

Does Deregulation Affect the Currency Markets? Evidence from the Yen-Dollar Exchange Rate in Three Markets

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Abstract

This paper examines how currency market deregulation affects the behaviors of the yen-dollar exchange rates in Tokyo, London, and New York. Using the intraday return (open to close) data, we find strong and consistent evidence that the three currency markets interact significantly, both before and after deregulation. For each of nine contracts, Tokyo positively affects London and New York, London positively affects New York and Tokyo, and New York positively affects Tokyo and London. In particular, the causality relationship is much stronger when one market trades right after another. When comparing basic statistics between the pre- and post-deregulation periods, we find that, after deregulation, the volatility of the yen-dollar exchange rate intraday returns increases, the range of the intraday returns broadens, the distribution of these returns becomes more left-skewed, and the distribution of the intraday returns moves further away from normality. These deregulation-induced changes hold true for all three markets and for most of nine contracts. We interpret our findings as evidence that foreign exchange deregulation encourages more participation and hence more competition, leading to a more efficient and unpredictable exchange rate in each currency market.

I. Introduction

The interdependence of national financial markets has long been of interest to academics, practitioners, and regulators. Academics tend to pay more attention to pricing mechanisms, practitioners to portfolio effects, and regulators to potential contagion effects. Studies of these relationships generally focus on portfolio diversification, the co-movements of equity prices, or the lead-lag relationships among national stock market indexes. For example, Schollhammer and Sand (1985) examine the co-movements of stock market indices in the United States and major European countries. They find a significant degree of interdependence between the stock prices of Germany, the UK, the Netherlands, and Switzerland. They also find evidence of the transfer of information between markets in that a change in US stock prices normally leads to a same-direction change in all the European markets except Italy.

Although most studies in market integration focus on national equity markets, a few papers explore non-equity markets. Chiou (2012) examines the gold markets in Hong Kong, London, and New York and shows that in terms of the intraday return, these three markets are not interdependent. However, he finds that when using the variable of the intraday return volatility, the Hong Kong market positively affects the London market, the London market positively affects the New York market, and the New York market positively affects the Hong Kong market. i.e., there are high degrees of volatility linkages between the three gold markets.

Chiou, Jordan-Wagner, and Yu (2005) investigate how one currency market affects another currency market in a different time zone, using the opening and closing yen/dollar exchange rates in Tokyo, London, and New York. They find strong and consistent evidence that the three major currency markets interact significantly.

This paper extends the market integration literature by investigating the interdependence between the yen/dollar exchange rates in London, New York, and Tokyo. Our paper is different from Chiou, Jordan-Wagner, and Yu (2005) in three important aspects. First, we use nine contracts of opening and closing yen/dollar exchange rates traded in three major currency markets. Second, we study how the April 1998 foreign exchange deregulation in Japan affects the behavior of yen/dollar intraday returns in three major markets. Finally, we employ more sophisticated econometric models to capture the causality relations between these markets.

We find strong and consistent evidence that the three major currency markets have significant degrees of interactions. For each of nine contracts we examine, Tokyo Granger-causes London and New York, London Granger-causes New York and Tokyo, and New York Granger-causes Tokyo and London. In particular, the causality relationship is much stronger when one market trades right after another. Although our results violate market efficiency, these findings may be due to some unique characteristics of each of three currency markets and do not necessarily imply the existence of easy arbitrage between these markets.

The remainder of this paper is organized as follows. Section II briefly discusses existing literature. In Section III, we describe the foreign exchange deregulation in Japan, data, and methodology. Section IV presents and discusses empirical results. We summarize and conclude in Section V.

II. Literature Review

There has been a progression of research on the topic of financial market integration. Early research on the synchronization among equity prices across different countries (e.g., Grubel (1968), Levy and Sarnat (1970), Agmon (1972), Ripley (1973), Hilliard (1979), and others) focuses on the role of international diversification in reducing the systematic risk in an investment portfolio. These studies, which used primarily weekly or monthly return data, show that international equity markets normally have relatively low degrees of correlation.

