Exchange Rate Regimes and Volatility

By Charles Engel and Craig S. Hakkio

The perception is widespread that foreign exchange rates are too volatile. In 1992, for example, the U.S. dollar rose more than 2 percent against the German mark in one day on seven separate occasions. While a 2 percent daily change may seem small, it nonetheless amounts to a change of more than 500 percent at an annual rate.

High volatility in exchange rates can have important adverse consequences. If investors equate volatility with risk, they may alter their investment decisions. As a result, long-term capital flows may be reduced, thereby retarding the efficient flow of capital in the world economy. Moreover, if the exchange value of foreign sales becomes more volatile, firms may be reluctant to engage in international trade. And, if exchange rate volatility spills over into the real economy or inhibits the smooth functioning of the financial system, monetary policymakers will be less able to achieve their policy goals.

To reduce exchange rate volatility, some observers recommend that the United States, Japan, and Germany abandon their system of flexible exchange rates and adopt a target zone system. Under a target zone system, exchange rates are fixed within a narrow band that can be periodically adjusted, or realigned.

Exchange rates are kept within a target zone in the European Monetary System (EMS). The European experience has shown, however, that a new kind of exchange rate volatility is introduced under this system due to the possibility of exchange rate realignments. Since the fall of 1992, European foreign exchange markets have been in intermittent turmoil, with realignments in September and November of last year and January and May of this year.

This article examines the European experience with a target zone system to learn whether a target zone for the U.S. dollar, yen, and mark would reduce exchange rate volatility. The first section of the article shows that exchange rate volatility is different for EMS and non-EMS countries, which supports the view that volatility in a target zone would be different from volatility in a flexible exchange rate regime. The next two sections provide reasons why volatility is different in the two kinds of exchange rate regimes. The article concludes that exchange rate volatility would probably not decline if the United States, Japan, and Germany were to adopt a target zone system.

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VOLATILITY OF EMS AND NON-EMS EXCHANGE RATES

How can volatility in a system of flexible exchange rates be compared with volatility in a system of fixed, but adjustable, exchange rates? One approach is to compare the volatility of the dollar/mark exchange rate under the current flexible rate system with its volatility during the fixed, but adjustable, Bretton Woods system prevailing after World War II. This comparison may be misleading, however, since the current environment is significantly different from the 1950s and 1960s. A preferred approach is to compare dollar/mark volatility with French franc/mark volatility in the current period, since the French franc/mark exchange rate belongs to the EMS target zone. More generally, comparing volatility of non-EMS exchange rates, such as the dollar/mark rate, with volatility of EMS exchange rates, such as the franc/mark rate, can provide information about how exchange rate volatility might change if the United States, Japan, and Germany adopted a target zone system.

Accordingly, this section first discusses how to measure exchange rate volatility and then compares the volatility of eight EMS and non-EMS currencies. Most of the discussion focuses on two exchange rates, the dollar/mark and French franc/mark. Results are also reported for four other EMS exchange rates—the Italian lira, Belgian franc, Danish krone, and Dutch guilder—and two other non-EMS exchange rates—the Canadian dollar and Japanese yen. All currencies are measured relative to the Deutsche mark because Germany is the largest European country.

How to measure exchange rate volatility

For analytical purposes, it is useful to think of exchange rate volatility as consisting of three types—normal volatility, extreme volatility, and all other volatility. Normal volatility refers to the ordinary variability of exchange rate changes—the modest rises and falls that commonly occur over time. Extreme volatility refers to the much larger changes in exchange rates that occur only occasionally. All other volatility are those changes that are neither normal nor extreme—that is, unclassified changes. Although terms like "ordinary," "occasional," and "large" are vague, they can be made precise.

Normal volatility is illustrated in Chart 1, which shows the month-to-month percent change in the franc/mark exchange rate from March 1979 to May 1993.[1] One-half of the changes during this period are between -0.3 percent and 0.1 percent at an annual rate, as indicated by the darkly shaded band in the middle of the chart. Since normal volatility refers to the ordinary ups and downs of the exchange rate, and since changes in the franc/mark are ordinarily between -0.3 and 0.1 percent, normal volatility of the franc/mark rate is defined to be between -0.3 percent and 0.1 percent.

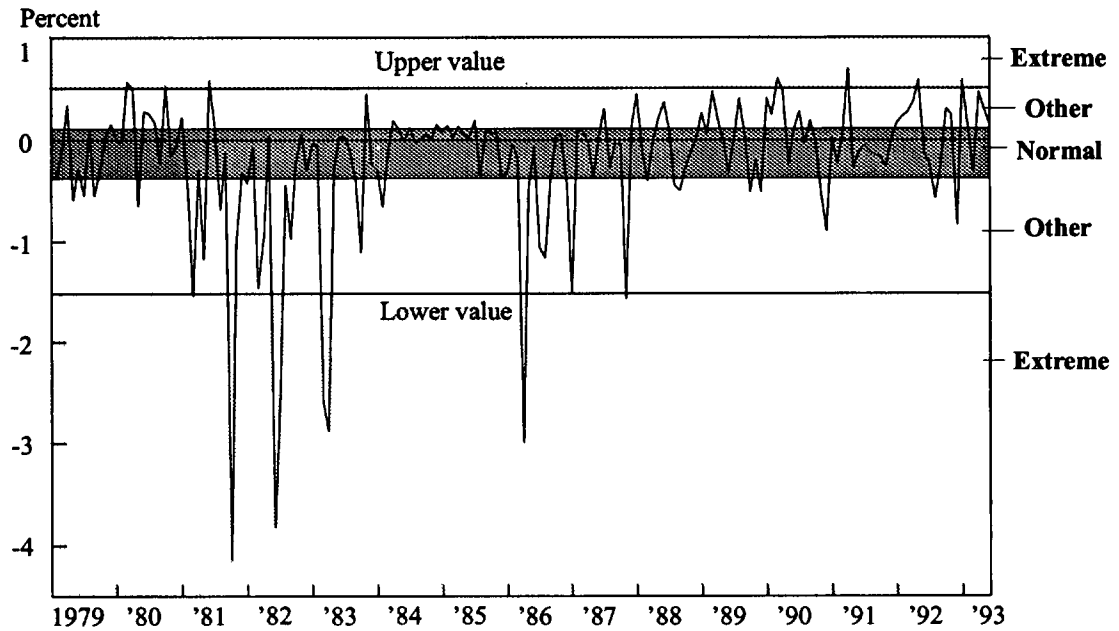
As shown by the example, normal volatility can be defined by a pair of numbers. The two numbers are chosen so that half of all exchange rate changes fall between the two numbers. More precisely, in looking at the distribution of franc/mark exchange rate changes in Chart 1, the 25th percentile is -0.3 percent and the 75th percentile is 0.1 percent. Since half of the exchange rate changes lie between the 25th and 75th percentiles, normal volatility is measured by these two numbers; that is, normal volatility is between -0.3 percent and 0.1 percent.

