0.0267***	−0.0226**	0.0067	−0.0046	−0.0253**	−0.0158	−0.0567***	13.46***
Close	0.0324***	−0.0293***	−0.0218**	0.0128	−0.0004	−0.0285***	−0.0240*	−0.0479***	10.69***

Panel C: $R_{i,t} = B_{0,i} + b_{1,i} * (R_{C2C1,t}) + b_{2,i} * (R_{C1O,t}) + \varepsilon_{i,t}$

Time intervals (minutes from open)	$B_{0,i}$: *Linear function of the intercept coefficients*									
	b_0	$b_{0\,JY}$	$b_{0\,AD}$	$b_{0\,EC}$	$b_{0\,SF}$	$b_{0\,CD}$	$b_{0\,ME}$	b_1	b_2	F
40	0.0072**	0.0021	−0.0065	0.0005	0.0075*	−0.0018	−0.0030	−0.0048***	−0.0143***	6.70***
80	0.0085**	−0.0011	−0.0059	0.0035	0.0076	−0.0041	−0.0009	−0.0101***	−0.0390***	20.03***
120	0.0139***	−0.0037	−0.0123*	0.0113	0.0052	−0.0111*	−0.0073	−0.0215***	−0.0640***	41.28***
160	0.0139***	−0.0084	−0.0119	0.0031	0.0040	−0.0156**	−0.0078	−0.0195***	−0.0775***	41.48***
200	0.0130**	−0.0110	−0.0117	−0.0028	−0.0011	−0.0155*	−0.0025	−0.0289***	−0.0842***	42.65***
240	0.0148**	−0.0140	−0.0120	0.0068	0.0000	−0.0163*	−0.0080	−0.0275***	−0.0708***	27.46***
280	0.0195***	−0.0198**	−0.0153	0.0026	−0.0039	−0.0199**	−0.0014	−0.0322***	−0.0714***	27.03***
320	0.0209***	−0.0204**	−0.0152	0.0072	−0.0015	−0.0201**	−0.0008	−0.0355***	−0.0655***	23.92***
360	0.0288***	−0.0273***	−0.0226**	0.0067	−0.0050	−0.0256**	−0.0148	−0.0340***	−0.0555***	18.60***
Close	0.0327***	−0.0297***	−0.0218**	0.0128	−0.0008	−0.0287***	−0.0232*	−0.0281***	−0.0469***	13.72***

Note. Multiple regressions are conducted on each of the 10 intervals. Intraday cumulative returns are regressed against two past returns [previous 1-day returns ($R_{C2C1,t}$) and opening-gap returns ($R_{C1O,t}$)]. The intercept coefficient is the linear function on dummy variables that represent each currency futures contracts. Equation (8): $R_{i,t} = B_{0,i} + b_{1,i} * (R_{C2C1,t}) + \varepsilon_{i,t}$. Equation (9): $R_{i,t} = B_{0,i} + b_{1,i} * (R_{C1O,t}) + \varepsilon_{i,t}$. Equation (10): $R_{i,t} = B_{0,i} + b_{1,i} * (R_{C2C1,t}) + b_{2,i} * (R_{C1O,t}) + \varepsilon_{i,t}$.
where

$$B_{0,i} = (b_0 + b_{0\,JY} * D_{JY} + b_{0\,AD} * D_{AD} + b_{0\,EC} * D_{EC} + b_{0\,SF} * D_{SP} + b_{0\,CD} * D_{CD} + b_{0\,ME} * D_{ME})$$

*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

TABLE VI

Regression Analysis on Intraday Cumulative Returns Following Two Past Price Measures

Time intervals (minutes from open)	*Intercept*	$D_{GLOBEX,t}$	$D_{Euro,t}$	$R_{C2C1,t}$	$R_{C2C1,t} * D_{GLOBEX,t}$	$R_{C2C1,t} * D_{Euro,t}$	$R_{C1O,t}$	$R_{C1O,t} * D_{GLOBEX,t}$	$R_{C1O,t} * D_{Euro,t}$	*F*
Panel A: Japanese yen futures contract										
40	0.0160***	−0.0097	−0.0093	−0.0113	0.0089	0.0044				1.11
	0.0158***	−0.0094	−0.0090				−0.0143	−0.0035	0.0178	1.98***
80	0.0114*	−0.0071	−0.0029	−0.0111	−0.0033	−0.0026				1.54
	0.0112*	−0.0069	−0.0027				−0.0090	−0.0034	0.0093	0.54***
120	0.0079	0.0000	0.0098	−0.0074	−0.0201	−0.0020				2.43**
	0.0077	0.0004	0.0101				−0.0154	−0.0013	0.0138	0.84***
160	0.0112	−0.0126	−0.0003	0.0078	−0.0340**	−0.0014				1.81
	0.0111	−0.0123	−0.0004				−0.0045	−0.0157	−0.0030	0.84***
200	0.0084	−0.0147	0.0005	0.0002	−0.0273	0.0052				1.60
	0.0082	−0.0143	0.0007				−0.0140	−0.0080	0.0137	0.92***
240	−0.0002	−0.0048	0.0120	0.0012	−0.0110	0.0079				0.48
	−0.0001	−0.0049	0.0122				0.0061	−0.0022	0.0141	0.52***
280	0.0007	−0.0047	0.0054	−0.0031	−0.0124	0.0021				0.40
	0.0009	−0.0047	0.0055				0.0066	−0.0003	0.0102	0.26***
320	0.0014	−0.0068	0.0080	−0.0108	−0.0019	0.0063				0.45
	0.0015	−0.0069	0.0084				0.0039	0.0140	0.0221	0.68***
360	0.0053	−0.0127	0.0057	−0.0095	0.0029	0.0073				0.37
	0.0056	−0.0130	0.0059				0.0165	0.0147	0.0121	1.29***
Close	0.0120	−0.0197	−0.0029	0.0139	−0.0154	−0.0167				0.43
	0.0129	−0.0206	−0.0033				0.0493*	−0.0117	−0.0243	2.11***
Panel B: Australian dollar futures contract										
40	0.0021	−0.0048	0.0012	0.0001	0.0034	−0.0087				0.89
	0.0021	−0.0048	0.0009				0.0121	−0.0019	−0.0268***	2.16***
80	0.0035	−0.0060	0.0042	0.0070	0.0085	−0.0199*				1.92*
	0.0036	−0.0061	0.0037				0.0295***	−0.0348**	−0.0761***	6.98***
120	−0.0029	−0.0009	0.0148	0.0157	−0.0117	−0.0380***				2.37**
	−0.0027	−0.0011	0.0140				0.0460***	−0.0645***	−0.0999***	8.03***