Later studies used daily data and found higher correlations between equity markets in some countries. Jaffe and Westerfield (1985), using daily closing prices for five countries, find that correlations between equity returns in the U.S. and the other four markets are generally positive and significant for each day of the week. Eun and Shim (1989) use the vector autoregression (VAR) methodology to investigate cross-country price transmissions of nine national stock markets and detect a high degree of linkage among these markets. They also find that the U.S. market is the most important information producer, often affecting other national stock markets unilaterally.

More recently, Becker, Finnerty, and Gupta (1990), using the opening price to the closing price returns of the Japanese and U.S. stock markets, find that the U.S. market Granger-causes

the Japanese market, while the Japanese market has only a small impact on the U.S. market return. Campbell and Hamao (1992) find evidence of common movements in expected excess stock returns between the Japanese and U.S. financial markets, suggesting a high degree of integration between the long-term capital markets of these two countries.

Koch and Koch (1991) examine the relationships between daily closing index prices of eight national stock markets for the years 1972, 1980, and 1987, and find that the degree of interdependence among national stock markets increased over time. This evidence is consistent with the increase in trade and capital flows across country borders in the past 50 years.

Although a lot of studies on the interactions of national equity markets exist, little has been done in the integration of national currency markets. This paper extends the existing literature by investigating how deregulation affects the yen/dollar exchange rate behaviors in London, New York, and Tokyo and how these three currency markets interact.

III. Foreign exchange deregulation in Japan, data, and methodology

a. FX deregulation in Japan

On November 11, 1996, Japan's Prime Minister Ryutaro Hashimoto announced a plan to open up, reform, and substantially deregulate the country's financial sector. Modeled on the Big Bang reform that shook the UK financial markets in October 1986, the Japanese "Big Bang" reform plan aimed at reviving the country's financial markets by making them free in competition, fair on rules, and global in terms of participants by 2001. The ultimate goal was to make the Tokyo financial markets among the largest international financial centers, comparable with those of London and New York. Among the proposed deregulation measures, the first and most important was to liberalize the foreign exchange markets and their transaction services in order to facilitate inbound and outbound capital flows and to enhance competition (Chiou and White 2005).

Under the revised *Foreign Exchange and Foreign Trade Control Law of 1949* that went into effect in 1980, only government-authorized banks could conduct foreign exchange business in Japan. Individuals and companies had to go through these government-licensed banks to convert U.S. dollars into Japanese yen or to buy U.S. dollars using yen. The monopolization of foreign exchange services meant that licensed Japanese banks easily collected a lot of transaction commissions without too much competition.

The completely revamped foreign exchange law became effective in April 1998. This new law allows any consumers or companies to buy and sell foreign currencies without government authorization. Also, any entity such as a convenience store can, in theory, engage in foreign exchange businesses. More importantly, Japanese companies can significantly cut currency transaction costs because they have obtained greater flexibilities in handling their payments and receipts denominated in different foreign currencies.

To test whether or not the new foreign exchange law in Japan affects the behaviors of the yen/dollar exchange rates in major currency markets, we divide the whole sample into two sub-

periods: October 1994 to February 1998 (pre-deregulation) and May 1998 to August 2001 (post-deregulation).

b. Sample

We obtained daily opening and closing yen/dollar exchange rates for the Tokyo, London, and New York markets from a Wall Street firm over the period October 1994-August 2001 (82 months). Our exchange-rate data include the spot contract, 1-month, 2-month, 3-month, 4-month, 5-month, 6-month, 9-month, and 1-year forward contracts (9 contracts in total), which are considered as the most liquid for the yen/dollar pair. All of the yen/dollar exchange rates in this paper are expressed in European terms (yen/\$); i.e., the foreign currency price of one U.S. dollar.

Because holidays in Japan, the UK, and the U.S. differ, we first aligned the opening and closing prices by date for each contract. To examine the pricing transmission of the yen/dollar exchange rate, we then calculated the intraday return ($= (\text{close} - \text{open})/\text{open}$) for each day, for each contract, and for each of three markets. We deleted the dates, in which at least one market did not trade.