Extreme volatility, which refers to occasional large changes in the exchange rate, is also illustrated in Chart 1. To quantify the term "occasional," two numbers called the "lower value" and "upper value" are chosen so that 5 percent of the time the exchange rate *falls more than* the "lower value," and 5 percent of the time the exchange rate *rises more than* the "upper value." Thus, the lower value is the 5th percentile, and

Chart 1

Exchange Rate Volatility: the French Franc/Mark Exchange Rate

Monthly percent change



the upper value is the 95th percentile. Looking at the largest 5 percent of the negative exchange rate changes and the largest 5 percent of the positive exchange rate changes reveals that extreme volatility is indeed both "occasional" and "large."

In Chart 1, extreme volatility is indicated by the lightly shaded area.[2] Within this area, five percent of the time the French franc falls more than 1.5 percent and 5 percent of the time the franc rises more than 0.5 percent. Extreme volatility for the franc, therefore, is defined by the pair of numbers -1.5 percent and 0.5 percent.

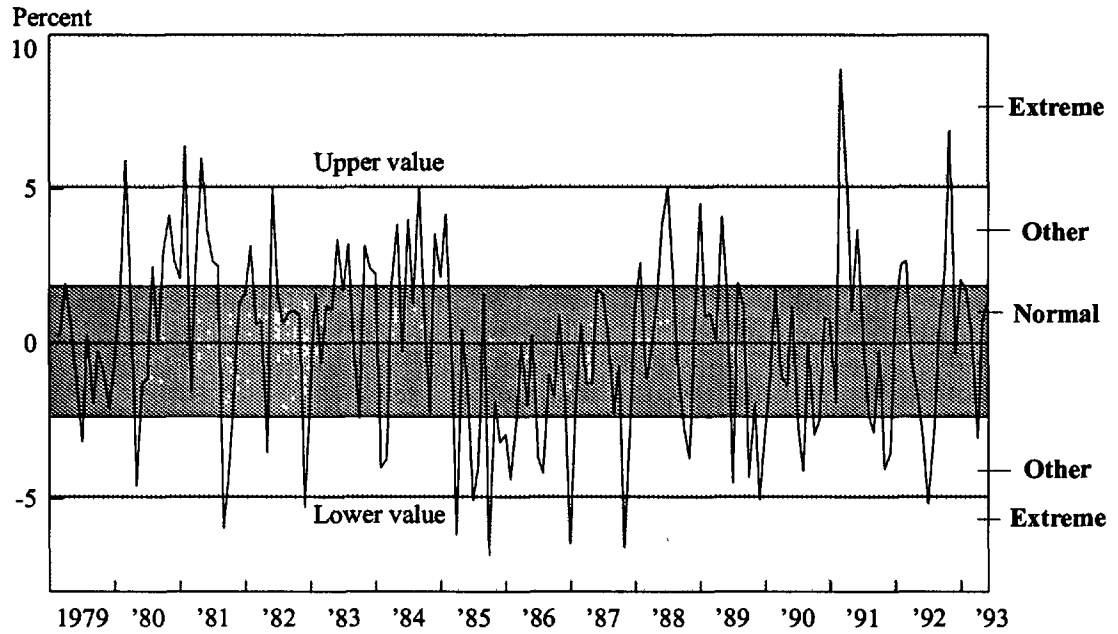
All other volatility, which is volatility that is neither normal nor extreme, is left unshaded in Chart 1. Using the definition of normal and extreme volatility, all other volatility refers to exchange rate changes that are between the 5th and 25th percentile, or between the 75th and 95th percentile. Since the three types of volatility—normal, extreme, and all other—are exhaustive, there is no need to formally study all other volatility in addition to normal and extreme volatility.

Comparing volatility

Exchange rate volatility for the EMS currencies differs from exchange rate volatility for the non-EMS currencies in both size and timing. This discussion focuses on volatility of month-to-month changes in the dollar/mark and French franc/mark exchange rates. The dollar/mark represents a flexible exchange rate and the franc/mark represents a fixed, but adjustable,

Chart 2

Exchange Rate Volatility: the U.S. Dollar/Mark Exchange Rate
Monthly percent change



exchange rate. Numerical results are also reported for four other EMS exchange rates and two other non-EMS exchange rates to show that the dollar/mark and franc/mark results are not unusual.

