Foreign exchange markets in the 1990s: intraday market volatility and the growth of electronic trading

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Abstract

Foreign exchange markets experienced broad structural changes in the 1990s, including the gradual introduction of electronic trading platforms, which now process the majority of inter-dealer spot transactions. The changes have raised concerns that liquidity in foreign exchange markets may have deteriorated over time. We briefly survey the growth of electronic trading in foreign exchange markets over the decade, and discuss why it may have affected market liquidity and volatility. Using high-frequency data, we then examine several measures of foreign exchange market volatility from the period 1987 to 2001. We consider the evolution of variance ratios over time to examine whether intraday volatility has changed relative to daily volatility, and study the incidence of large intraday movements, a possible indicator of reduced liquidity. We find no evidence of a substantial change over time in the level of volatility or in the frequency of large movements in foreign exchange markets.

1.   Introduction

The foreign exchange market has undergone several important structural changes in the past decade. At a macro level, the number of major participants in inter-dealer markets decreased considerably due to numerous mergers and acquisitions, particularly in the latter half of the decade, and the introduction of the euro in 1999 eliminated many trades. At the micro level, extensive changes in trading technology were evident. The adoption of electronic trading methods for inter-dealer transactions in the major currency pairs, though gradual, became widespread, particularly relative to fixed income and equity markets. The structure of foreign exchange markets at the beginning of this decade is therefore very different from that at the beginning of the 1990s.

These changes in the structure of foreign exchange markets have raised concerns about a possible decrease in market liquidity and an increase in market volatility in the past few years. In particular, some market analysts have voiced fears that a reported drop in the number of market-makers and in the total amount of capital dedicated to market-making may have had negative effects on the depth of foreign exchange markets. The increased presence of electronic trading is thought to be one of the factors contributing to this reported decrease in market-making activity. In this note, we first briefly review the growth of electronic trading in FX markets in the past few years and discuss how it may have affected the provision of market-making services. Using intraday high-frequency data from the period 1987 to 2001, we then study the evolution over time of several measures of volatility in the dollar-yen and dollar-mark (and euro-dollar) markets. We also examine the frequency of large exchange rate movements, a possible indicator of reduced liquidity.

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[1]   The views in this note are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.

2. A very brief history of electronic trading in foreign exchange

The earliest ventures into electronic trading in foreign exchange markets were clearly just a better telephone. Reuters launched its Monitor Dealing Service in the early 1980s, and replaced it with Reuters Dealing 2000-1 in 1989. These early systems allowed communications between two foreign exchange dealers on the initiative of one of the counterparties, but did not perform the more complex matching function between a number of potential counterparties traditionally done by voice brokers. This changed in April 1992, when Reuters launched Dealing 2000-2, a true electronic broking system, automatically matching buy and sell quotes from ex ante anonymous (but pre-screened) dealers. The Minex Corporation, largely owned by Japanese foreign exchange brokers and banks, set up its own automated foreign exchange broking system in April 1993. Finally, in September 1993, EBS (Electronic Broking Service), formed by a group of large dealing banks which had pulled out of early tests of Reuters Dealing 2000-2, launched its trading system. Minex transferred its business rights to EBS in 1996, leaving us in 2001 with two major inter-dealer electronic broking systems, Reuters (now 3000) and EBS. Over time, each of the systems has gained an almost completely monopolistic role in the inter-dealer market for given currency pairs, with EBS dominant in dollar-yen and euro-dollar, and Reuters dominant in transactions involving sterling and emerging market currencies.

For inter-dealer transactions, these systems, first introduced in the early 1990s, had become the primary trading vehicles by the end of the 1990s. For customer-to-dealer transactions, however, the emergence of electronic trading has so far been much less widespread. Many financial institutions attempted late in the 1990s to launch single-dealer electronic trading platforms allowing them to transact foreign exchange electronically with their own customers. These platforms received little acceptance as customers appeared to value highly the ability to receive simultaneous quotes from several potential counterparties. A new generation of multidealer platforms is now being introduced, in part spurred by the success of Currenex, a reverse auction matching service developed independently of the banking community, which was launched in April 2000. Two large groups of banks have since launched their own multidealer trading platforms, Atriax and Fxall.

