

Tail Estimates of East European Exchange Rates

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In the literature, a consensus exists that distributions of exchange-rate returns are fat tailed. We use a nonparametric tail-index estimator based on extreme-value theory to shed light on some of the characteristics of the empirical distribution of black-market exchange-rate returns for seven East European currencies between 1955 and 1990, focusing on the information in the tails of the distribution. We modify an existing tail-index estimator to take into account information in both tails. The results support the existence of finite second moments in exchange-rate returns. Implicitly, the sum-stable distribution is rejected.

KEY WORDS: Extreme-value theory; Fat tails; Maximum moment exponent; Nonparametric estimation

In empirical exchange-rate studies, knowledge of the true distribution of exchange-rate returns is important for at least two reasons. First, the appropriate (dispersion) measure of uncertainty regarding exchange-rate movements generally is distribution dependent. Second, estimation techniques and tests of hypotheses usually assume normality of the underlying distribution, which may be unwarranted and lead to unreliable results.

As is well documented in the literature (Boothe and Glassman 1987; Westerfield 1977), the empirical distribution of exchange-rate returns in fixed and floating exchange-rate regimes has fatter tails than the normal distribution; that is, a relatively high number of extreme realizations is observed. Although the fat-tailed property of floating exchange rates has been well established, no consensus exists on which distribution is the appropriate one.

The empirical evidence for other exchange-rate regimes is even more limited. As an exception, Akgiray, Booth, and Seifert (1988) studied the distribution properties of black-market exchange rates in Latin America. In this article, we extend the existing empirical literature and focus on the empirical distribution of black-market exchange rates in Eastern Europe between 1955 and 1990. We investigate the exchange rates of the Bulgarian lev, the Czechoslovak koruna, the East German mark, the Hungarian forint, the Polish zloty, the Rumanian lei, and the Soviet ruble versus the U.S. dollar.

We do not try, however, to find the true parametric distribution generating exchange-rate returns but take a more modest approach instead. We concentrate on the tail shapes of the empirical distributions by estimating the *tail index* or maximum moment exponent α . This tail index is a measure of the amount of fat-tailed-

ness of the distribution under investigation. In general, for a distribution with tail index α , only moments of order smaller than (or equal to) α exist. We use extreme value theory to obtain an estimator of this tail index α .

Using the empirical estimates of α , we formally test for the existence of finite second moments in exchange-rate returns ($H_0: \alpha \geq 2$ vs. $H_a: \alpha < 2$), on which, for example, the applicability of the central limit theorem depends. Simultaneously, this test allows us to discriminate between Student-*t* and symmetric stable Paretian distributions, both of which have been suggested in the past to account for the fat-tailed distributions of exchange-rate returns.

In general, distinguishing between these two alternative models for the distribution of exchange-rate changes is troublesome because they are not nested. Estimates of the distribution's parameters are necessarily dependent on the maintained hypothesis and, consequently, disagreement on the appropriate distribution underlying exchange-rate changes remains. We show, however, that the tail-index estimates are independent of the maintained hypothesis of the underlying distribution.

The plan of this article is as follows. In Section 1 we introduce a tail-index estimator, based on extreme-value theory. In Section 2, we present East European black-market exchange-rate data for the period from January 1955 to December 1990 and provide statistical characteristics of exchange-rate returns. In Section 3, Monte Carlo experiments concerning the appropriate choice of the number of tail observations to take into account in estimating the tail index are described. In Section 4, empirical results are presented and discussed, and in Section 5, conclusions are given.

1. EXTREME-VALUE THEORY AND THE TAIL-INDEX ESTIMATOR

Consider $\phi_1, \phi_2, \dots, \phi_n$ to be a stationary sequence of iid exchange-rate returns with distribution function $F(\cdot)$. Define M_n as the maximum of this sequence of returns:

$$M_n := \max(\phi_1, \phi_2, \dots, \phi_n). \quad (1)$$

It may then be shown that the distribution function $F^n(x)$ of M_n for large n converges toward the same limiting distribution $G(x)$, independent of whether the exchange-rate returns were generated by a Student- t or sum-stable distribution. As the competing distributions are thus nested within the same limit law $G(x)$, no maintained hypothesis about the correct $F(x)$ is required.