160	0.0014	−0.0062	0.0083	0.0195	−0.0112	−0.0373**				1.60
	0.0017	−0.0064	0.0075				0.0521***	−0.0814***	−0.1247***	9.79***
200	0.0043	−0.0147	0.0072	0.0073	−0.0081	−0.0398**				2.31**
	0.0044	−0.0147	0.0063				0.0443**	−0.0798***	−0.1069***	6.71***
240	0.0067	−0.0137	0.0035	0.0037	−0.0036	−0.0369*				1.80
	0.0067	−0.0136	0.0026				0.0438**	−0.0721***	−0.0903***	3.85***
280	0.0064	−0.0112	0.0061	−0.0065	−0.0025	−0.0304				1.91*
	0.0062	−0.0110	0.0054				0.0391**	−0.0633**	−0.0725***	2.25***
320	0.0069	−0.0089	0.0066	−0.0113	0.0027	−0.0260				1.83
	0.0066	−0.0086	0.0060				0.0458**	−0.0685**	−0.0645**	1.81***
360	0.0083	−0.0129	0.0087	−0.0214	0.0121	−0.0090				1.72
	0.0078	−0.0124	0.0084				0.0493**	−0.0636**	−0.0807***	2.25***
Close	0.0163	−0.0219	0.0096	−0.0214	0.0186	−0.0191				2.67**
	0.0157	−0.0214	0.0092				0.0689***	−0.0704**	−0.0968***	3.34***
Panel C: British pound futures contract										
40	0.0104**	−0.0047	−0.0038	0.0025	0.0142	−0.0300***				2.66**
	0.0096**	−0.0039	−0.0035				−0.0358***	0.0260*	0.0266	3.30***
80	0.0109*	−0.0054	0.0017	0.0020	0.0115	−0.0314**				1.55
	0.0102	−0.0039	0.0020				−0.0316**	0.0535***	0.0243	1.87***
120	0.0086	0.0040	0.0171	0.0033	−0.0011	−0.0484***				2.38**
	0.0077	0.0051	0.0171				−0.0397***	0.0457*	0.0194	2.30***
160	0.0149*	−0.0016	0.0049	0.0048	−0.0214	−0.0547***				1.99*
	0.0139	−0.0003	0.0047				−0.0432**	0.0615**	0.0097	1.90***
200	0.0139	0.0030	0.0003	−0.0075	−0.0225	−0.0433*				2.15*
	0.0130	0.0041	−0.0004				−0.0363*	0.0555*	−0.0100	1.45***
240	0.0060	0.0167	0.0142	0.0054	−0.0379*	−0.0604**				2.23**
	0.0064	0.0166	0.0129				0.0155	0.0104	−0.0301	0.59***
280	0.0129	0.0154	0.0085	0.0028	−0.0294	−0.0556**				1.66
	0.0132	0.0159	0.0074				0.0131	0.0288	−0.0236	0.68***
320	0.0099	0.0212	0.0149	−0.0043	−0.0212	−0.0468				1.60
	0.0106	0.0220	0.0134				0.0279	0.0345	−0.0431	1.48***
360	0.0184	0.0183	0.0156	0.0055	−0.0297	−0.0539*				1.33
	0.0193	0.0190	0.0138				0.0367	0.0297	−0.0538	1.65***
Close	0.0261**	0.0148	0.0071	0.0232	−0.0368	−0.0816***				1.69
	0.0279**	0.0153	0.0042				0.0689***	0.0136	−0.0883**	3.08***

(*Continued*)

TABLE VI

Regression Analysis on Intraday Cumulative Returns Following Two Past Price Measures (*Continued*)

Time intervals (minutes from open)	*Intercept*	$D_{GLOBEX,t}$	$D_{Euro,t}$	$R_{C2C1,t}$	$R_{C2C1,t} * D_{GLOBEX,t}$	$R_{C2C1,t} * D_{Euro,t}$	$R_{C1O,t}$	$R_{C1O,t} * D_{GLOBEX,t}$	$R_{C1O,t} * D_{Euro,t}$	*F*
Panel D: Swiss franc futures contract										
40	0.0172***	−0.0002	−0.0058	0.0027	0.0046	−0.0288**				1.96*
	0.0154**	0.0008	−0.0037				−0.0497***	0.0259	0.0566***	4.43***
80	0.0119	0.0094	0.0073	0.0037	−0.0130	−0.0449***				2.97**
	0.0104	0.0103	0.0080				−0.0421***	0.0229	0.0285	2.19***
120	0.0069	0.0176	0.0261**	−0.0083	−0.0040	−0.0469***				4.47***
	0.0050	0.0182	0.0267**				−0.0557***	0.0114	0.0349	4.21***
160	0.0124	0.0129	0.0116	0.0063	−0.0266	−0.0762***				4.34***
	0.0106	0.0136	0.0116				−0.0520**	0.0122	0.0197	2.43***
200	0.0111	0.0059	0.0062	−0.0017	−0.0160	−0.0642***				2.87**
	0.0092	0.0060	0.0057				−0.0552**	−0.0035	0.0118	2.80***
240	0.0039	0.0144	0.0267	−0.0017	−0.0044	−0.0733***				3.15***
	0.0032	0.0136	0.0255				−0.0221	−0.0320	−0.0117	1.59***
280	0.0054	0.0147	0.0242	−0.0039	0.0025	−0.0744***				2.94**
	0.0049	0.0140	0.0225				−0.0164	−0.0233	−0.0226	1.04***
320	0.0091	0.0120	0.0271	−0.0036	−0.0005	−0.0769***				2.91**
	0.0089	0.0116	0.0249				−0.0087	−0.0167	−0.0355	0.85***
360	0.0144	0.0073	0.0288	−0.0016	−0.0061	−0.0756**				2.69**
	0.0142	0.0072	0.0275				−0.0060	−0.0047	−0.0197	0.51***
Close	0.0233	0.0035	0.0299	0.0254	−0.0277	−0.0968***				2.65**
	0.0241	0.0023	0.0273				0.0300	−0.0428	−0.0618	0.82***
Panel E: Canadian dollar futures contract										
40	0.0060*	−0.0037	0.0027	−0.0051	−0.0138	−0.0303**				5.72***
	0.0063**	−0.0037	0.0018				−0.0532***	0.0073	0.0585***	6.18***
80	0.0078*	−0.0111**	0.0027	0.0079	−0.0172	−0.0551***				5.93***
	0.0084**	−0.0114**	0.0013				−0.0656***	−0.0114	0.0486*	8.90***
120	0.0072	−0.0182***	0.0077	0.0131	−0.0426**	−0.0658***				8.43***
	0.0080*	−0.0185***	0.0058				−0.0886***	−0.0286	0.0404	16.50***