Because of the decentralised over-the-counter nature of foreign exchange markets, the exact share of global foreign exchange trading volume conducted through these electronic broking services is not easy to determine precisely. An estimate of the share of inter-dealer trading volume executed through electronic platforms puts the share at less than 5% in 1992, a bit more than 10% in 1995, about 40% in 1998, and about 60% in 2001. These data probably understate the true importance of electronic broking in these markets. First, the share of the number of transactions conducted through e-brokers is likely to be higher than the share of trading volume, as large transactions tend more often not to be conducted electronically, using instead direct personal contact between counterparties. And second, with most inter-dealer transactions routed through electronic brokers, this is clearly where the process of price discovery occurs. As far as customer-to-dealer transactions are concerned, it is generally thought that at present (2001) no more than 10% of these transactions are conducted through electronic platforms.

3. Electronic trading, market structure, liquidity and volatility

It is not immediately obvious that the adoption of electronic trading venues should necessarily have affected the liquidity and volatility of foreign exchange markets. The modern electronic trading platforms are, after all, simply a replacement for a system of telephones and voice brokers. They perform essentially the same functions, receiving large amounts of data from buyers and sellers, and arranging feasible matches. Most voice brokers have been forced into retirement since the mid-1990s, reportedly in great part due to the cost advantage of the electronic systems. There is little doubt, however, that the process of price discovery and the way the current price is disseminated among dealers and to the public have changed substantially with the spread of electronic trading. There is clearly much more price transparency now than in the days before electronic broking, in the sense that: (1) through centralisation there is greater clarity and precision of price; (2) most dealers have instant access to current prices; and (3) customers can also gain real-time access to these prices much more easily.

In the past, when the foreign exchange market was a conglomeration of two-way phone or e-mail conversations and of a number of voice brokers, the true market price was likely to be a bit fuzzy,

potentially differing from dealer to dealer. In order to be continuously informed about the price, dealers tended to execute small trades regularly throughout the trading session, not just to look for profit opportunities, but also to attempt to gather information about the current price. Today, with price discovery automated and centralised, the over-the-counter foreign exchange market has taken on some of the characteristics of an exchange, including the existence of a widely broadcast single price at any one moment. In 2001, any dealing room with an EBS terminal instantly knows the current dollar price of the euro and yen, certainly for trades of the size typically dealt through EBS. As a consequence, the amount of trading activity designed primarily to gather information has greatly diminished. This new clarity and transparency of the price are very probably one of the factors explaining the dramatic drop in inter-dealer spot trading volume reported in the latest Triennial Central Bank Survey.

Table 1
Reported global daily FX trading volume
(USD billions)

Year	1992	1995	1998	2001
Total volume	394	494	568	387
With other dealers	282	325	348	218
With other financials	47	94	121	111
With non-financials	65	75	99	58

So, what could be the effects on the market of this increased clarity and access to price? On the one hand, the increased transparency could make it easier for new dealers to enter the trading arena, as the costs and the critical mass (of traders, analysts, market contacts, etc) required to run a foreign exchange operation with a reasonable chance of success have probably decreased. On the other hand, for the players who had previously established an information advantage, there may now be incentives to reduce their presence in the market, as the returns on their information gathering may not be as large as in the past. So, in theory at least, within the inter-dealer community, as these two forces compete, the net effect on the amount of market-making activity is uncertain.

The effect of the increased price clarity and transparency on the relationship between dealers and customers appears to be less ambiguous. The recent failures of many of the single-dealer dealer electronic platforms dedicated to dealer-to-customer trading testify to the increased price competition this has brought to the industry. Even before the actual birth of these business-to-consumer sites, the increased clarity in price at a given moment, combined with better information technology, made performing price comparisons much easier for customers. When these customers were first given instantaneous access to price information through single-dealer electronic platforms, they very quickly began to require simultaneous access to many price sources. The result has been a clear increase in price competition, and the market power of the industry as a whole over its customers appears to have eroded greatly. It is therefore generally believed that, in great part due to this increase in price transparency, industry profits from FX trading as a whole have declined on net in the last few years. It is also widely believed that, in part as a result of the scenario just described, the overall amount of capital assigned to market-making has fallen, as has the amount of proprietary trading done by dealers.

Due to the nature of the foreign exchange business, there is, however, no more than anecdotal evidence to back these "beliefs". And it is, of course, impossible to untangle how much of this may be due primarily to the rise of electronic trading, and how much may be due to other structural changes in the industry, in particular the numerous mergers. Still, there are concerns among some market participants that these changes will soon adversely affect liquidity and volatility in foreign exchange markets if they have not done so already. The analysis in the next section attempts to uncover whether or not these concerns are currently warranted.