The limiting distribution $G(x)$ is of the following form, with $\gamma > 0$ and the tail index α equal to $1/\gamma$:

$$G(x) = 0, \quad x < 0 \\ = \exp(-x)^{-1/\gamma} = \exp(-x)^{-\alpha}, \quad x \geq 0. \quad (2)$$

Relevant references on this result are the works of Mood, Graybill, and Boes (1974, p. 261) and Leadbetter, Lindgren, and Rootzen (1983, chap. 1). Leadbetter et al. (1983, chap. 3) showed that the theory also holds in case the assumption of independence for the exchange-rate returns is inappropriate, provided that the dependency is not too strong.

For the family of symmetric stable Paretian distributions, the tail index α in (2) may be interpreted as the characteristic exponent of the stable distribution, which ranges between 0 and 2. Roughly speaking, the lower the value of α , the thicker are the tails of the distribution, all other things being equal. For the class of Student- t distributions, the tail index α in (2) equals the number of degrees of freedom of the distribution, ranging from 0 to infinity.

Recently, the following simple and efficient estimator of the tail index has been proposed:

$$\hat{\gamma} = 1/\hat{\alpha} = \frac{1}{m} \sum_{i=1}^m [\log \phi_{(n+1-i)} - \log \phi_{(n-m)}]. \quad (3)$$

Here, n represents the total number of return observations and m the number of tail observations used to estimate α . The statistic $\hat{\gamma}$ first appeared in the work of Hill (1975). Mason (1982) proved that under some regularity conditions $\hat{\gamma}$ is a consistent estimator for γ . Goldie and Smith (1987) showed that $(\hat{\gamma} - \gamma)m^{1/2}$ is asymptotically normal with mean 0 and variance γ^2 . Consequently, $\hat{\alpha}$ is also asymptotically normal with mean α and variance α^2/m , and asymptotic confidence intervals may be constructed to test specific hypotheses. An empirical application of this estimator may be found in the work of Koedijk, Schafgans, and De Vries (1990).

As is clear from (3), the preceding estimator only uses the positive (right) tail of exchange-rate returns to estimate α and neglects the information content of the

large negative observations in the other tail. Conditional on the right and left tails having the same tail index, for which we test explicitly, we combine the information in the right and left tails by taking absolute values of the exchange-rate returns ϕ before ordering them and applying (3). This way, the precision of our tail-index estimates may be significantly improved. The number of tail observations m to be used is determined through Monte Carlo simulations. The results of these simulations are given in Section 3.

2. EAST EUROPEAN BLACK-MARKET EXCHANGE-RATE DATA

We examine monthly exchange-rate observations of seven East European currencies in terms of the U.S. dollar for the period from January 1955 to December 1990. The investigated currencies are the Bulgarian lev, the Czechoslovak koruna, the East German mark, the Hungarian forint, the Polish zloty, the Rumanian lei, and the Soviet ruble. From June 1990 onward, no black-market quotations for the East German mark exist, due to German unification and the formal replacement of the East German mark by the West German mark. The rates are the black-market exchange rates reported in various issues of *Pick's Currency Yearbook* and *World Currency Yearbook*; they are reproduced in the Appendix.

These data sources provide end-of-month quotations and make special efforts to ensure that quotations are consistently reported. We conclude from Pick's description corresponding to the data for the East European countries investigated here that black-market conditions in each of these countries have been characterized by many participants—both buyers and sellers—and many transactions over most of the period. We therefore feel confident that the data are reasonably consistent and accurate.