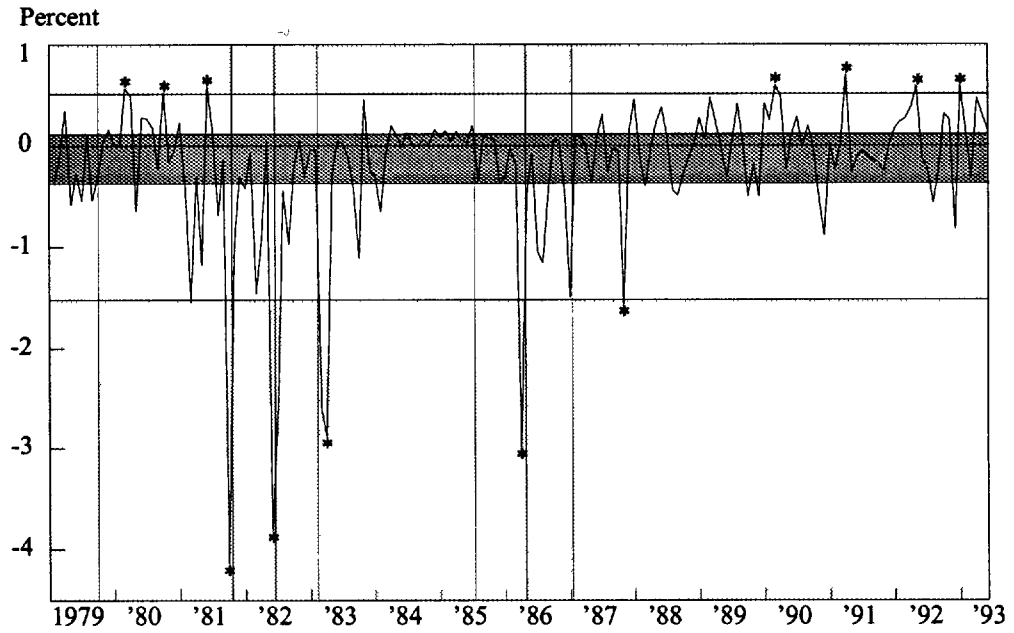
Chart 2 shows the month-to-month percent change in the dollar/mark exchange rate from March 1979 to January 1993. As shown by the darkly shaded area, changes in the dollar/mark are ordinarily between -2.1 percent and 1.8 percent. Therefore, normal volatility is defined as between -2.1 percent and 1.8 percent. Also, as shown by the lightly shaded area, the dollar/mark *occasionally* falls more than 4.9 percent and rises more than 5.1 percent. Therefore, extreme volatility is defined as the pair of numbers -4.9 percent and 5.1 percent.

The volatility of the dollar/mark and franc/mark rates differs in three important ways. First, normal volatility for the franc/mark is much less than for the dollar/mark. Normal volatility for the franc/mark is between -0.3 percent and 0.1 percent, while for the dollar/mark it is between -2.1 percent and 1.8 percent. Therefore, *ordinary* changes in the franc/mark are less than *ordinary* changes in the dollar/mark.

A second difference is that extreme volatility for the franc/mark is less than for the dollar/mark. Extreme volatility for the franc/mark is given by the numbers -1.5 percent and 0.5 percent, while for the dollar/mark it is given by -4.9 percent and 5.1 percent. Therefore, *occasional large* changes in the franc/mark are less than *occasional large* changes in the dollar/mark.

Chart 3

Volatility and Realignments: the French Franc/Mark Exchange Rate
Monthly percent change



* Denotes an extreme change in the exchange rate. The vertical lines indicate the month of a realignment of the French franc/mark exchange rate.

A third difference is that extreme volatility for the franc/mark tends to occur at the time of a realignment, whereas extreme volatility for the dollar/mark does not occur at any particular time. Chart 3 illustrates this third difference. The dates of realignments in the franc/mark exchange rate are indicated with a vertical line.[3] Extreme changes are indicated by an "*." Most of the extreme changes in the franc/mark occur in the month of a realignment. In fact, of the seven realignments involving the franc/mark, four were characterized by extreme volatility. The probability that this would happen by chance is about zero.[4] In contrast, the timing of EMS realignments and extreme changes in the dollar/mark exchange rate are not correlated.

The differences between the franc/mark and dollar/mark exchange rates apply generally to EMS and non-EMS exchange rates, as shown in Table 1. Normal volatility, as measured by the pair of numbers that define *ordinary* changes in the exchange rate, is less for EMS exchange rates than for non-EMS exchange rates. Extreme volatility, as measured by the pair of numbers that define *occasional and large* changes in the exchange rate, is also less for EMS exchange rates than for non-EMS exchange rates. Extreme volatility and realignments are correlated for four of the five EMS exchange rates, but are independent for the non-EMS exchange rates.

In summary, volatility of EMS exchange rates differs from volatility of non-EMS exchange rates in three ways. First, EMS exchange rates have smaller normal volatility than non-EMS

Table 1

Differences between non-EMS and EMS exchange rates

Exchange rate relative to the mark	Normal volatility	Extreme volatility	Is extreme volatility independent of realignments?
	non-EMS exchange rates		
U. S. dollar	(-2.1%, 1.8%)	(-4.9%, 5.1%)	yes
Japanese yen	(-1.4%, 2.0%)	(-3.9%, 4.6%)	yes
Canadian dollar	(-2.2%, 1.8%)	(-4.7%, 4.4%)	yes
	EMS exchange rates		
French franc	(-.3%, .1%)	(-1.5%, .5%)	no
Italian lira	(-.6%, .1%)	(-2.4%, .7%)	no
Danish krone	(-.4%, .2%)	(-1.2%, .5%)	no
Belgian franc	(-.2%, .1%)	(-1.0%, .4%)	yes
Dutch guilder	(-.1%, .1%)	(-.4%, .4%)	no

Note: The column labeled "Is extreme volatility independent of realignments?" summarizes the result of Fisher's exact test for independence of extreme changes and EMS realignments. Fisher's exact test tests the hypothesis that extreme volatility and EMS realignment are independent. "Yes" means that the hypothesis cannot be rejected; "no" means that the hypothesis of independence can be rejected.

exchange rates. Second, EMS exchange rates have smaller extreme volatility than non-EMS exchange rates. The final difference highlights the important role played by realignments in understanding EMS volatility. Namely, extreme changes in EMS exchange rates occur around the time of a realignment.

These findings suggest some of the ways in which exchange rate volatility may change if the United States, Japan, and Germany adopted a target zone. Some analysts might conclude that volatility of exchange rates would decline if the United States adopted a target zone. Before evaluating such a claim, however, the reasons that volatility in a flexible exchange rate system differ from volatility in a fixed, but adjustable, exchange rate system must be addressed.

VOLATILITY IN A SYSTEM OF FLEXIBLE EXCHANGE RATES

Understanding why volatility differs in the two regimes is important to policymakers who want to reduce exchange rate volatility. This section examines the factors that help determine exchange rate volatility in a system of flexible exchange rates. The next section discusses why volatility is different in a system of fixed, but adjustable, exchange rates.

Determinants of the exchange rate

Because the exchange rate is the price of one currency relative to another, any factor that

affects the supply of or demand for either currency affects their rate of exchange. For expositional purposes, such factors can be grouped into two categories: (1) current market fundamentals and (2) market expectations. If current market fundamentals or market expectations change, so will the demand for or supply of either currency and so will the current rate of exchange.