Table 1 shows the summary statistics of intraday (open-to-close) returns over the 82-month period for each contract, for each period (pre-deregulation and post-deregulation), and for each of three markets. For the spot contract (Panel A), the New York market has the highest average returns in both pre-deregulation and post-deregulation periods (0.047% and -0.0155%, respectively) while the Tokyo market has the lowest average returns for both periods (0.032% and -0.0261%, respectively). In the pre-deregulation period, the New York market has the highest standard deviation of the intraday returns (0.717%) while the Tokyo market has the lowest standard deviation of the intraday returns (0.672%). Interestingly, the standard deviation result turns opposite in the post-deregulation period in that the Tokyo market has the highest standard deviation of the intraday returns (0.852%) while the New York market has the lowest standard deviation of the intraday returns (0.824%). All else being equal, the April 1998 foreign exchange deregulation in Japan seems to increase the intraday volatility in the Tokyo market relative to those of London and New York.

Table 1 Summary statistics of the intraday returns of 9 yen/dollar exchange rate (yen/dollar) contracts in Tokyo, London, and New York for two different periods

Pre = pre-deregulation period from October 1994 to February 1998

Post = post-deregulation period from May 1998 to August 2001

N = sample size

J-B = Jarque-Bera statistic = $(N/6)[(\text{skewness})^2 + 0.25(\text{kurtosis} - 3)^2]$

Panel A: Spot contract (yen/US\$)

Spot contract	Tokyo	London	New York
N (pre)	873	873	873
N (post)	873	873	873

Mean (pre, %)	0.03204236	0.042560329	0.047010847
Mean (post, %)	-0.026153696	-0.016974757	-0.015567172
Median (pre, %)	0.030994937	0.064929795	0.052283025
Median (post, %)	0	-0.018268177	0
SD (pre, %)	0.672319344	0.699718705	0.717310464
SD (post, %)	0.852547844	0.826445326	0.82443173
Max (pre, %)	3.244481968	3.442377592	3.833422317
Max (post, %)	3.858933696	3.168462743	3.398236591
Min (pre, %)	-3.805987468	-3.31769437	-3.554040896
Min (post, %)	-7.84848728	-5.983167559	-6.871401152
Kurtosis (pre)	4.474273168	4.094663458	4.510719303
Kurtosis (post)	12.63140222	5.013238999	7.14117278
Skewness (pre)	-0.402146132	-0.293491257	-0.337979469
Skewness (post)	-1.448739208	-0.774273955	-0.989182905
J-B (pre)	102.5908649	56.12067981	99.63815619
J-B (post)	3679.669172	234.6599227	766.1754741

When we compare the intraday return distributions, we find that the distribution of the Tokyo market has the largest peakedness in each of two periods with kurtoses equal to 4.474 and 12.63, respectively, while the London market has the smallest kurtosis in each of the same periods. Also, in each of two periods, the Tokyo market is the most left-skewed (the largest negative skewness) while the London market has the least skewness. In addition, the Jarque-Bera statistic of the Tokyo market is the highest in each of two periods (102.59 and 3679.67, respectively) while the null hypothesis of the normal distribution is rejected for each market and each period.

Furthermore, the summary statistics of 7 other forward contracts (1-month, 2-month, 3-month, 4-month, 5-month, 6-month, 9-month, and 1-year) show similar results we just discussed with a few exceptions. This seems not too surprising because the pricing of all forward contracts is related to the spot contract. To save space, we report only the summary statistics of the 1-month forward contract in Panel B.

Panel B: 1-month forward contract (yen/US\$)

1-Month forward	Tokyo	London	NY
Sample size (pre)	866	866	866
Sample size(post)	866	866	866
Mean (pre, %)	0.031625188	0.041387617	0.048492034

Mean (post, %)	-0.026523517	-0.017380128	-0.016339699
Median (pre, %)	0.029804445	0.065608452	0.055528684
Median (post, %)	-0.003475601	-0.017481801	0.008995531
SD (pre, %)	0.677540844	0.702947137	0.72241285
SD (post, %)	0.858774836	0.832971738	0.828736071
Max (pre, %)	3.256264375	3.447164948	3.851104913
Max (post, %)	3.870086508	3.182533074	3.394207711
Min (pre, %)	-3.821062442	-3.330716609	-3.570031299
Min (post, %)	-7.882646893	-6.01659751	-6.879531081
Kurtosis (pre)	4.422519618	4.104129326	4.454655741
Kurtosis (post)	12.56577653	4.97925153	7.067902133
Skewness (pre)	-0.395390105	-0.2999082	-0.337462407
Skewness (post)	-1.445718722	-0.773287854	-0.983518554
J-B (pre)	95.58097583	56.97129958	92.78998149
J-B (post)	3603.443724	227.6617671	736.7156808

c. Methodology

To further examine the causality relationships between Tokyo, London, and New York, we first calculate the correlation coefficients between different pairs of currency markets. Then, we compare the intraday returns between different pairs of markets and between the pre-deregulation and post-deregulation periods. Finally, we conduct the Granger-causality tests.