4. Data and analysis

We use intraday exchange rate data on dollar-yen and dollar-mark exchange rates (euro-dollar after 1999) covering the period from January 1987 to September 2001. The data, collected by Olsen and Associates, are based on Reuters indicative quotes, which have been shown to be an accurate source of high-frequency price data (but a poor source of bid-offer spread and transaction volume data). Using the midpoint of the bid and offer rates of the data, we construct time series of log differences of the exchange rates at 24-hour (at 21:00 GMT), 15-minute and five-minute intervals.

From these series of log differences, we compute three measures of volatility. The first is a standard measure of volatility based on squared daily returns. The second and third are "integrated volatility" measures based, respectively, on squared 15-minute and squared five-minute returns. Our volatility measures are not demeaned, and we express both as annualised standard deviations. We also calculate the ratios of the daily volatility to each of the integrated volatilities, presented in the right-hand columns. These variance ratios would be expected to be equal to exactly one if exchange rates behaved precisely as standard random walks. Values below one indicate a higher level of intraday price movement relative to the daily exchange rate movement, in other words the presence of mean reversion at higher frequencies than day-to-day. Table 2 presents these data per year for dollar-mark and euro-dollar, and Table 3 displays the data for dollar-yen. The mean value of each statistic and its standard deviation are presented in the last two rows of each table.

Table 2
DEM: annualised volatility and variance ratios

	1 day	**15 min**	**5 min**	**1d/15min**	**1d/5min**
1987	0.1165	0.1089	0.1090	1.0700	1.0684
1988	0.1098	0.0959	0.0955	1.1451	1.1501
1989	0.1202	0.1153	0.1155	1.0422	1.0405
1990	0.1028	0.1053	0.1094	0.9763	0.9393
1991	0.1388	0.1298	0.1340	1.0698	1.0363
1992	0.1401	0.1446	0.1503	0.9694	0.9324
1993	0.1093	0.1086	0.1153	1.0065	0.9478
1994	0.0954	0.0964	0.0994	0.9900	0.9597
1995	0.1297	0.1308	0.1324	0.9915	0.9797
1996	0.0704	0.0755	0.0814	0.9325	0.8649
1997	0.1018	0.0997	0.1013	1.0219	1.0049
1998	0.0903	0.0994	0.1011	0.9082	0.8932
1999	0.0971	0.1055	0.1107	0.9206	0.8778
2000	0.1233	0.1363	0.1405	0.9045	0.8777
2001	0.1101	0.1088	0.1145	1.0123	0.9620
mean	0.1103	0.1107	0.1140	0.9690	0.9708
sd	0.0187	0.0181	0.0184	0.0672	0.0800

Though daily volatility has varied substantially from year to year in both currencies, we see neither a clear trend over time nor an outsized movement in the last few years. Recent annual readings of daily volatility are, in fact, generally statistically close to the mean. It would also be difficult to find much of a trend in integrated volatility at 15- and five-minute intervals over the period in either of the currencies. Readings for 2001, for instance, are at or below their mean level over the sample period. The data therefore do not indicate that a wholesale change in market volatility, either daily or intraday, has occurred since the introduction of electronic trading. A look at the evolution of the two variance ratios over time in both tables also shows little substantial change. The two ratios remain close to one throughout the sample, though a bit more often below one than above. Recent values are either above their mean in our sample years, or statistically indistinguishable. If variance ratios had decreased in the later years, that would have been consistent with the story of a reduced presence of

market-makers as electronic trading became widespread. In theory, one would then have expected customer trades to move the price more easily initially, only to be later reversed, yielding an increased short-term volatility not matched by larger movements in daily returns (a nice story, but clearly not in the data).