160	0.0066	−0.0214***	−0.0012	0.0219	−0.0513**	−0.0726***				6.01***
	0.0076	−0.0219***	−0.0034				−0.1055***	−0.0314	0.0267	17.47***
200	0.0045	−0.0182**	−0.0008	0.0146	−0.0516*	−0.0811***				6.21***
	0.0057	−0.0188**	−0.0034				−0.1472***	−0.0232	0.0805**	19.45***
240	0.0005	−0.0155*	0.0123	0.0051	−0.0284	−0.0811***				6.66***
	0.0015	−0.0160*	0.0098				−0.1283***	−0.0179	0.0646	13.79***
280	−0.0010	−0.0110	0.0152	0.0027	−0.0302	−0.0817***				6.30***
	−0.0001	−0.0114	0.0127				−0.1241***	−0.0308	0.0524	13.26***
320	0.0007	−0.0127	0.0162	0.0015	−0.0351	−0.0891***				7.36***
	0.0015	−0.0130	0.0136				−0.1212***	−0.0260	0.0531	11.77***
360	0.0011	−0.0120	0.0222**	0.0058	−0.0356	−0.1115***				9.75***
	0.0018	−0.0122	0.0194*				−0.0977***	−0.0537	0.0265	11.29***
Close	0.0058	−0.0171*	0.0156	0.0221	−0.0444	−0.1317***				9.41***
	0.0065	−0.0174*	0.0127				−0.0624*	−0.0796*	−0.0136	8.91***

Note. Simple regression are conducted on each of the 10 intraday intervals. Intraday cumulative returns are regressed against the past price measure (previous 1-day return ($R_{C2C1,t}$) or opening-gap return ($R_{C1O,t}$). The intercept coefficients (B_0), and the slope coefficients (B_1), are linear functions of dummy variables, representing the GLOBEX (1993–1998) or Euro (1999–2003) periods. Equations: $R_{i,t} = B_{0,i} + B_{1,i}(R_{C2C1,t}) + \varepsilon_{i,t}$ where $B_{0,i} = (b_0 + b_{0\ \mathrm{GLOBEX}} * D_{\mathrm{GLOBEX}} + b_{0\ \mathrm{Euro}} * D_{\mathrm{Euro}})$ and $B_{1,i} = (b_1 + b_{1\ \mathrm{GLOBEX}} * D_{\mathrm{GLOBEX}} + b_{1\ \mathrm{Euro}} * D_{\mathrm{Euro}})$ or $R_{i,t} = B_{0,i} + B_{1,i}(R_{C1O,t}) + \varepsilon_{i,t}$, where $B_{0,i} = (b_0 + b_{0\ \mathrm{GLOBEX}} * D_{\mathrm{GLOBEX}} + b_{0\ \mathrm{Euro}} * D_{\mathrm{Euro}})$, and $B_{1,i} = (b_1 + b_{1\ \mathrm{GLOBEX}} * D_{\mathrm{GLOBEX}} + b_{1\ \mathrm{Euro}} * D_{\mathrm{Euro}})$.

Column 1: Intercept for selected past price measure in first subperiod
Columns 1 + 2: Intercept for selected past price measure in second subperiod
Columns 1 + 3: Intercept for selected past price measure in third subperiod
Column 4: Slope coefficient for previous 1-day return in first subperiod
Columns 4 + 5: Slope coefficient for previous 1-day return in second subperiod
Columns 4 + 6: Slope coefficient for previous 1-day return in third subperiod
Column 7: Slope coefficient for opening-gap return in first subperiod
Columns 7 + 8: Slope coefficient for opening-gap return in second subperiod
Column 7 + 9: Slope coefficient for opening-gap return in third subperiod
Column 10: *F* statistics

*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

and post-GLOBEX subperiods. All slope coefficients are statistically insignificant for all futures contracts. In contrast, there is a violation of weak-form market efficiency in the post-euro subperiod (column 6) for BP, SF, and CD futures contracts and to a lesser extent in the AD futures contract. This leads to the conclusion that previous 1-day returns show the currency futures markets to be efficient after the introduction of the GLOBEX in 1992 but not after the introduction of the euro in 1999.

When opening-gap returns are used as the past measure (columns 7–9), the BP, SF, and CD futures contracts exhibit reversals in column 7, whereas the AD futures contract exhibits persistence, leading to the conclusion that these contracts are inefficient in the pre-GLOBEX subperiod. In the post-GLOBEX and post-euro subperiods, it is found that the markets are generally efficient for all contracts, except the AD futures contracts. It is concluded that with the use of opening-gap returns, the currency futures markets appear to be inefficient in the pre-GLOBEX subperiod and mostly efficient in the post-GLOBEX subperiod. In the post-euro subperiod, although the futures markets are marked by some inefficiencies, these are not as dramatic as when previous 1-day returns are used as the past measure.