IV. Major findings and interpretations

Table 2 presents the results of intraday return correlations between 4 pairs of currency markets. For each pair, the correlation coefficients of both pre-deregulation and post-deregulation periods are very close. Also, the correlation coefficient between the London and New York markets on Day t is the highest for each of two periods. This may be due to the traditional tie between these two markets and the trading-hour overlap. Notice that for each period, the correlation coefficient between the New York market on Day t and the Tokyo market on Day $t+1$ is lower than that between Tokyo market on Day t and the New York market on Day t . This seems to suggest that the pricing transmission is relatively weaker from New York to Tokyo over a trading-day change.

Table 2 Intraday return correlations between selected pairs of currency markets for 9 yen/dollar rate contracts

L = London market

NY = New York market
T = Tokyo market

t = calendar Day t
t + 1 = calendar Day t + 1

(L_t, NY_t) = correlation coefficient between Day t intraday return in London and Day t intraday return in New York

(NY_t, T_{t+1}) = correlation coefficient between Day t intraday return in New York and Day t + 1 intraday return in Tokyo

Pre = pre-deregulation period from October 1994 to February 1998

Post = post-deregulation period from May 1998 to August 2001

N = sample size

	N	(L_t, NY_t)		(T_t, L_t)		(T_t, NY_t)		(NY_t, T_{t+1})	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Spot	873	0.9103	0.9135	0.6764	0.6534	0.5963	0.5819	0.3247	0.3773
1-Month	866	0.9130	0.9130	0.6786	0.6535	0.5964	0.5821	0.3252	0.3785
2-Month	868	0.9129	0.9136	0.6781	0.6539	0.5959	0.5843	0.3249	0.3719
3-Month	869	0.9128	0.9130	0.6784	0.6540	0.5956	0.5808	0.3247	0.3770
4-Month	864	0.9123	0.9128	0.6780	0.6535	0.5940	0.5798	0.3247	0.3740
5-Month	862	0.9128	0.9128	0.6777	0.6535	0.5949	0.5774	0.3247	0.3744
6-Month	868	0.9122	0.9107	0.6779	0.6534	0.5937	0.5774	0.3258	0.3740
9-Month	867	0.9129	0.9074	0.6786	0.6533	0.5959	0.5718	0.3239	0.3775
1-Year	868	0.9118	0.9069	0.6788	0.6551	0.5936	0.5754	0.3269	0.3734

Table 3 shows the results of paired t-tests for different pairs of markets and for the pre-deregulation and post-deregulation periods. As Panels A, B, and C show, all paired t-tests cannot reject, at the 5% level, the null hypothesis that the two samples are likely to have come from the same two underlying populations that have the same mean. The result in Panel D still cannot reject the null hypothesis at the 5% level. Overall, these results suggest that the behaviors of the yen/dollar intraday returns are similar across three major currency markets and that the foreign exchange deregulation in Japan does not significantly change the behavior of the yen/dollar intraday returns from the pre-deregulation period to the post-deregulation period.

Table 3 Paired t-test results of the spot-contract intraday returns between different pairs of markets and between the pre-deregulation and post-deregulation periods

L = London market
NY = New York market
T = Tokyo market

t = calendar Day t

$t + 1 =$ calendar Day $t + 1$

$\text{Prob}(L_t, NY_t) =$ the probability of the paired t-test result between Day t intraday return in London and Day t intraday return in New York

$\text{Prob}(NY_t, T_{t+1}) =$ the probability of the paired t-test result between Day t intraday return in New York and Day $t + 1$ intraday return in Tokyo

Pre = pre-deregulation period from October 1994 to February 1998

Post = post-deregulation period from May 1998 to August 2001

Table 4 presents the results of Granger-causality tests for the spot contract. Panel A shows that in the pre-deregulation period, the London market Granger-causes the Tokyo market with an adjusted R-square of 17.39%. The same result holds true in the post-deregulation period, as shown in Panel B.