Table 3
JPY: annualised volatility and variance ratios

	1 day	**15 min**	**5 min**	**1d/15min**	**1d/5min**
1987	0.1203	0.1057	0.1067	1.1385	1.1276
1988	0.1118	0.0985	0.1001	1.1360	1.1178
1989	0.1193	0.1103	0.1130	1.0813	1.0558
1990	0.1189	0.1136	0.1191	1.0463	0.9976
1991	0.1035	0.1039	0.1108	0.9968	0.9345
1992	0.0929	0.0971	0.1036	0.9573	0.8975
1993	0.1196	0.1223	0.1296	0.9778	0.9229
1994	0.1045	0.1116	0.1187	0.9358	0.8797
1995	0.1464	0.1499	0.1556	0.9765	0.9410
1996	0.0759	0.0886	0.0967	0.8565	0.7842
1997	0.1275	0.1279	0.1322	0.9970	0.9645
1998	0.1687	0.1825	0.1798	0.9241	0.9379
1999	0.1339	0.1447	0.1467	0.9251	0.9125
2000	0.0982	0.1056	0.1081	0.9301	0.9085
2001	0.0984	0.0965	0.0995	1.0191	0.989
mean	0.1159	0.1172	0.1213	0.9581	0.96388
sd	0.0228	0.0250	0.0236	0.0801	0.0900

Next we briefly examine the frequency of large intraday movements at five and 15-minute intervals over the sample period. A reduced presence of market-makers in foreign exchange markets would be consistent with an increase in the frequency of "gapping", sudden large movements in the price often interpreted as a sign of reduced market liquidity. We study the presence of gapping in these two markets by measuring, for each year in our sample, the frequency of movements of a given size relative to the volatility based on daily returns. Tables 4 and 5 show, by year, the frequency of absolute five-minute price movements within certain ranges, in units of standard deviations (expected standard deviations of five-minute movements based on yearly levels of volatility calculated from squared daily returns). The first column shows the frequency of absolute five-minute movements up to one standard deviation, the second between one and two standard deviations, and so forth. The rightmost column shows the frequency of movements exceeding six standard deviations.[2] Tables 6 and 7 display similar results for 15-minute intervals. The last two rows of each table show the mean and standard deviation of each column.

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[2] For reference, a one-standard deviation five-minute movement in a year with a daily volatility near 0.12 (about average) represents about a 0.05% move in the exchange rate (so a 6σ move is about 0.3%). For 15-minute movements, a 6σ move is about 0.5%.

Table 4

DEM: distribution of five-minute movements

σ	0-1	1-2	2-3	3-4	4-5	5-6	6+
Year							
1987	0.8347	0.1261	0.0266	0.0077	0.0025	0.0012	0.0012
1988	0.8516	0.1176	0.0221	0.0052	0.0018	0.0006	0.0010
1989	0.8191	0.1383	0.0299	0.0075	0.0028	0.0012	0.0013
1990	0.7770	0.1652	0.0400	0.0113	0.0037	0.0013	0.0015
1991	0.8225	0.1357	0.0283	0.0083	0.0025	0.0010	0.0016
1992	0.8041	0.1460	0.0336	0.0091	0.0033	0.0017	0.0023
1993	0.7850	0.1611	0.0370	0.0108	0.0032	0.0011	0.0018
1994	0.8057	0.1463	0.0316	0.0092	0.0034	0.0015	0.0023
1995	0.8180	0.1352	0.0303	0.0094	0.0036	0.0014	0.0022
1996	0.7387	0.1938	0.0459	0.0134	0.0044	0.0019	0.0019
1997	0.7916	0.1615	0.0335	0.0084	0.0027	0.0010	0.0013
1998	0.7591	0.1769	0.0441	0.0115	0.0046	0.0018	0.0020
1999	0.7466	0.1853	0.0465	0.0134	0.0044	0.0018	0.0020
2000	0.7740	0.1641	0.0413	0.0118	0.0049	0.0021	0.0019
2001	0.7756	0.1662	0.0403	0.0112	0.0038	0.0013	0.0016
mean	0.7936	0.1546	0.0354	0.0099	0.0034	0.0014	0.0017
sd	0.0326	0.0219	0.0074	0.0023	0.0009	0.0004	0.0004