Market fundamentals include such factors as the money supply and real income. A change in the money supply in either country will affect the exchange rate. For example, an increase in the U.S. money supply relative to the German money supply will cause the price of the dollar to fall. In short, the dollar will depreciate in terms of the German mark.[5] A change in real income will also affect the exchange rate. For example, when real income in the United States rises, consumers will buy more goods produced at home and abroad. If consumers buy more German goods, the increased demand for marks will drive up the value of the mark relative to the dollar, thereby causing the dollar to depreciate.

Market fundamentals also include monetary and fiscal policies. Monetary policy is a market fundamental because it helps determine the money supply.[6] In the same way, fiscal policy—the tax and spend policies of the government—is a market fundamental because it helps determine real income.

Additional factors included as market fundamentals are the profitability and riskiness of domestic and foreign assets. Just as firms demand dollars and marks to buy international goods and services, firms also demand dollars and marks to buy and sell foreign assets. Suppose a U.S. mutual fund decides that a German pharmaceutical company has good profit prospects. The mutual fund will demand marks so that it can buy shares of the German pharmaceutical, thereby causing an increase in the dollar price of marks.

Market expectations also help determine exchange rates. All current asset prices reflect expectations about an asset's future price. For example, if investors expect gold prices to rise in the next month, investors will take action that will cause gold prices to rise immediately. The exchange rate is no different. If investors expect the dollar to decline, they will postpone their purchases in hope of buying dollars at a lower price. Thus, a depreciation expected in the future will cause a reduction in the current demand for dollars, leading to a drop in the current exchange rate. And, since exchange rates in the future will be influenced by the future value of market fundamentals, the expected value of future market fundamentals also affects today's exchange rate.

Determinants of exchange rate volatility

Exchange rate volatility stems in part from volatility in market fundamentals. Fluctuations in exchange rates, however, are sometimes too large to be explained solely by such factors. For example, exchange rates can change by two percentage points or more in a single day. But changes in market fundamentals—money supply, real income, or the relative quality of investment opportunities—do not change frequently or significantly enough to fully explain such exchange rate volatility.[7] Other factors, therefore, must contribute to exchange rate volatility.

Much exchange rate volatility can be explained by volatility in market expectations. Expectations can change as investors gain new information about market fundamentals. Expectations can also change even without apparent news about market fundamentals.

New information leads to volatility. Knowing that future market fundamentals affect current exchange rates, investors have an incentive to base their decisions on all the available information. When new information becomes available, investors may change their expectations of future market fundamentals.

An important source of new information is

news of policy changes. For example, when the Federal Reserve announces new monetary growth targets, or when Congress or the Administration announces new tax or spending programs, expectations of future exchange rates may change, leading to immediate changes in exchange rates. In this way, changes in policy can make exchange rates volatile.

Speculative bubbles lead to volatility. Sometimes investors change their expectations about future exchange rates even without new information about market fundamentals. These changed expectations can also affect the current exchange rate. An example is when the exchange rate is affected by a "speculative bubble."

Suppose investors expect a particular currency to appreciate. This expectation need not be based on any knowledge of market fundamentals. Perhaps traders "charting" the day-to-day movements of the exchange rate conclude that the currency is ripe for a takeoff. Typically, such unfounded expectations lead to losses for any speculator who bases trades on them. But, imagine a situation where a significant number of speculators expect the currency to appreciate. The speculators will therefore buy the currency, leading to an increase in the value of the currency. If enough speculators act on the belief that the currency will appreciate, their actions will cause the currency to appreciate. Thus, the expectations become self-fulfilling.

It is easy to imagine a situation where a speculative bubble will grow. For example, some analysts might believe a particular currency will rise in value regardless of market fundamentals. As the speculative bubble causes the currency to rise, speculators' expectations tend to be confirmed, their confidence in the currency grows, and they buy more of the currency. Thus, the currency can take off on a steady or even spectacular climb with no change in market fundamentals backing the upward movement.

At any time, of course, a speculative bubble is likely to burst. Investors may suddenly realize market fundamentals do not justify a rise in the value of the currency and will try to sell it, driving down sharply the currency's value.

Thus, actions by speculators can increase volatility of exchange rates under a floating exchange rate system. Bubbles can drive a currency upward for no fundamental reason, and then when the bubble bursts the currency can fall back down.

In a system of flexible exchange rates, exchange rate volatility depends on the volatility of market fundamentals and expectations. Hence, some analysts believe that if policymakers could reduce the volatility of market fundamentals or the volatility of expectations, exchange rate volatility might also decline.

VOLATILITY IN A FIXED, BUT ADJUSTABLE, EXCHANGE RATE REGIME

This section shows why volatility in a system of fixed, but adjustable, exchange rates differs from volatility in a system of flexible exchange rates. The key idea is that a system of fixed, but adjustable, exchange rates introduces a new kind of volatility: volatility caused by the expectations of exchange rate realignments. That is, volatility does not disappear when countries adopt a system of fixed, but adjustable, exchange rates; it simply takes a different form.

For analytical purposes, consider a system of absolutely fixed exchange rates. With the exchange rate fixed, investors need not form expectations about the future exchange rate because they can be certain the rate will always be within a narrow band. By eliminating the market's uncertainty about the future exchange rate, a system of absolutely fixed exchange rates reduces volatility.

Rates in a system like the EMS, however, are not absolutely fixed—they are fixed, but

adjustable. Investors know the exchange rate will stay within a band for some period of time, but the bands are able to be adjusted. In other words, a realignment may occur and exchange rate volatility will reflect this possibility. Expectations of the future exchange rate may be stable for some period of time, resulting in a stable exchange rate. But eventually expectations of a realignment—of its timing and magnitude—become important. As investors speculate about the realignment's size and timing, volatility will increase. Between realignments, exchange rate volatility will tend to be within normal limits, but around the time of realignments, exchange rate volatility can be extreme.[8]

Divergent market fundamentals lead to realignments.

Realignments become likely when exchange rates diverge from market fundamentals. Consider an investor in August 1992 trying to determine whether the Italian lira would be realigned. The previous realignment of the lira occurred in January 1987. From then until August 1992, the Italian money supply grew 8.0 percent annually, while the German money supply grew only 6.2 percent annually.[9] More importantly, Italian inflation during that period was 5.7 percent, while German inflation was only 2.7 percent. With market fundamentals so different, a realignment seemed inevitable.