Table 4 The results of Granger-causality tests for the spot contract

R = intraday return of yen/US\$ = (close- open)/open

L = London market

NY = New York market

T = Tokyo market

$t =$ calendar Day t

$t - 1 =$ calendar Day $t - 1$

$t - 2 =$ calendar Day $t - 2$

Panel A: Trading sequence: Tokyo, London, and New York

Dependent variable = T_t				
<i>Regression Statistics</i>				
Multiple R	0.421592178			
R Square	0.177739965			
Adjusted R Square	0.173941997			
Standard Error	0.006117397			
Observations	871			
<i>ANOVA</i>				
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	4	0.007005306	0.001751326	46.79870204
Residual	866	0.032407921	3.74225E-05	
Total	870	0.039413227		
<i>Coefficients</i>				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	0.000150919	0.000208159	0.725015368	0.468638452

T _{t-1}	-0.505203555	0.048560092	-10.40367781	5.75237E-24
T _{t-2}	-0.260860141	0.045373941	-5.749118063	1.24294E-08
L _{t-1}	0.5878717	0.043951865	13.37535272	3.16066E-37
L _{t-2}	0.375898014	0.046909302	8.013293729	3.59851E-15
		Pre	Post	
	Prob(T _t , L _t)	0.573898982	0.698280344	
	Prob(T _t , NY _t)	0.479787214	0.683554566	
	Prob(L _t , NY _t)	0.661937224	0.903597645	

Panel A (Spot rate): Pre-deregulation period

Panel B: Trading sequence: London, New York, and Tokyo

	Pre	Post
Prob(L _t , NY _t)	0.661937224	0.903597645
Prob(L _t , T _{t+1})	0.687449972	0.777927675
Prob(NY _t , T _{t+1})	0.562599264	0.732607041

Panel B (Spot rate): Post-deregulation period (**Dependent variable = T_t**)

<i>Regression Statistics</i>				
Multiple R	0.428568651			
R Square	0.183671089			
Adjusted R Square	0.179900516			
Standard Error	0.007723688			
Observations	871			
<i>ANOVA</i>				
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	4	0.011623661	0.002905915	48.71172649
Residual	866	0.051661535	5.96554E-05	
Total	870	0.063285196		
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	-0.000295377	0.000261987	-1.127449002	0.259864972
T _{t-1}	-0.43245358	0.046504924	-9.299092208	1.12508E-19
T _{t-2}	-0.247961134	0.043328216	-5.722855887	1.44308E-08
L _{t-1}	0.611661815	0.04445297	13.75975146	4.18663E-39
L _{t-2}	0.294211566	0.047945982	6.136313258	1.28396E-09

Panel C shows that in the pre-deregulation period, the Tokyo market Granger-causes the London market with an adjusted R-square of 55.36%. Panel D reveals the same result in the post-deregulation period.

Panel C: Trading sequence: New York, Tokyo, and London

	Pre	Post
Prob(NY _t , T _{t+1})	0.562599264	0.732607041
Prob(NY _t , L _{t+1})	0.868864241	0.989047023
Prob(T _{t+1} , L _{t+1})	0.579369107	0.663098028

Panel C (Spot rate): Pre-deregulation period (**Dependent variable = L_t**)

<i>Regression Statistics</i>				
Multiple R	0.74543701			
R Square	0.55567634			
Adjusted R Square	0.55362404			
Standard Error	0.00467935			
Observations	871			
<i>ANOVA</i>				
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	4	0.0237144	0.0059286	270.757422
Residual	866	0.01896225	2.1896E-05	
Total	870	0.04267665		
<i>Coefficients</i>				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	0.00029082	0.00015927	1.8258984	0.06820978
L _{t-1}	-0.4776445	0.03456053	-13.82052	2.0985E-39
L _{t-2}	-0.1123213	0.02485534	-4.5190011	7.0756E-06
T _t	0.8368202	0.02551096	32.80238	4.95E-154
T _{t-1}	0.37680721	0.03593615	10.4854626	2.6756E-24