Table 5

JPY: distribution of five-minute movements

σ	0-1	1-2	2-3	3-4	4-5	5-6	6+
Year							
1987	0.8449	0.1203	0.0242	0.0064	0.0024	0.0007	0.0010
1988	0.8508	0.1158	0.0219	0.0069	0.0024	0.0011	0.0012
1989	0.8222	0.1352	0.0291	0.0088	0.0024	0.0011	0.0013
1990	0.8064	0.1440	0.0341	0.0098	0.0031	0.0012	0.0014
1991	0.7824	0.1633	0.0368	0.0105	0.0035	0.0018	0.0015
1992	0.7586	0.1784	0.0424	0.0132	0.0039	0.0017	0.0017
1993	0.7773	0.1641	0.0394	0.0110	0.0044	0.0018	0.0020
1994	0.7605	0.1764	0.0413	0.0128	0.0046	0.0020	0.0025
1995	0.7947	0.1510	0.0363	0.0104	0.0040	0.0018	0.0018
1996	0.7006	0.2098	0.0596	0.0176	0.0065	0.0030	0.0028
1997	0.7971	0.1535	0.0335	0.0094	0.0038	0.0013	0.0015
1998	0.8034	0.1460	0.0331	0.0102	0.0036	0.0013	0.0024
1999	0.7827	0.1613	0.0367	0.0112	0.0041	0.0018	0.0022
2000	0.7660	0.1741	0.0409	0.0115	0.0040	0.0016	0.0019
2001	0.7830	0.1663	0.0352	0.0098	0.0030	0.0014	0.0014
mean	0.7887	0.1573	0.0363	0.0106	0.0037	0.0016	0.0018
sd	0.0382	0.0246	0.0091	0.0028	0.0011	0.0006	0.0005

Table 6

DEM: distribution of 15-minute movements

σ	0-1	1-2	2-3	3-4	4-5	5-6	6+
Year							
1987	0.8450	0.1168	0.0253	0.0076	0.0027	0.0009	0.0018
1988	0.8649	0.1065	0.0195	0.0051	0.0018	0.0007	0.0015
1989	0.8276	0.1312	0.0281	0.0077	0.0031	0.0009	0.0015
1990	0.7890	0.1586	0.0360	0.0104	0.0034	0.0013	0.0013
1991	0.8280	0.1323	0.0277	0.0069	0.0028	0.0010	0.0015
1992	0.8153	0.1372	0.0313	0.0092	0.0039	0.0011	0.0020
1993	0.8033	0.1501	0.0319	0.0091	0.0030	0.0012	0.0015
1994	0.8203	0.1357	0.0281	0.0097	0.0029	0.0013	0.0021
1995	0.8233	0.1316	0.0288	0.0088	0.0035	0.0020	0.0021
1996	0.7693	0.1741	0.0395	0.0100	0.0040	0.0014	0.0016
1997	0.7951	0.1604	0.0316	0.0083	0.0029	0.0006	0.0010
1998	0.7644	0.1753	0.0408	0.0121	0.0040	0.0014	0.0020
1999	0.7710	0.1707	0.0402	0.0104	0.0043	0.0014	0.0021
2000	0.7863	0.1555	0.0375	0.0128	0.0045	0.0017	0.0017
2001	0.7951	0.1523	0.0369	0.0097	0.0036	0.0009	0.0015
mean	0.0806	0.1459	0.0322	0.0092	0.0034	0.0012	0.0017
sd	0.0290	0.0207	0.0062	0.0020	0.0007	0.0004	0.0003

Table 7

JPY: distribution of 15-minute movements

σ	0-1	1-2	2-3	3-4	4-5	5-6	6+
Year							
1987	0.8509	0.1169	0.0222	0.0059	0.0018	0.0010	0.0012
1988	0.8608	0.1085	0.0212	0.0051	0.0023	0.0010	0.0011
1989	0.8304	0.1310	0.0260	0.0075	0.0030	0.0007	0.0014
1990	0.8086	0.1475	0.0309	0.0081	0.0030	0.0007	0.0012
1991	0.8000	0.1520	0.0328	0.0096	0.0032	0.0009	0.0016
1992	0.7894	0.1577	0.0361	0.0109	0.0032	0.0015	0.0014
1993	0.7957	0.1533	0.0354	0.0093	0.0029	0.0014	0.0020
1994	0.7878	0.1570	0.0363	0.0110	0.0044	0.0014	0.0020
1995	0.8010	0.1501	0.0334	0.0091	0.0033	0.0015	0.0016
1996	0.7288	0.1986	0.0497	0.0143	0.0046	0.0019	0.0020
1997	0.7979	0.1578	0.0300	0.0082	0.0033	0.0013	0.0014
1998	0.7936	0.1556	0.0337	0.0100	0.0035	0.0013	0.0023
1999	0.7876	0.1587	0.0361	0.0100	0.0037	0.0018	0.0020
2000	0.7748	0.1689	0.0385	0.0101	0.0041	0.0018	0.0017
2001	0.7883	0.1632	0.0337	0.0102	0.0024	0.0014	0.0007
mean	0.7997	0.1518	0.0331	0.0093	0.0032	0.0013	0.0016
sd	0.0322	0.0218	0.0071	0.0023	0.0008	0.0004	0.0004