Figures 1–7 display the time paths of the seven East European black-market exchange rates between 1955 and 1990. For all countries, except for Bulgaria and the

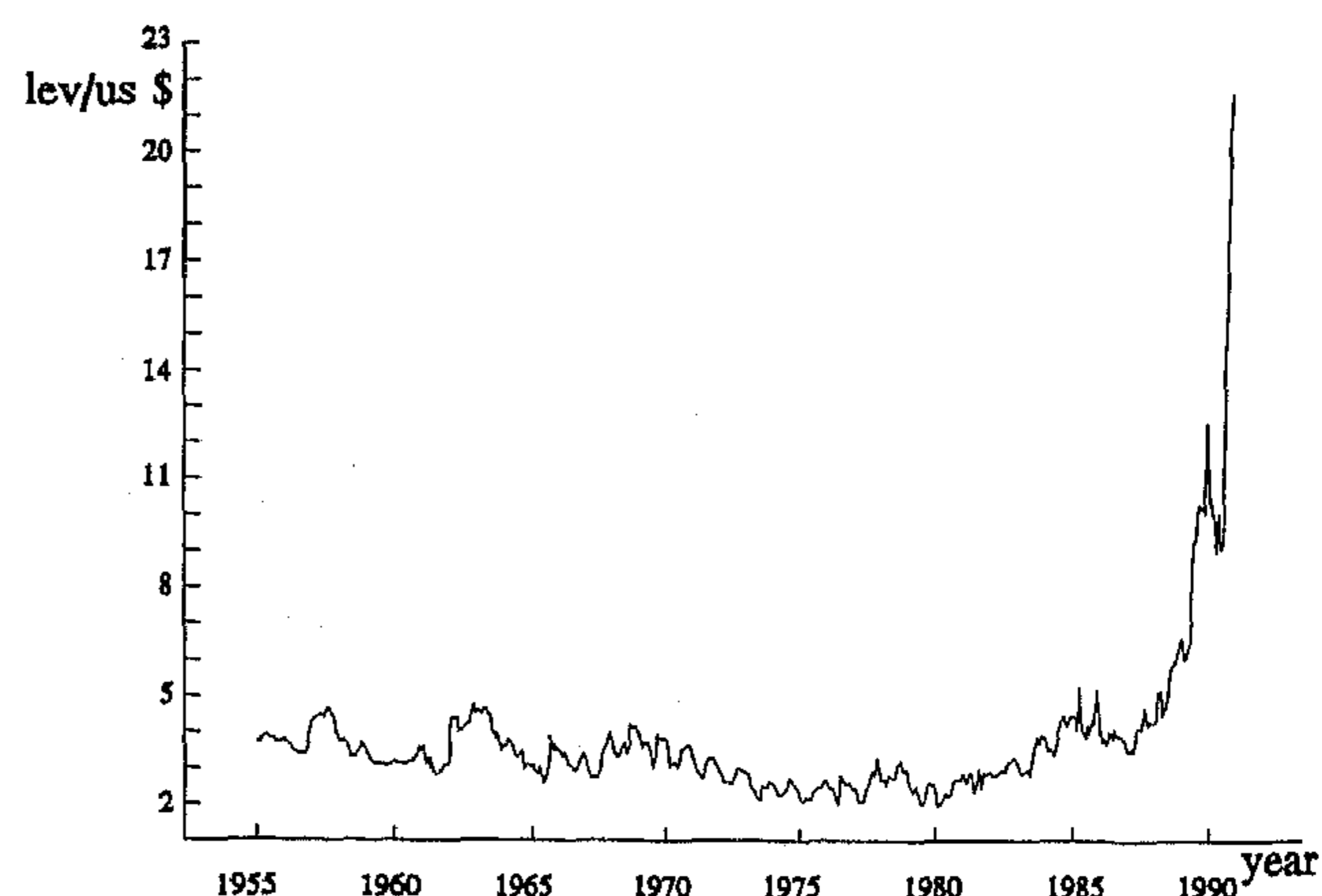


Figure 1. The Exchange Rate of the Bulgarian Lev Expressed in U.S. Dollars, January 1955–December 1990.