Panel D: Paired t-test for the pre-deregulation and post-deregulation periods

T: pre v. post	0.108876308
L: pre v. post	0.10185402
NY: pre v. post	0.085973667

Panel D (Spot rate): Post-deregulation period (**Dependent variable = L_t**)

<i>Regression Statistics</i>				
Multiple R	0.70659012			
R Square	0.49926959			
Adjusted R Square	0.49695675			

Standard Error	0.00586788			
Observations	871			
ANOVA				
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	4	0.02973116	0.00743279	215.868388
Residual	866	0.02981815	3.4432E-05	
Total	870	0.05954932		
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	3.1478E-05	0.00019905	0.15814213	0.87438167
L _{t-1}	-0.3877656	0.03526193	-10.996722	2.0187E-26
L _{t-2}	-0.0858841	0.02598201	-3.3055239	0.00098696
T _t	0.74114642	0.02534177	29.2460354	2.514E-131
T _{t-1}	0.31034319	0.03417093	9.08208334	7.0711E-19

Panel E exhibits that in the pre-deregulation period, the Tokyo market Granger-causes the New York market with an adjusted R-square of 47.33%. The same result holds true in the post-deregulation period, as shown in Panel F. To save space, other Granger-causality results are not reported here. Because the results of other 8 contracts are very similar, we do not report them here.

Panel E (Spot rate): Pre-deregulation period (Dependent variable = NY_t)

<i>Regression Statistics</i>				
Multiple R	0.68977932			
R Square	0.4757955			
Adjusted R Square	0.47337424			
Standard Error	0.0052109			
Observations	871			
ANOVA				
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	4	0.0213434	0.00533585	196.506759
Residual	866	0.02351495	2.7154E-05	
Total	870	0.04485835		
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	0.00040525	0.0001775	2.28316468	0.02266217
NY _{t-1}	-0.5075808	0.03607303	-14.070922	1.1945E-40
NY _{t-2}	-0.1458213	0.02815087	-5.1799921	2.7613E-07
T _t	0.81819752	0.0292999	27.9249255	7.055E-123
T _{t-1}	0.35996017	0.03839203	9.37590871	5.8211E-20

Panel F (Spot rate): Post-deregulation period (Dependent variable = NY_t)

<i>Regression Statistics</i>				
Multiple R	0.64096608			
R Square	0.41083752			
Adjusted R Square	0.40811621			
Standard Error	0.00634798			
Observations	871			
<i>ANOVA</i>				
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	4	0.02433456	0.00608364	150.970786
Residual	866	0.03489703	4.0297E-05	
Total	870	0.0592316		
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	2.8764E-05	0.00021533	0.13358176	0.89376434
NY _{t-1}	-0.3736356	0.03671364	-10.177024	4.6855E-23
NY _{t-2}	-0.0920091	0.02897599	-3.1753558	0.00154946
T _t	0.68969298	0.02823268	24.4288903	1.124E-100
T _{t-1}	0.27813636	0.03548148	7.83891706	1.3317E-14

Overall, all Granger-causality tests indicate that the currency markets in Tokyo, London, and New York affect one another significantly.

V. Summary and conclusions

We study how the 1998 foreign exchange deregulation in Japan affects the behaviors of the yen-dollar exchange rates in Tokyo, London, and New York. We find strong and consistent evidence that the three major currency markets interact significantly in the pre- and post-deregulation periods. For each of nine contracts, Tokyo positively affects London and New York, London positively affects New York and Tokyo, and New York positively affects Tokyo and London. In particular, the causality relationship is much stronger when one market trades right after another. Although these results are violations of market efficiency, the findings seem due to some unique characteristics of each of three currency markets that cannot be explained easily.

When comparing basic statistics in the pre- and post-deregulation periods, we find that, after deregulation, the volatility of the intraday returns increases, the range of the intraday returns widens, the distribution of these returns becomes more left-skewed, and the distribution of the intraday returns moves further away from normality. These deregulation-induced changes hold true for all of the three markets and for most of nine contracts. These findings suggest that foreign exchange deregulation increases participation and hence competition, making the yen/dollar exchange rate more unpredictable and efficient in each currency market.

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