Note first that the distribution of high-frequency exchange rate movements is, as is expected, leptokurtic (too much mass within one standard deviation, for instance, and too much also in the tails). Small changes from year to year in the distribution of these high-frequency movements are evident, but again one would be hard pressed to conclude from these data that the frequency of large movements has increased substantially in the last few years, either for dollar-mark or dollar-yen. Aggregating some of the data, Figures 1 and 2 present the frequency of five-minute movements larger than three standard deviations and larger than five standard deviations by year for both currencies. Figures 3 and 4 show similar data for 15-minute movements. If one disregards the increases of the late 1980s, which we suspect may be due in part to the price reporting behaviour of the dealers at the time, the frequency of relatively large movements has not increased in recent years. In other words, the incidence of "gapping", a common symptom of illiquidity, does not appear to have risen in a substantial way with the advent of electronic trading.

5.   Conclusion

Despite our best efforts to look for trouble, we have been unable to uncover evidence that the recent changes in the structure of foreign exchange markets, including the adoption of electronic trading, have had a negative effect on market liquidity and volatility. Daily and intraday volatilities have not changed appreciably, ratios of daily to intraday volatilities have remained within past ranges, and the frequency of large intraday movements has not risen substantially in the past few years. To the optimist, this is evidence that these markets are resilient to wholesale changes, and that new sources of liquidity may have emerged as old ones dropped out. It also perhaps suggests that the cost savings associated with electronic trading have been sufficient to counteract, in great part, the loss of information advantage suffered by large dealers. If one insists on being pessimistic, one could perhaps argue that the deepest changes in the structure of foreign exchange markets are yet to come, as the various multidealer-to-customer platforms gain further acceptance and further erode the dealers' information advantage. Whether or not trouble is brewing in the future, the price data we have examined do not indicate that foreign exchange markets have experienced a noteworthy increase in volatility in the past few years.

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Figure 1
Cumulative frequency of large five-minute movements
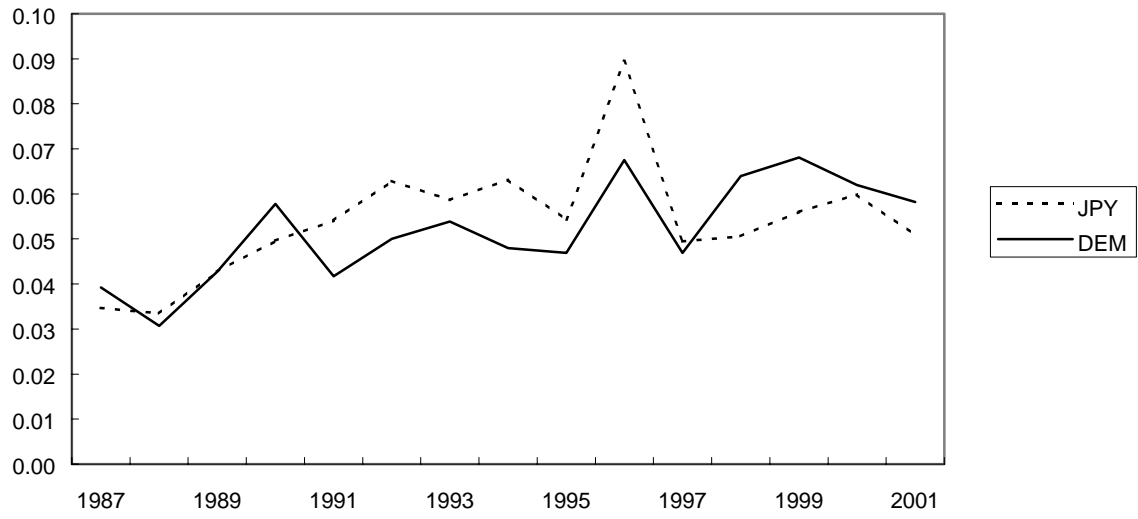(three standard deviations and larger)