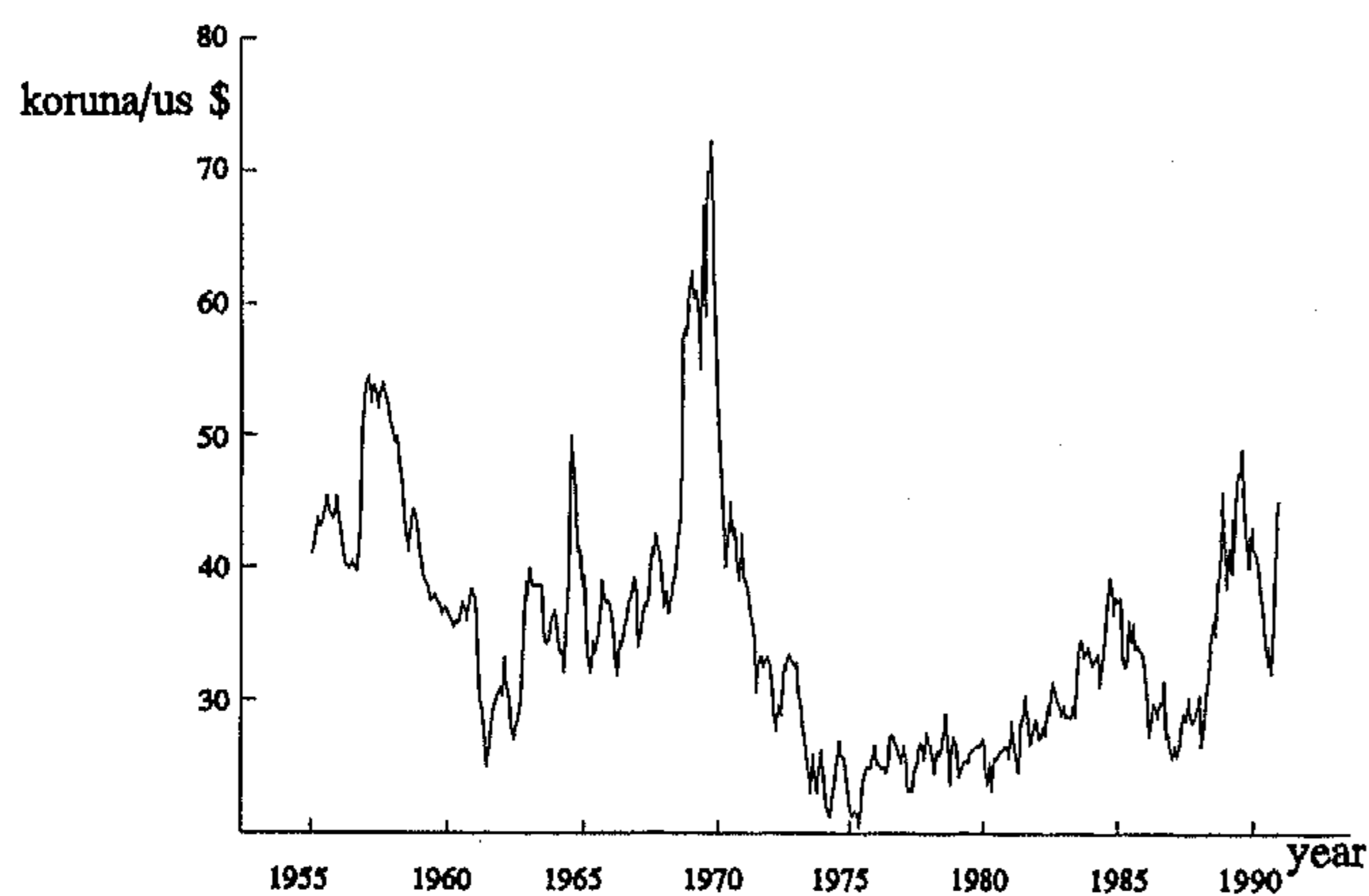


Figure 2. The Exchange Rate of the Czechoslovak Koruna Expressed in U.S. Dollars, January 1955–December 1990.