By late August 1992, it had become obvious that the lira was overvalued in real terms and a devaluation of the lira was imminent.[10] Holding lira assets made little sense, when the alternative was holding German mark assets. Fairly certain that the lira would be devalued significantly against the mark, investors sold lira assets in favor of mark assets. As demand for the lira fell and demand for the mark rose by large amounts, additional pressure was put on European central banks to defend the EMS parities. Nonetheless, over the September 12-13 weekend, the lira was devalued by 7 percent against the mark.

To see why the lira realignment was inevitable, a frame of reference such as the "equilibrium" exchange rate is needed. The equilibrium exchange rate is the value of the exchange rate implied by market fundamentals. If the equilibrium rate is trending upward or downward, then either the upper or lower band of a target zone will eventually be violated. Figures 1-4 illustrate this point. The official exchange rate is shown by the horizontal line in the middle of the chart. The two horizontal bands surrounding the official rate represent the upper and lower bands of the EMS target zone system. In the EMS, the bands are plus or minus 2.25 percent of the official rate.[11] In Figure 1, the heavy solid line is the equilibrium value of the mark relative to the lira, and it is shown to be trending upward over time.[12] The thin solid line is the actual price of the mark, which may differ from the equilibrium exchange rate.

The equilibrium exchange rate, as shown in Figure 1, will cross the upper band at time t_A with no change in economic fundamentals. A change in monetary or fiscal policy, however, could change the market fundamentals so that the exchange rate does not cross its upper band. As shown in Figure 2, for example, a reduction in Italian money growth would slow the rate of depreciation of the lira, or the rate of appreciation of the mark, so that no realignment is needed. However, if neither the German nor Italian authorities change their policies, then a realignment becomes inevitable.

Realignments lead to extreme volatility

When a realignment becomes likely, exchange rate volatility tends to increase—that is, volatility becomes extreme. In the same way that new information about market fundamentals leads to volatility in a flexible exchange rate

Figure 1 Realignment in the EMS

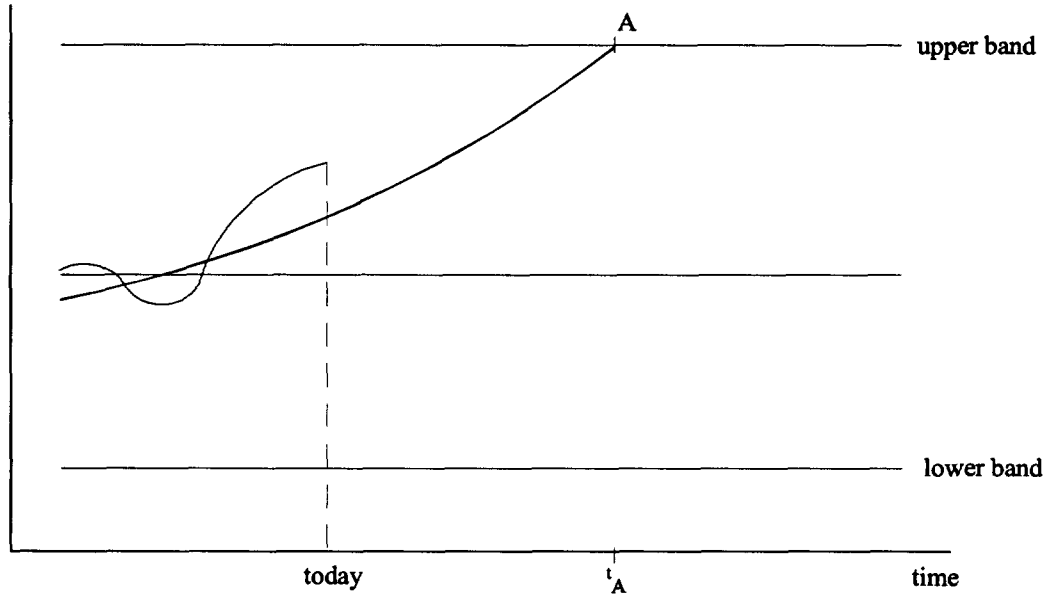
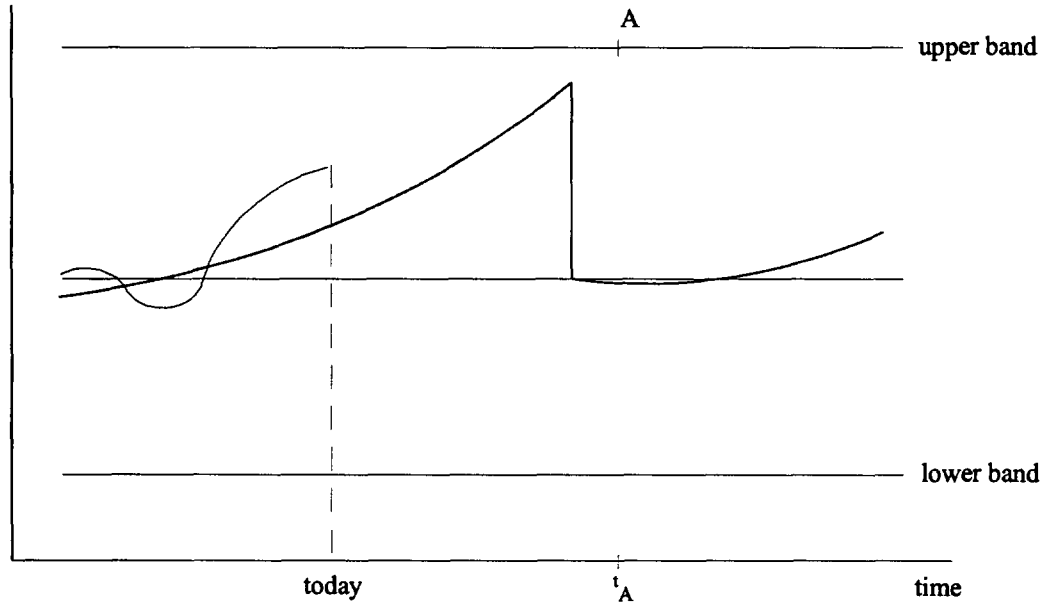


Figure 2 No Realignment



regime, new information about a possible realignment leads to volatility in an EMS-like regime.