Magnitude Effect

The regression results for Equations (13) and (14) are presented in Table VII, Panels A–G. It is found that for previous positive 1-day returns (column 3 in each panel), only EC futures contracts exhibit significant price patterns, and for negative 1-day returns (column 4), only ME futures contracts exhibit significant patterns. For the intraday patterns following positive opening-gap returns (column 5), significant patterns are found for all futures contracts except BP. For negative opening-gap returns (column 6), significant patterns are observed only for ME and somewhat significant patterns for the JY, EC, and AD futures contracts. This supports the notion that the currency futures markets generally violate weak-form market efficiency, with the degree of violation being more pronounced when positive opening-gap return is used as the past price measure.

Friday Effect

Equations (15) and (16) are examined to test whether traders unwind their positions on Fridays to reduce their risk exposure over the weekend.

TABLE VII

Regression Analysis on Intraday Cumulative Returns Following Two Past Price Measures

Time intervals (minutes from open)	*Intercept*	$D_{Negative,t}$	$R_{C2C1,t}$	$R_{C2C1,t} * D_{Negative,t}$	$R_{C1O,t}$	$R_{C1O,t} * D_{Negative,t}$	*F*
Panel A: Japanese yen futures contract							
40	0.0060	−0.0021	0.0009	−0.0172			1.54
	0.0123**	−0.0063			−0.0142	−0.0012	1.68
80	0.0082	−0.0094	−0.0103	−0.0166			2.97**
	0.0043	−0.0046			0.0030	−0.0292	1.32
120	0.0225***	−0.0137	−0.0317***	0.0172			3.65**
	0.0051	0.0053			−0.0013	−0.0159	1.07
160	0.0131	−0.0096	−0.0160	0.0068			0.72
	0.0039	−0.0072			−0.0032	−0.0302	1.26
200	0.0129	−0.0144	−0.0223	0.0095			1.11
	0.0034	−0.0111			−0.0087	−0.0259	1.12
240	0.0087	−0.0134	−0.0085	0.0005			0.23
	−0.0084	−0.0088			0.0382*	−0.0735**	2.29*
280	0.0078	−0.0147	−0.0147	−0.0015			0.54
	−0.0060	−0.0080			0.0299	−0.0542*	1.23
320	0.0153	−0.0288	−0.0225	−0.0029			1.19
	−0.0100	−0.0022			0.0456**	−0.0640*	1.92
360	0.0116	−0.0240	−0.0126	−0.0113			0.68
	−0.0210	0.0114			0.0763***	−0.0897***	4.10***
Close	0.0078	−0.0197	0.0032	−0.0224			0.50
	−0.0222				0.0906***	−0.0949***	5.46***
Panel B: Australian dollar futures contract							
40	−0.0012	−0.0084	0.0060	−0.0244**			2.82**
	0.0106**	−0.0254***			−0.0111	−0.0107	5.90***
80	0.0057	−0.0058	−0.0021	0.0024			0.26
	0.0234***	−0.0312***			−0.0504***	0.0337**	7.29***
120	0.0037	−0.0045	−0.0056	0.0013			0.12
	0.0217***	−0.0272**			−0.0537***	0.0407**	4.95***
160	−0.0021	0.0030	0.0088	−0.0100			0.14
	0.0196**	−0.0238**			−0.0581***	0.0363	4.82***
200	−0.0018	−0.0023	−0.0028	−0.0164			0.84
	0.0177*	−0.0181			−0.0589***	0.0446*	3.77**
240	−0.0028	−0.0091	0.0051	−0.0411*			1.85
	0.0077	−0.0034			−0.0273	0.0196	0.95
280	0.0028	−0.0170	−0.0078	−0.0392			2.85**
	0.0067	0.0034			−0.0198	0.0241	0.51
320	0.0062	−0.0196	−0.0123	−0.0361			2.96**
	0.0019	0.0180			−0.0033	0.0274	0.66
360	0.0118	−0.0258	−0.0211	−0.0271			2.84**
	0.0115	0.0050			−0.0216	0.0434	0.63
Close	0.0171	−0.0242	−0.0244	−0.0217			2.65**
	0.0208*	0.0032			−0.0217	0.0628*	1.31

(*Continued*)

TABLE VII

Regression Analysis on Intraday Cumulative Returns Following Two Past Price Measures (*Continued*)

Time intervals (minutes from open)	*Intercept*	$D_{Negative,t}$	$R_{C2C1,t}$	$R_{C2C1,t} * D_{Negative,t}$	$R_{C1O,t}$	$R_{C1O,t} * D_{Negative,t}$	*F*
Panel C: British pound futures contract							
40	0.0031	0.0074	0.0070	−0.0035			0.34
	0.0059	0.0002			−0.0191	−0.0062	4.00***
80	0.0058	0.0097	0.0023	0.0051			0.34
	0.0081	−0.0029			−0.0048	−0.0167	0.75
120	0.0071	0.0140	0.0046	−0.0061			0.80
	0.0132	−0.0010			−0.0163	−0.0136	1.77
160	0.0008	0.0261*	0.0072	−0.0096			2.08
	0.0127	0.0037			−0.0192	−0.0030	1.42
200	0.0074	0.0106	−0.0115	−0.0105			2.52*
	0.0095	0.0067			−0.0128	−0.0091	1.12
240	0.0124	0.0092	−0.0137	0.0018			1.23
	0.0102	0.0195			0.0160	0.0226	0.72
280	0.0171	0.0051	−0.0107	−0.0068			0.97
	0.0182	0.0154			0.0124	0.0305	0.74
320	0.0183	0.0043	−0.0130	−0.0090			1.20
	0.0214	0.0175			0.0162	0.0490	1.62
360	0.0249*	0.0072	−0.0066	−0.0069			0.61
	0.0310**	0.0123			0.0198	0.0436	1.69
Close	0.0294**	0.0031	0.0039	−0.0123			0.10
	0.0329**	0.0217			0.0389	0.0602	4.02***
Panel D: Swiss franc futures contract							
40	0.0062	−0.0004	0.0125	−0.0327**			1.99
	0.0186**	−0.0129			−0.0265*	−0.0134	4.36***
80	0.0089	0.0076	−0.0004	−0.0174			1.99
	0.0166*	−0.0146			−0.0153	−0.0420	3.99***
120	0.0067	0.0052	0.0017	−0.0432**			4.82***
	0.0269**	−0.0186			−0.0480**	−0.0146	5.68***
160	0.0116	−0.0017	−0.0062	−0.0359			3.22**
	0.0329**	−0.0216			−0.0649**	0.0137	4.14***
200	0.0006	0.0078	−0.0018	−0.0378			2.85**
	0.0349**	−0.0318			−0.0913***	0.0290	5.49***
240	0.0126	−0.0062	−0.0114	−0.0286			1.86
	0.0399**	−0.0330			−0.0800**	0.0366	2.72**
280	0.0163	−0.0111	−0.0147	−0.0271			1.67
	0.0476***	−0.0452*			−0.0845**	0.0386	2.49*
320	0.0252	−0.0231	−0.0208	−0.0295			1.93
	0.0461**	−0.0334			−0.0717*	0.0425	1.50
360	0.0293	−0.0208	−0.0215	−0.0250			1.70
	0.0463**	−0.0267			−0.0532	0.0385	0.73
Close	0.0398**	−0.0220	−0.0116	−0.0180			0.50
	0.0573***	−0.0287			−0.0494	0.0478	0.66