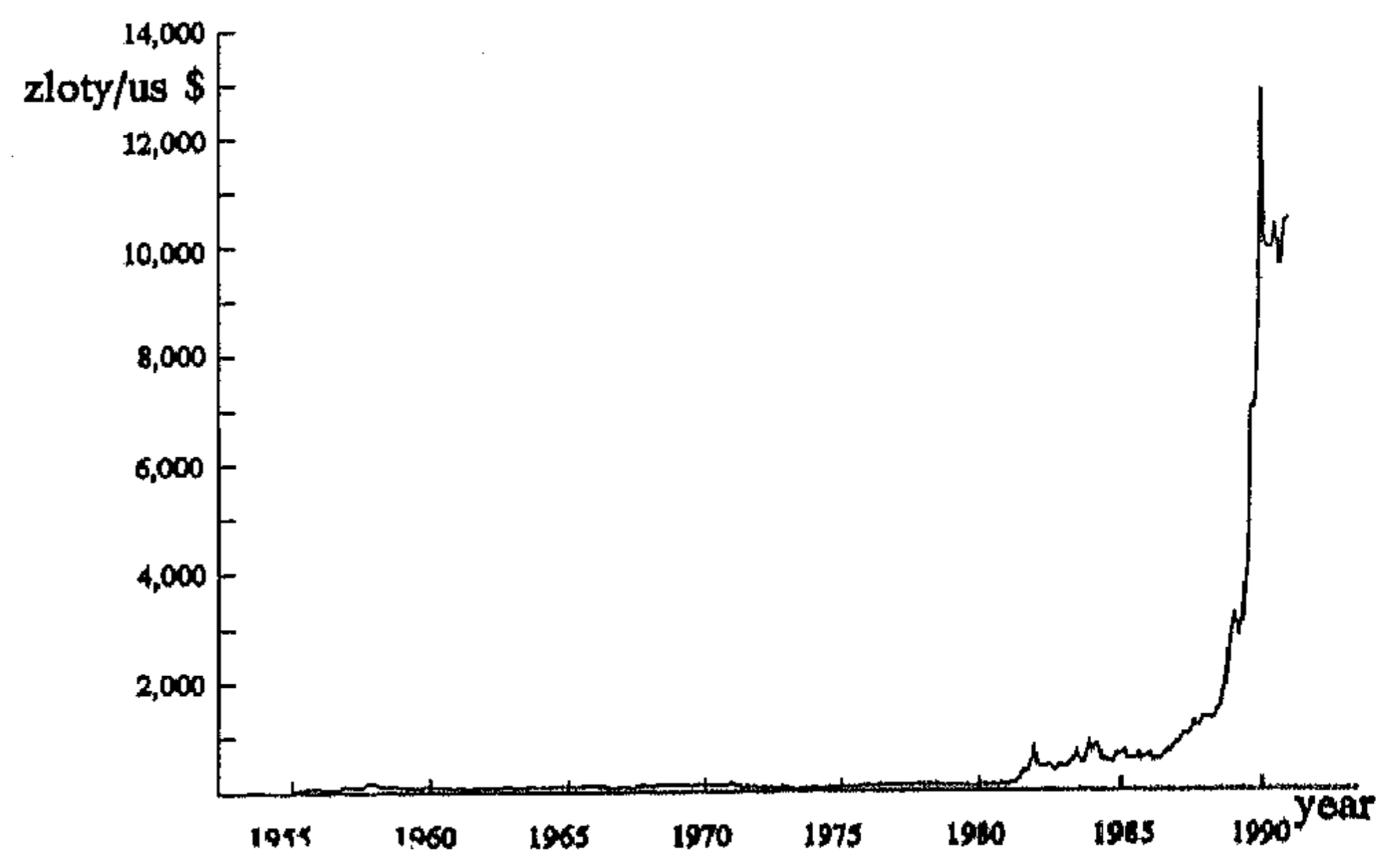


Figure 5. The Exchange Rate of the Polish Zloty Expressed in U.S. Dollars, January 1955–December 1990.