New information about whether there will be a realignment contributes to volatility. Say, for example, the equilibrium exchange rate for the mark/lira is trending upward. If investors decide that a realignment will occur, they may try to buy marks before the government raises the official rate, causing the price of marks to rise quickly. But suppose the Italian government announces a rise in interest rates or declares that a realignment will not occur. With investors no longer expecting a realignment, the exchange rate will soon fall back. As investors continually revise their expectations about a possible realignment, exchange rates can rise and then fall, thereby contributing to volatility.

New information about the size of a realignment also contributes to volatility. Some analysts may believe a realignment of 7 percent is justified by the fundamentals, while others may believe a realignment of 10 percent is justified. As investors revise their expectations about the size of a realignment, the exchange rate will rise and fall, leading to volatility.

New information about the timing of a realignment further contributes to volatility. Consider a group of investors who decide a realignment will occur. If the investors expect an early realignment, the exchange rate will rise quickly to the upper band, as shown in Figure 3. Alternatively, if the Italian government raises short-term interest rates or announces that a realignment is unnecessary, investors may change their expectations about the timing of a realignment, as depicted in Figure 4. If investors believe the government will not keep interest rates high for long, they still believe a realignment will occur, but at a later date. Thus, the investors may reverse their decision to buy marks. As a result, the exchange rate may fall temporarily. Again, as investors change their expectations, the exchange rate becomes volatile.

If the equilibrium exchange rate is constant, rather than trending upward or downward, realignment volatility should not exist. A constant equilibrium exchange rate means that realignments are unnecessary because no fundamental economic forces are pushing the exchange rate through its upper or lower band. Although the actual exchange rate will be volatile, it will be volatile around a constant equilibrium value. Any move toward the upper or lower band will not generate expectations of a realignment because investors believe the equilibrium value is constant. Thus, under an EMS-type system with a constant equilibrium exchange rate, the extreme volatility arising from the uncertainty about a realignment should not be present.

Speculative attacks lead to volatility

A system like the EMS is not immune to exchange rate volatility due to speculation. When investors form expectations of realignments that are not based on market fundamentals, such a condition is called a speculative attack.

As an illustration, suppose that a significant number of investors believe the French franc will be devalued against the mark, despite the lack of market fundamentals to support such a belief. Investors will begin to sell franc assets to buy mark assets, causing the mark to rise relative to the franc. Other speculators will notice the demand for francs has fallen and the demand for marks has risen. Feeling confident that central banks will continue to keep the franc's official value pegged at the current rate, speculators will sell franc assets and buy mark assets, putting additional downward pressure on the franc. If the authorities decide to realign the official rate, the actions by speculators will have increased volatility by causing a realignment not based on market fundamentals. If the currency is not realigned, exchange rate volatility still increases

Figure 3 Early Realignment

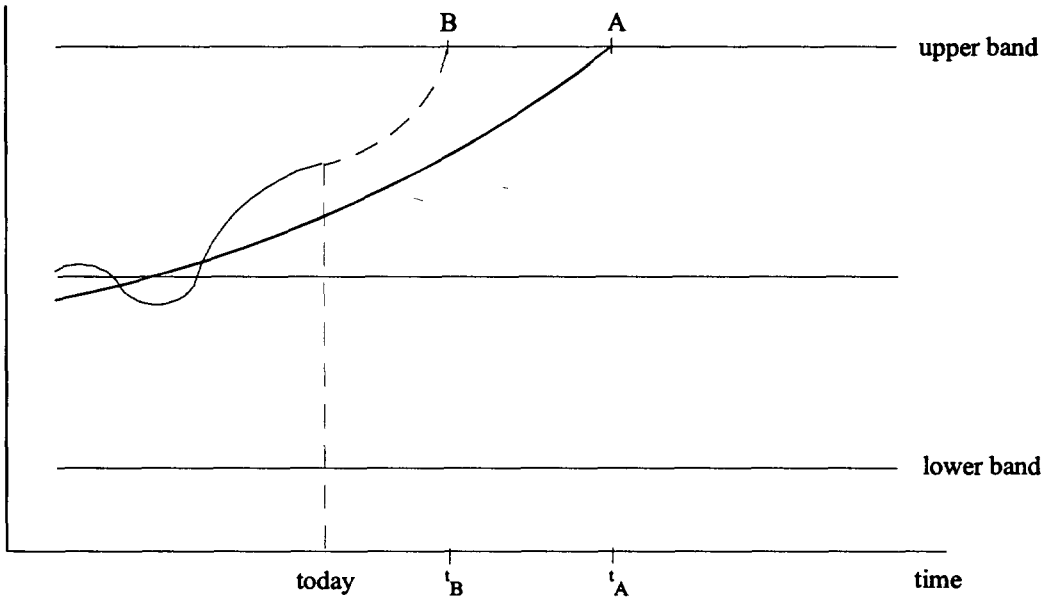
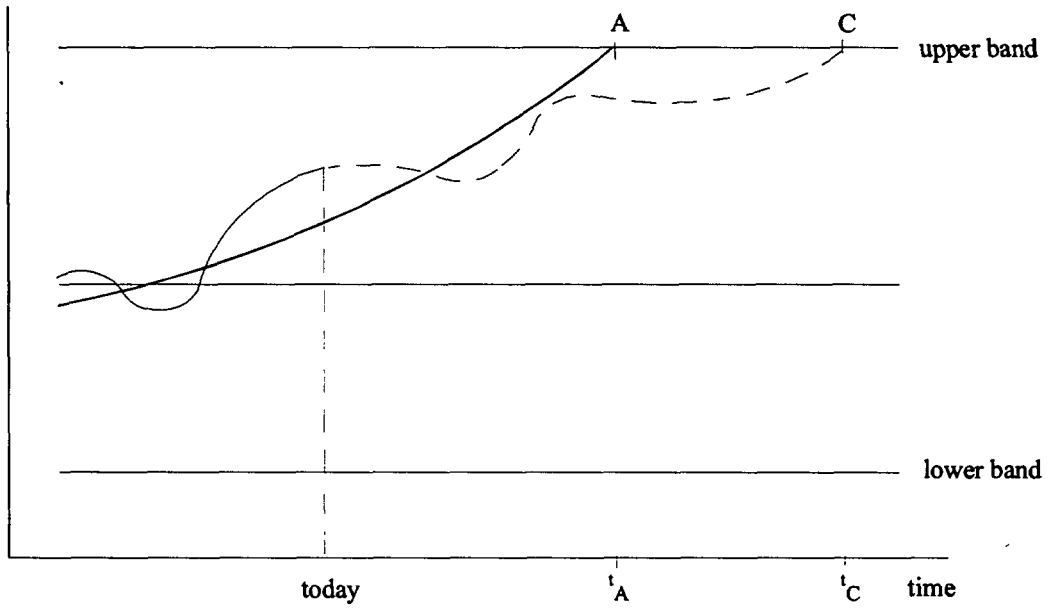