TABLE VII
(*Continued*)

Time intervals (minutes from open)	*Intercept*	$D_{Negative,t}$	$R_{C2C1,t}$	$R_{C2C1,t} * D_{Negative,t}$	$R_{C1O,t}$	$R_{C1O,t} * D_{Negative,t}$	*F*
Panel E: Euro futures contract							
40	0.0004	0.0076	−0.0127	−0.0168			4.28***
	0.0165	−0.0070			−0.0291	0.0266	0.68
80	0.0169	−0.0075	−0.0404**	−0.0025			5.10***
	0.0320**	−0.0296			−0.0618**	0.0200	2.35*
120	0.0290*	0.0161	−0.0614**	0.0335			6.95***
	0.0662***	−0.0404			−0.1300***	0.1018*	4.83***
160	0.0309	0.0126	−0.0863***	0.0633			6.70***
	0.0576**	−0.0327			−0.1438***	0.1211*	4.35***
200	0.0314	0.0053	−0.0990***	0.0772			5.94***
	0.0621**	−0.0338			−0.1895***	0.1812**	6.11***
240	0.0488*	−0.0077	−0.1139***	0.0772			6.08***
	0.0603**	0.0031			−0.1633***	0.2166***	4.57***
280	0.0482*	−0.0163	−0.1131***	0.0567			5.90***
	0.0671**	−0.0097			−0.1731***	0.2136***	4.17***
320	0.0533*	−0.0262	−0.1094***	0.0354			5.78***
	0.0728**	−0.0132			−0.1737***	0.2035**	4.03***
360	0.0539*	−0.0175	−0.1041**	0.0273			5.88***
	0.0810***	−0.0038			−0.1641***	0.2341***	3.59**
Close	0.0612**	−0.0077	−0.1024**	0.0365			5.50***
	0.1111***	−0.0270			−0.2074***	0.2779***	4.74***
Panel F: Canadian dollar futures contract							
40	0.0026	0.0030	−0.0140	−0.0114			7.24***
	0.0076**	−0.0038			−0.0374***	0.0045	5.70***
80	−0.0007	0.0062	−0.0068	−0.0166			4.08***
	0.0037	0.0016			−0.0508***	0.0007	10.06***
120	−0.0013	0.0024	−0.0151	−0.0234			5.26***
	0.0003	0.0031			−0.0753***	−0.0118	19.89***
160	−0.0043	−0.0008	−0.0159	−0.0231			3.36**
	−0.0057	0.0059			−0.0930***	−0.0133	24.45***
200	−0.0025	−0.0084	−0.0308	−0.0316			5.58***
	−0.0059	0.0065			−0.1167***	−0.0031	26.97***
240	−0.0016	−0.0108	−0.0292	−0.0423			5.55***
	−0.0095	0.0079			−0.0767***	−0.0496	18.82***
280	0.0015	−0.0102	−0.0411*	−0.0241			5.40***
	−0.0070	0.0061			−0.0881***	−0.0425	18.58***
320	0.0021	−0.0089	−0.0458*	−0.0240			6.43***
	−0.0076	0.0072			−0.0732**	−0.0595	16.34***
360	0.0007	−0.0046	−0.0399*	−0.0380			7.59***
	−0.0046	0.0066			−0.0732**	−0.0548	14.52***
Close	0.0054	−0.0105	−0.0456*	−0.0300			6.11***
	0.0005	0.0009			−0.0792**	−0.0370	10.72***

(*Continued*)

TABLE VII
Regression Analysis on Intraday Cumulative Returns Following Two Past Price Measures (*Continued*)

Time intervals (minutes from open)	*Intercept*	$D_{Negative,t}$	$R_{C2C1,t}$	$R_{C2C1,t} * D_{Negative,t}$	$R_{C1O,t}$	$R_{C1O,t} * D_{Negative,t}$	*F*
Panel G: Mexican peso futures contract							
40	−0.0142	−0.0405**	0.0664***	−0.1536***			19.93***
	0.0055	−0.0341**			0.0249	−0.0919***	6.86***
80	−0.0051	−0.0534**	0.0440*	−0.1517***			10.84***
	0.0163	−0.1404***			−0.0216	−0.3985***	124.34***
120	−0.0178	−0.1073***	0.0584**	−0.3073***			37.72***
	0.0053	−0.1591***			−0.0745*	−0.5591***	223.68***
160	−0.0151	−0.0992***	0.0498	−0.2754***			25.53***
	0.0180	−0.1718***			−0.1995***	−0.5164***	257.42***
200	0.0024	−0.1454***	0.0111	−0.3098***			37.60***
	0.0089	−0.1493***			−0.1889***	−0.5536***	234.19***
240	−0.0095	−0.1463***	0.0256	−0.3504***			40.08***
	0.0017	−0.1432***			−0.2050***	−0.5739***	232.74***
280	−0.0078	−0.1553***	0.0403	−0.4110***			46.96***
	0.0013	−0.1400***			−0.1746***	−0.6590***	235.56***
320	0.0169	−0.1697***	−0.0172	−0.3422***			38.81***
	0.0092	−0.1244***			−0.2339***	−0.5704***	193.31***
360	0.0194	−0.1762***	−0.0300	−0.3179***			32.58***
	0.0049	−0.1172***			−0.2243***	−0.5292***	145.24***
Close	0.0102	−0.1717***	−0.0253	−0.3335***			32.63***
	0.0085	−0.1251***			−0.2590***	−0.4973***	137.75***