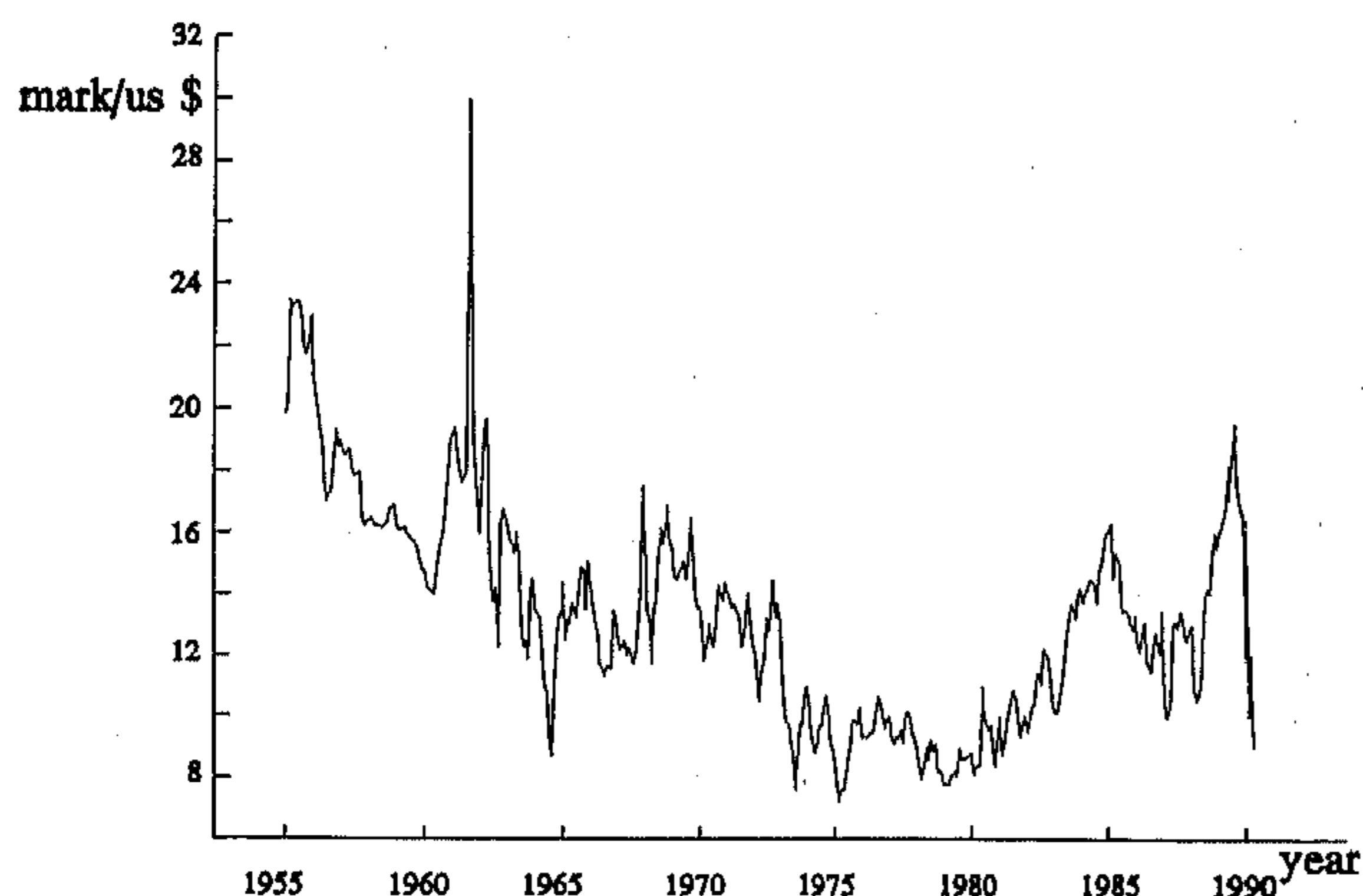


Figure 3. The Exchange Rate of the East German Mark Expressed in U.S. Dollars, January 1955–May 1990.