Figure 4 Late Realignment



as the currency is repeatedly attacked.

If market pressures ultimately force a realignment, exchange rate volatility increases despite market fundamentals that are stable. Thus, realignment volatility exists even though fundamentals are stable and the equilibrium exchange rate is constant.

Empirical evidence on volatility and realignments

Statistical evidence provides support for the hypothesis that exchange rate volatility in a system like the EMS is greater when the equilibrium value is rising than when it is constant. The relation between volatility and the trend in the equilibrium exchange rate is first investigated for the Italian lira and Dutch guilder. The hypothesis is then tested using five EMS exchange rates. However, before formally investigating the hypothesis, an estimate of the equilibrium value of the exchange rate is required.

Purchasing power parity (PPP) is one way to measure the dollar's equilibrium value.[13] In its simplest form, PPP states that identical goods should cost the same in all countries. But before the cost of goods in different countries can be compared, prices must be converted to a common currency. After converting marks to dollars, for example, a sweater bought in Germany should cost the same as an identical sweater bought the United States.

The above example can be generalized to say that the price of a basket of goods produced in two countries should be the same when expressed in a common currency. Since the Consumer Price Index can be viewed as the price of a basket of goods, the equilibrium exchange rate should equal the ratio of consumer prices in both countries. PPP also says that if U.S. inflation is greater than German inflation, the dollar will depreciate. With a cheaper dollar, Germans can buy more dollars. But with high U.S. inflation, Germans also need more dollars to buy the same amount of goods. Thus, higher U.S. inflation and a lower dollar go hand in hand.

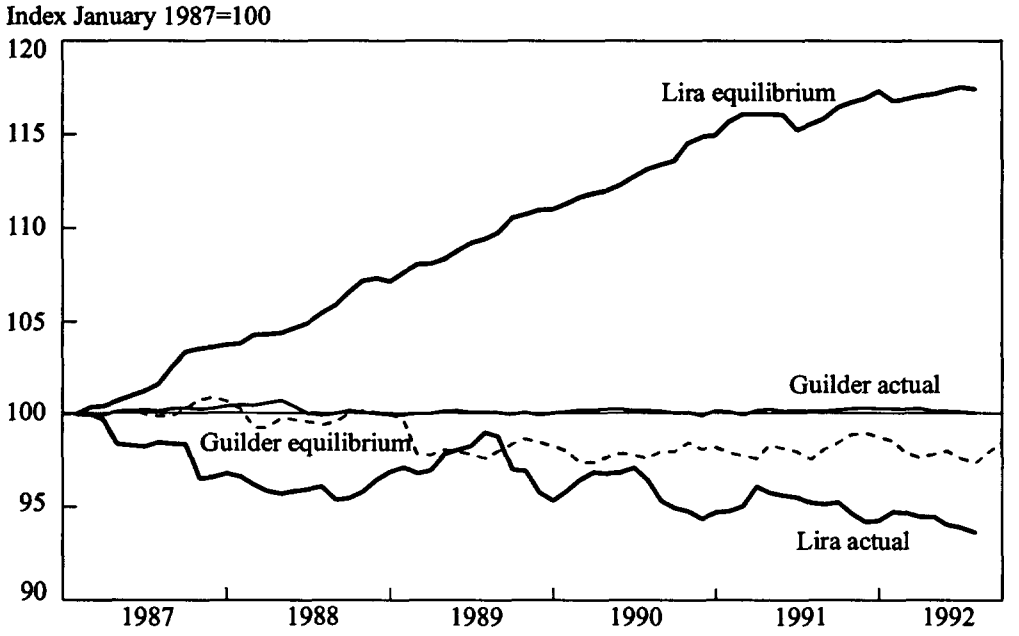
Chart 4 shows the actual and equilibrium value of the Italian lira and the Dutch guilder (relative to the mark) from January 1987 to August 1992. Exchange rates were realigned in January 1987 and September 1992. The actual and equilibrium exchange rates have been normalized so that they equal 100 in January 1987. Since Italian inflation was much greater than German inflation, the actual value of the lira fell relative to the mark. In addition, the lira became progressively overvalued, as measured by the growing discrepancy between the equilibrium value and the actual value of the lira. For example, right before the September 1992 realignment, the mark's equilibrium value had risen almost 20 percent above its value in January 1987. Dutch inflation, on the other hand, was about the same as German inflation. As a result, the equilibrium value of the Dutch guilder relative to the mark was approximately constant.

Since the trend in the lira is greater than the trend in the guilder, the theory implies that the volatility of the lira should be greater than the volatility of the guilder. The evidence supports the theory. Normal volatility for the lira—which is between -0.6 percent and 0.1 percent—is greater than normal volatility for the guilder—which is between -0.1 percent and 0.1 percent. Similarly, extreme volatility for the lira—which is defined by the pair of numbers -2.4 percent and 0.7 percent—is greater than extreme volatility for the guilder—which is defined by -0.4 percent and 0.4 percent.