Note. Simple regressions are conducted on each of the 10 intraday intervals. Intraday cumulative returns are regressed against the past price measure (previous 1-day return ($R_{C2C1,t}$) or opening-gap return ($R_{C1O,t}$). The intercept coefficients (B_0), and the slope coefficients (B_1), are linear functions of one dummy variable, representing negative past price measures. Equations: $R_{i,t} = B_{0,i} + B_{1,i}(R_{C2C1,t}) + \varepsilon_{i,t}$ where $B_{0,i} = (b_0 + b_{0\ Negative} * D_{Negative})$ and $B_{1,i} = (b_1 + b_{1\ Negative} * D_{Negative})$ or $R_{i,t} = B_{0,i} + B_{1,i}(R_{C1O,t}) + \varepsilon_{i,t}$ where $B_{0,i} = (b_0 + b_{0\ Negative} * D_{Negative})$ and $B_{1,i} = (b_1 + b_{Negative} * D_{Negative})$.

Column 1: Intercept for selected positive past price measure
Columns 1 + 2: Intercept for selected negative past price measure
Column 3: Slope coefficient for positive previous 1-day return
Columns 3 + 4: Slope coefficient for negative previous 1-day return
Column 5: Slope coefficient for positive opening-gap return
Columns 5 + 6: Slope coefficient for negative opening-gap return
Column 7: *F* statistics

*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

The results in Table VIII indicate that there is a strong Friday effect for BP and SF futures contracts, when previous 1-day returns are used as the past price measure. Most of the other currency futures contracts have significant price (reversal) patterns following either past price measure on non-Fridays, but weak or inconclusive price patterns are observed on Fridays.

TABLE VIII

Regression Analysis on Intraday Cumulative Returns Following Two Past Price Measures

Time intervals (minutes from open)	*Intercept*	$D_{Friday,t}$	$R_{C2C1,t}$	$R_{C2C1,t} * D_{Friday,t}$	$R_{C1O,t}$	$R_{C1O,t} * D_{Friday,t}$	*F*
Panel A: Japanese yen futures contract							
40	0.0095***	0.0000	−0.0039	−0.0102			1.13
	0.0096***	−0.0011			−0.0105*	−0.0022	1.50
80	0.0105**	−0.0132	−0.0120**	−0.0057			3.10**
	0.0107**	−0.0149			−0.0060	−0.0129	1.48
120	0.0147***	−0.0193*	−0.0209***	0.0198			4.41***
	0.0150***	−0.0202*			−0.0126	0.0004	1.95
160	0.0087	−0.0123	−0.0105	0.0121			0.98
	0.0089	−0.0128			−0.0138	0.0026	1.09
200	0.0074	−0.0229*	−0.0162*	0.0275			2.34*
	0.0076	−0.0227*			−0.0175	0.0169	1.80
240	0.0063	−0.0230	−0.0031	0.0081			0.86
	0.0063	−0.0222			0.0067	0.0106	1.06
280	0.0067	−0.0312**	−0.0121	0.0212			1.91
	0.0070	−0.0302*			0.0062	0.0142	1.58
320	0.0074	−0.0311*	−0.0151	0.0277			2.07
	0.0077	−0.0294*			0.0121	0.0229	2.00
360	0.0064	−0.0213	−0.0093	0.0172			0.83
	0.0067	−0.0196			0.0240*	0.0131	2.12*
Close	0.0104	−0.0343*	−0.0009	0.0190			1.43
	0.0106	−0.0317*			0.0336**	0.0123	3.93***
Panel B: Australian dollar futures contract							
40	0.0030	−0.0119**	−0.0019	0.0006			1.81
	0.0030	−0.0115**			0.0063	−0.0256**	3.69**
80	0.0038	−0.0073	−0.0023	0.0241**			1.87
	0.0037	−0.0054			−0.0043	−0.0359**	3.44**
120	0.0019	−0.0036	−0.0083	0.0293**			1.55
	0.0018	−0.0017			−0.0083	−0.0287	2.09*
160	0.0029	−0.0071	−0.0032	0.0255			0.99
	0.0028	−0.0053			−0.0201**	−0.0135	2.86**
200	0.0012	−0.0018	−0.0123	0.0110			0.76
	0.0011	−0.0010			−0.0234**	0.0010	2.17*
240	0.0021	0.0019	−0.0128	0.0080			0.74
	0.0020	0.0025			−0.0123	−0.0139	0.88
280	0.0023	0.0086	−0.0184*	−0.0013			1.77
	0.0022	0.0084			−0.0076	−0.0129	0.49
320	0.0034	0.0103	−0.0210**	0.0049			2.01
	0.0033	0.0103			0.0023	−0.0243	0.44
360	0.0046	0.0071	−0.0222**	0.0085			1.86
	0.0045	0.0074			0.0039	−0.0371	0.64
Close	0.0116*	−0.0041	−0.0258**	0.0194			2.08
	0.0116*	−0.0033			0.0195	−0.0599**	1.51

(*Continued*)

TABLE VIII

Regression Analysis on Intraday Cumulative Returns Following Two Past Price Measures (*Continued*)