Figure 2
Cumulative frequency of large five-minute movements
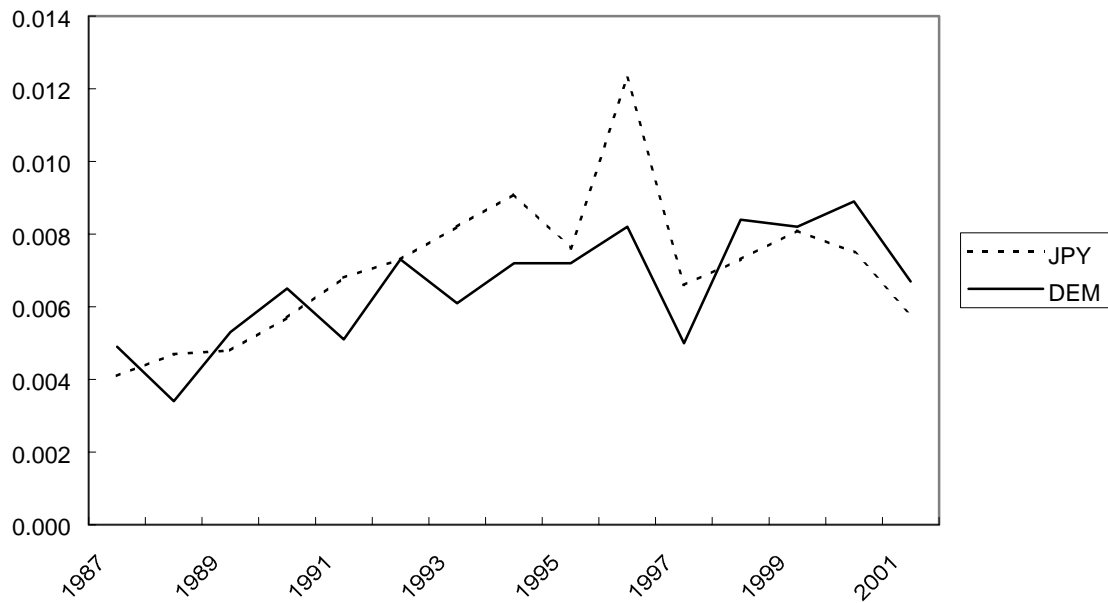(five standard deviations and larger)

Figure 3

Cumulative frequency of large 15-minute movements
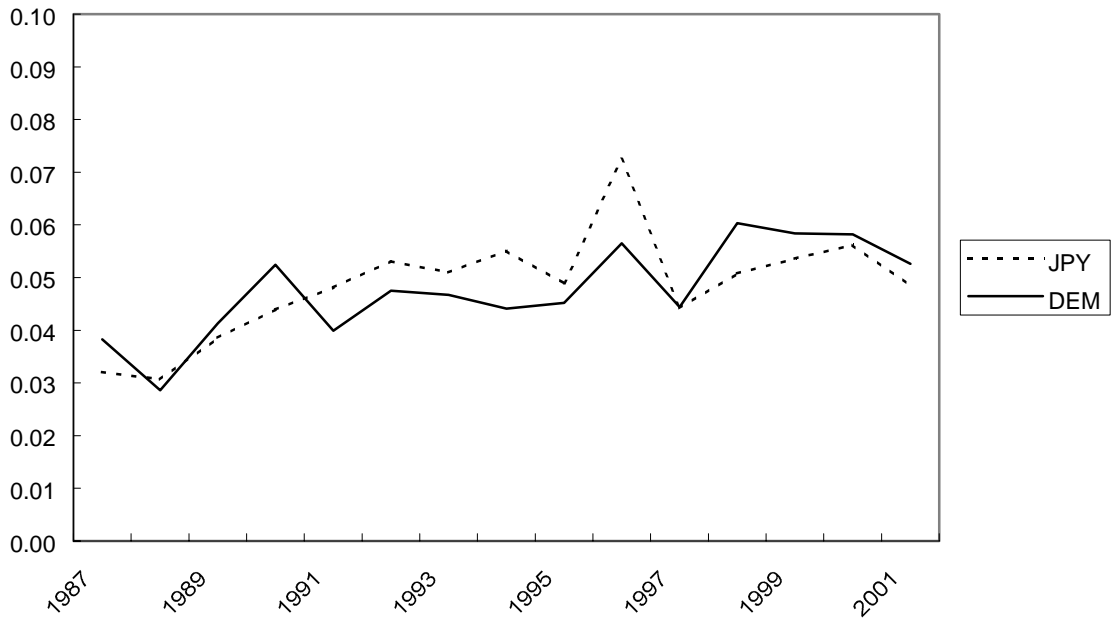
(three standard deviations and larger)

Figure 4

Cumulative frequency of large 15-minute movements

(five standard deviations and larger)