Not only do the guilder and lira provide strong support for the theory, but all EMS exchange rates are consistent with the theory. That is, currencies with the greatest trend in their equilibrium value have the greatest amount of volatility. To test this hypothesis, the correlation

Chart 4

Actual and Equilibrium Exchange Rates



between the trend in the PPP exchange rate and the amount of normal and extreme volatility for the five EMS exchange rates are calculated. The correlation between the trend and normal volatility is 0.74. Thus, currencies with a large trend tend to have high normal volatility. In addition, the correlation between the trend and extreme volatility is 0.85. Both results confirm the hypothesis.[14]

The last two sections have discussed the reasons for exchange rate volatility in a flexible exchange rate system and in a fixed, but adjustable, exchange rate systems. Exchange rates in both systems are volatile because market fundamentals are volatile. In addition, expectations are volatile in both systems. In a flexible exchange rate system, investors form expectations about the future exchange rate. In a fixed, but adjustable, exchange rate system, investors form expectations about a possible realignment.

CONCLUSIONS

Exchange rate volatility differs in the EMS and non-EMS systems. EMS exchange rates are characterized by small normal volatility and by small extreme volatility. In contrast, non-EMS exchange rates are characterized by high normal volatility and by high extreme volatility. It would be wrong to conclude, though, that exchange rate volatility would necessarily decline if the United States, Japan, and Germany adopted a target zone system, like the EMS.

Exchange rate volatility would not necessar-

ily decline because exchange rates in a target zone are subject to a type of volatility that does not affect exchange rates in a flexible exchange rate system. Realignment volatility arises from new information about possible exchange rate realignments. In the EMS, extreme volatility generally occurs around the time of a realignment. Therefore, to determine whether volatility would change if the United States, Japan, and Germany were to adopt a target zone, the key issue lies in determining whether realignments would occur.

Realignments depend on whether the economic fundamentals lead to a constant equilibrium exchange rate. If the equilibrium exchange rate is constant, then realignments are infrequent and volatility is reduced. If the equilibrium rate trends upward or downward toward the boundaries of the target zone, however, then realignments become inevitable, bringing with them extreme volatility.

Economic fundamentals differ in the United States, Japan, and Germany. For example, according to the International Monetary Fund, average real GDP growth for 1993-94 is expected to be 3.2 percent in the United States, 2.2 percent in Japan, and 0.2 percent in Germany.[15] Average consumer price inflation for 1993-94 is expected to be 3.0 percent in the United States, 1.2 percent in Japan, and 3.4 percent in Germany. With such divergent economic fundamentals, it is not likely that the equilibrium exchange rate would be constant, and realignments would become inevitable.

Monetary policy also differs in the United States, Japan, and Germany. In the EMS, it is generally agreed that the Bundesbank acts as the anchor for monetary policy. As a result, monetary policy in the EMS countries, while not identical, is similar. Normal and extreme volatility for EMS currencies, in turn, is less than for non-EMS currencies. It is unlikely, however, that a single central bank would act as a policy anchor for the United States, Japan, or Germany. Without such an anchor, if policy in one country diverges from the other two, the equilibrium exchange rate would not be constant and realignments would become inevitable.

In summary, it is doubtful that the United States, Japan, and Germany would be able to keep the equilibrium exchange rate between their currencies constant over time, which would make realignments inevitable. Consequently, exchange rate volatility would probably not decline if the United States, Japan, and Germany were to adopt a target zone system.

ENDNOTES

[1] March 1979 was chosen because the Exchange Rate Mechanism of the EMS began on March 13, 1979.

[2] Extreme volatility is not symmetric because the franc was generally depreciating over time. As a result, there are more negative changes than positive changes.

[3] Some EMS realignments did not involve the franc/mark exchange rate. In particular, the EMS realignments in the fall of 1992 and spring of 1993 did not involve the franc.

[4] Specifically, Fisher's exact test is used to test the null hypothesis that realignments and dates of extreme volatility are independent. The marginal significance level is 0.002. Since the hypothesis of independence can be rejected, the article concludes that realignments and extreme volatility are "correlated."

[5] The discussion assumes that all other factors are held constant. This allows the analysis to focus on the particular change.

[6] Some changes in the money supply are unrelated to monetary policy decisions by the Federal Reserve. For example, if investors change the composition of their portfolio from money market funds to mutual funds, the money supply will change.

[7] Flood and Rose (1992) argue that although fixed

exchange rates are less volatile than flexible exchange rates, the volatility of market fundamentals is about the same in both systems.

[8] Volatility can also be extreme even without a realignment crisis due to extreme changes in expected market fundamentals or speculative bubbles.

[9] The growth of German M3 is calculated as a weighted average of growth from January 1987 to December 1990, and from January 1991 to January 1992. The reason is that the German money supply jumped in January 1991 due to reunification. Money growth was 5.8 percent in the first period and 6.3 percent in the second period. The weights (0.7966 and 0.2034) were proportional to the relative size of the two sample periods.

[10] Other factors also contributed to the expectation of a realignment. Denmark voted against the Maastricht treaty in early summer. The French were going to vote on the Maastricht treaty in mid-September; opinion polls showed that the vote was going to be close. With the future of European monetary union in question, investors began to believe that exchange rates could be realigned.

A question not addressed in this paper, and one for which there is no answer, is why investors did not expect a realignment earlier. The overvaluation did not suddenly occur in August 1992. It had been gradually occurring since the time of the previous realignment in January 1987. For some reason, investors came to believe that governments would no longer realign exchange rates. While this belief may have been justified in 1991, it was no longer justified in September 1992. But why this belief was no longer justified in September, rather than July, is not known.

[11] For much of the period, the band for the lira was set at plus or minus 6 percent. In August, the bands for most other countries were widened to plus or minus 15 percent.

[12] The exchange rate has units of lira/DM.

[13] See "Is Purchasing Power Parity a Useful Guide to the Dollar?" by Craig S. Hakkio, *Economic Review*, Third Quarter 1992, for further information about the different concepts of PPP and the use of PPP as a measure of the equilibrium value of the dollar.

[14] For this calculation, normal volatility is measured by the absolute value of the 25th percentile plus the 75th percentile. Similarly, extreme volatility is measured by the absolute value of the 5th percentile plus the 95th percentile. Finally, the value of the trend in the PPP exchange rate is given by the coefficient on time in a regression of the log of the PPP exchange rate on a linear time trend over the period January 1987 to August 1992.

[15] The projections come from the May 1993 *World Economic Outlook*, published by the International Monetary Fund.

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