Time intervals (minutes from open)	*Intercept*	$D_{Friday,t}$	$R_{C2C1,t}$	$R_{C2C1,t} * D_{Friday,t}$	$R_{C1O,t}$	$R_{C1O,t} * D_{Friday,t}$	*F*
Panel C: British pound futures contract							
40	0.0069**	0.0021	−0.0017	0.0142			0.62
	0.0066**	0.0005			−0.0163**	−0.0354**	5.40***
80	0.0124***	−0.0165*	−0.0064	0.0334**			2.71**
	0.0124***	−0.0180**			−0.0019	−0.0565**	3.65**
120	0.0207***	−0.0281***	−0.0125*	0.0361**			3.97***
	0.0203***	−0.0288***			−0.0187*	−0.0276	4.41***
160	0.0203***	−0.0239*	−0.0170**	0.0273			2.65**
	0.0198***	−0.0239*			−0.0256**	0.0047	2.72**
200	0.0208***	−0.0307**	−0.0311***	0.0476**			5.29***
	0.0202***	−0.0288**			−0.0312**	0.0402	3.17**
240	0.0220***	−0.0293*	−0.0243**	0.0374			2.97**
	0.0221***	−0.0266*			0.0043	0.0362	1.62
280	0.0285***	−0.0377**	−0.0217*	0.0298			3.08**
	0.0287***	−0.0357**			0.0102	0.0243	2.21*
320	0.0294***	−0.0364**	−0.0262**	0.0381			3.22**
	0.0299***	−0.0344**			0.0243	0.0114	2.41*
360	0.0356***	−0.0290*	−0.0194	0.0318			1.82
	0.0360***	−0.0254			0.0242	0.0426	2.41*
Close	0.0411***	−0.0382**	−0.0094	0.0332			1.90
	0.0419***	−0.0334*			0.0441**	0.0413	4.70***
Panel D: Swiss franc futures contract							
40	0.0165***	−0.0063	−0.0039	0.0034			0.36
	0.0159***	−0.0084			−0.0191**	−0.0260	4.58***
80	0.0212***	−0.0189*	−0.0196***	0.0349**			4.38***
	0.0207***	−0.0207*			−0.0214**	−0.0255	4.16***
120	0.0245***	−0.0166	−0.0317***	0.0486***			6.50***
	0.0237***	−0.0191			−0.0363***	−0.0305	6.14***
160	0.0229***	−0.0117	−0.0317***	0.0435**			4.19***
	0.0221***	−0.0151			−0.0344**	−0.0432	4.44***
200	0.0200**	−0.0264	−0.0375***	0.0669***			5.65***
	0.0188**	−0.0286			−0.0489***	−0.0249	5.51***
240	0.0216**	−0.0230	−0.0375***	0.0752***			4.87***
	0.0209**	−0.0238			−0.0353**	−0.0114	2.34*
280	0.0236**	−0.0280	−0.0373***	0.0737***			4.40***
	0.0230**	−0.0289			−0.0295	−0.0133	1.82
320	0.0256***	−0.0205	−0.0394***	0.0775***			4.21***
	0.0253***	−0.0212			−0.0233	−0.0137	1.04
360	0.0277***	−0.0107	−0.0372***	0.0675**			3.23**
	0.0276***	−0.0104			−0.0146	0.0029	0.28
Close	0.0385***	−0.0255	−0.0236*	0.0700**			2.47*
	0.0386***	−0.0242			−0.0053	0.0057	0.42

TABLE VIII
(*Continued*)

Time intervals (minutes from open)	*Intercept*	$D_{Friday,t}$	$R_{C2C1,t}$	$R_{C2C1,t} * D_{Friday,t}$	$R_{C1O,t}$	$R_{C1O,t} * D_{Friday,t}$	*F*
Panel E: Euro futures contract							
40	0.0102*	−0.0077	−0.0175**	−0.0372**			5.59***
	0.0099*	−0.0092			−0.0056	−0.0219	0.80
80	0.0190***	−0.0243	−0.0290***	−0.0398*			6.83***
	0.0176**	−0.0253			−0.0241	−0.0193	2.47*
120	0.0348***	−0.0321	−0.0480***	−0.0295			7.77***
	0.0329***	−0.0331			−0.0339*	−0.0654	4.39***
160	0.0291***	−0.0407	−0.0503***	−0.0594			7.90***
	0.0264**	−0.0418*			−0.0496**	−0.0398	3.89***
200	0.0246**	−0.0516*	−0.0577***	−0.0322			6.60***
	0.0212*	−0.0515*			−0.0628**	−0.0492	4.96***
240	0.0367***	−0.0569*	−0.0668***	−0.0243			6.73***
	0.0337**	−0.0572*			−0.0520*	−0.0300	3.17**
280	0.0353**	−0.0473	−0.0699***	−0.0302			6.41***
	0.0319**	−0.0474			−0.0591**	−0.0054	2.56*
320	0.0375**	−0.0298	−0.0733***	−0.0191			5.84***
	0.0339**	−0.0294			−0.0630**	−0.0025	2.21*
360	0.0450***	−0.0326	−0.0756***	−0.0254			6.18***
	0.0425***	−0.0334			−0.0436	−0.0128	1.35
Close	0.0561***	−0.0394	−0.0732***	−0.0335			6.00***
	0.0532***	−0.0401			−0.0508	0.0032	1.58
Panel F: Canadian dollar futures contract							
40	0.0043**	0.0060	−0.0222***	−0.0023			7.56***
	0.0039**	0.0076*			−0.0280***	−0.0103	6.55***
80	0.0042	0.0012	−0.0241***	0.0113			3.72**
	0.0038	0.0035			−0.0487***	−0.0210	10.40***
120	0.0020	0.0042	−0.0306***	0.0057			5.02***
	0.0013	0.0079			−0.0787***	−0.0364	20.76***
160	−0.0009	−0.0042	−0.0304***	0.0157			3.37**
	−0.0016	−0.0001			−0.1008***	−0.0356	24.66***
200	−0.0010	−0.0072	−0.0440***	0.0255			5.58***
	−0.0020	−0.0028			−0.1253***	−0.0101	26.88***
240	−0.0010	−0.0021	−0.0436***	0.0191			4.80***
	−0.0019	0.0027			−0.1019***	−0.0531	18.80***
280	0.0010	−0.0071	−0.0452***	0.0102			5.18***
	0.0001	−0.0018			−0.1054***	−0.0601	18.94***
320	0.0015	−0.0034	−0.0469***	−0.0092			6.14***
	0.0006	0.0020			−0.1021***	−0.0533	16.18***
360	0.0038	−0.0027	−0.0531***	−0.0062			7.17***
	0.0029	0.0031			−0.0953***	−0.0717*	14.92***
Close	0.0044	−0.0017	−0.0507***	0.0035			5.65***
	0.0036	0.0036			−0.0831***	−0.0771*	11.59***

(*Continued*)

TABLE VIII
Regression Analysis on Intraday Cumulative Returns Following Two Past Price Measures (*Continued*)

Time intervals (minutes from open)	*Intercept*	$D_{Friday,t}$	$R_{C2C1,t}$	$R_{C2C1,t} * D_{Friday,t}$	$R_{C1O,t}$	$R_{C1O,t} * D_{Friday,t}$	*F*
Panel G: Mexican peso futures contract							
40	0.0001	0.0060	0.0312***	−0.1472***			18.61***
	0.0023	0.0115			−0.0091	−0.1328***	4.80***
80	−0.0018	0.0318	0.0126	−0.1320***			8.55***
	0.0070	0.0305			−0.2412***	0.1115**	64.53***
120	0.0026	0.0144	−0.0545***	−0.0576*			8.52***
	0.0125	0.0166			−0.3965***	0.1105*	134.96***
160	0.0033	0.0070	−0.0527***	−0.0411			5.66***
	0.0160	0.0102			−0.4799***	0.0536	179.40***
200	0.0039	0.0294	−0.0857***	−0.0609			12.90***
	0.0154	0.0376			−0.5013***	0.0043	170.01***
240	−0.0004	0.0355	−0.0917***	−0.0687			13.60***
	0.0119	0.0437			−0.5365***	0.0262	173.79***
280	0.0097	0.0432	−0.1070***	−0.0685			15.61***
	0.0224	0.0500			−0.5755***	0.1126	172.68***
320	0.0136	0.0380	−0.1218***	−0.0603			16.48***
	0.0257*	0.0447			−0.5844***	0.1481*	154.20***
360	0.0070	0.0414	−0.1178***	−0.0615			14.15***
	0.0181	0.0493			−0.5452***	0.1035	117.33***
Close	−0.0010	0.0610	−0.1183***	−0.0835			15.34***
	0.0102	0.0710*			−0.5492***	0.0578	113.87***

Note. Simple regression are conducted on each of the 10 intraday intervals. Intraday cumulative returns are regressed against the past price measure (previous 1-day return ($R_{C2C1,t}$) or opening-gap return ($R_{C1O,t}$) The intercept coefficients (B_0), and the slope coefficients (B_1), are linear functions of one dummy variable, representing the Fridays. Equations: $R_{i,t} = B_{0,i} + B_{1,i}(R_{C2C1,t}) + \varepsilon_{i,t}$ where $B_{0,i} = (b_0 + b_{0\ \text{Friday}} * D_{\text{Friday}})$ and $B_{1,i} = (b_1 + b_{1\ \text{Friday}} * D_{\text{Friday}})$ or $R_{i,t} = B_{0,i} + B_{1,i}(R_{C1O,t}) + \varepsilon_{i,t}$ where $B_{0,i} = (b_0 + b_{0\ \text{Friday}} * D_{\text{Friday}})$ and $B_{1,i} = (b_1 + b_{1\ \text{Friday}} * D_{\text{Friday}})$.

Column 1: Intercept for selected past price measure on non-Fridays
Columns 1 + 2: Intercept for selected past price measure on Fridays
Column 3: Slope coefficient for previous 1-day return on non-Fridays
Columns 3 + 4: Slope coefficient for previous 1-day return on Fridays
Column 5: Slope coefficient for opening-gap return on non-Fridays
Columns 5 + 6: Slope coefficient for opening-gap return on Fridays
Column 7: *F* statistics

*Significant at 10% level.
**Significant at 5% level.
***Significant at 1% level.

CONCLUSION

This research tests how the previous 1-day returns and opening-gap returns influence the intraday price patterns (reversal or persistence) in seven major currency futures contracts during the floor-trading sessions. The intraday futures returns patterns following past price measures

(previous 1-day returns and opening-gap returns) are examined for the period 1988–2003 as a whole, as well as the return patterns over three subperiods. The data of the first subperiod (1988–1992) is from before the introduction of the on-line 24-hour trading system GLOBEX, the second subperiod (1993–1998) considers the period after the introduction of GLOBEX in 1992, and the third subperiod (1999–2003) constitutes the period after the introduction of the euro in 1999. The question addressed here is whether the introduction of the GLOBEX made the futures markets more efficient, eliminating significant price patterns. Also of interest here is whether the introduction of the euro and the resulting loss of diversification created inefficiencies or whether the composite currency made the markets more efficient.

Significant price patterns are found in the overall period for most of the currency futures contracts, regardless of the choice of the past price measures (Table IV). In particular, the magnitude and the significance of the price patterns are greater following positive opening-gap returns as compared with previous positive 1-day returns.

When these patterns are examined by subperiods, significant patterns of market inefficiencies are found in the first subperiod, 1988–1992. However, the introduction of electronic trading platform of GLOBEX in 1992 reduced the predictability of significant price patterns for most of the currencies in the second subperiod, 1993–1998. Further, the introduction of the euro in 1999 made the currency futures markets more volatile, leading to significant price patterns, mostly reversals, in most of the currencies in the third subperiod (Tables III and VI). Overall, it is concluded that the subperiod before the introduction of the GLOBEX (1988–1992) and the subperiod following the introduction of the euro (1999–2003) display significant price patterns. However, the introduction of the near 24-hour trading platform GLOBEX in 1992 resulted in making the currency futures markets more efficient over the (1993–1998) second subperiod.

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