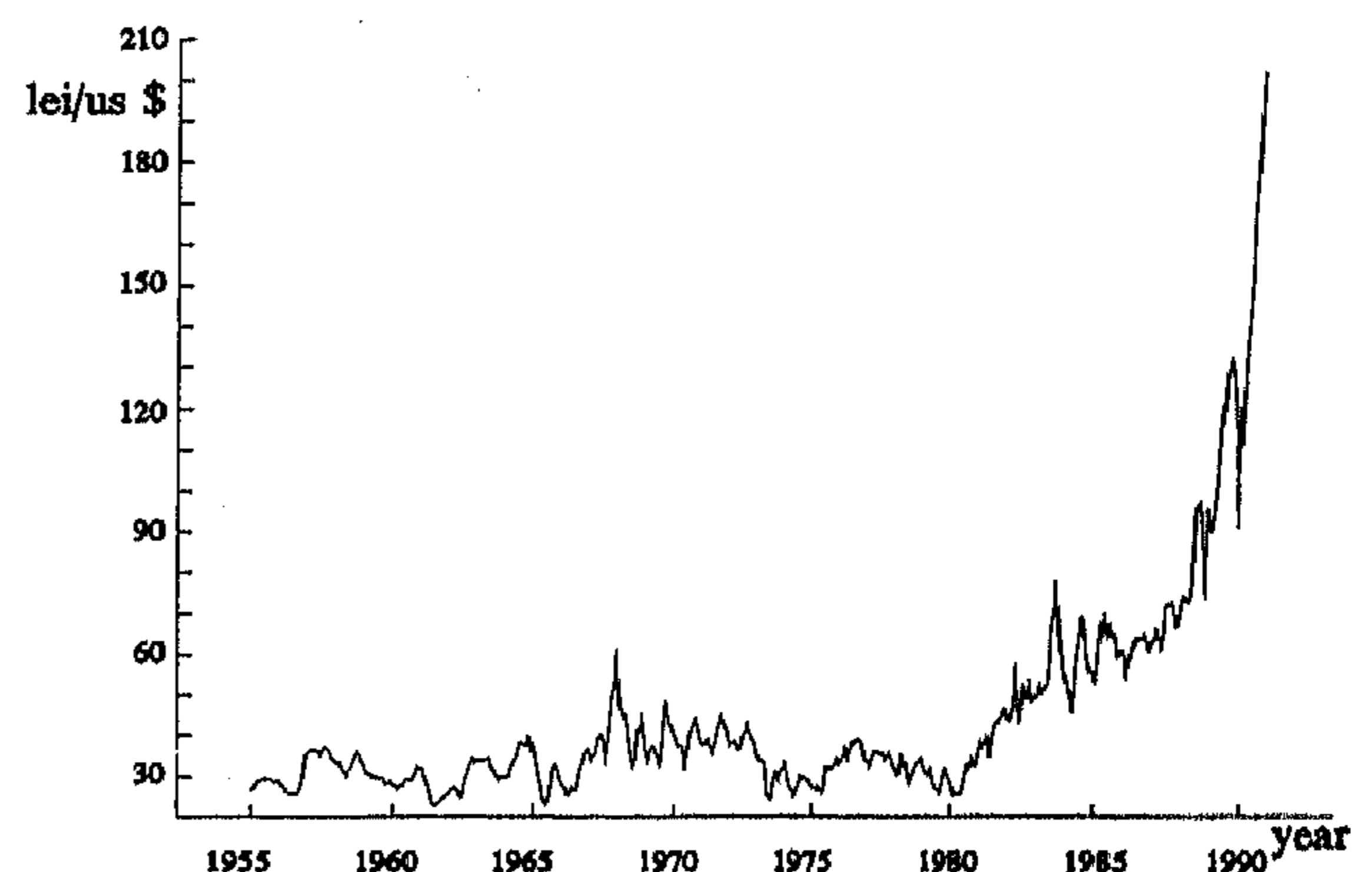


Figure 6. The Exchange Rate of the Rumanian Lei Expressed in U.S. Dollars, January 1955–December 1990.

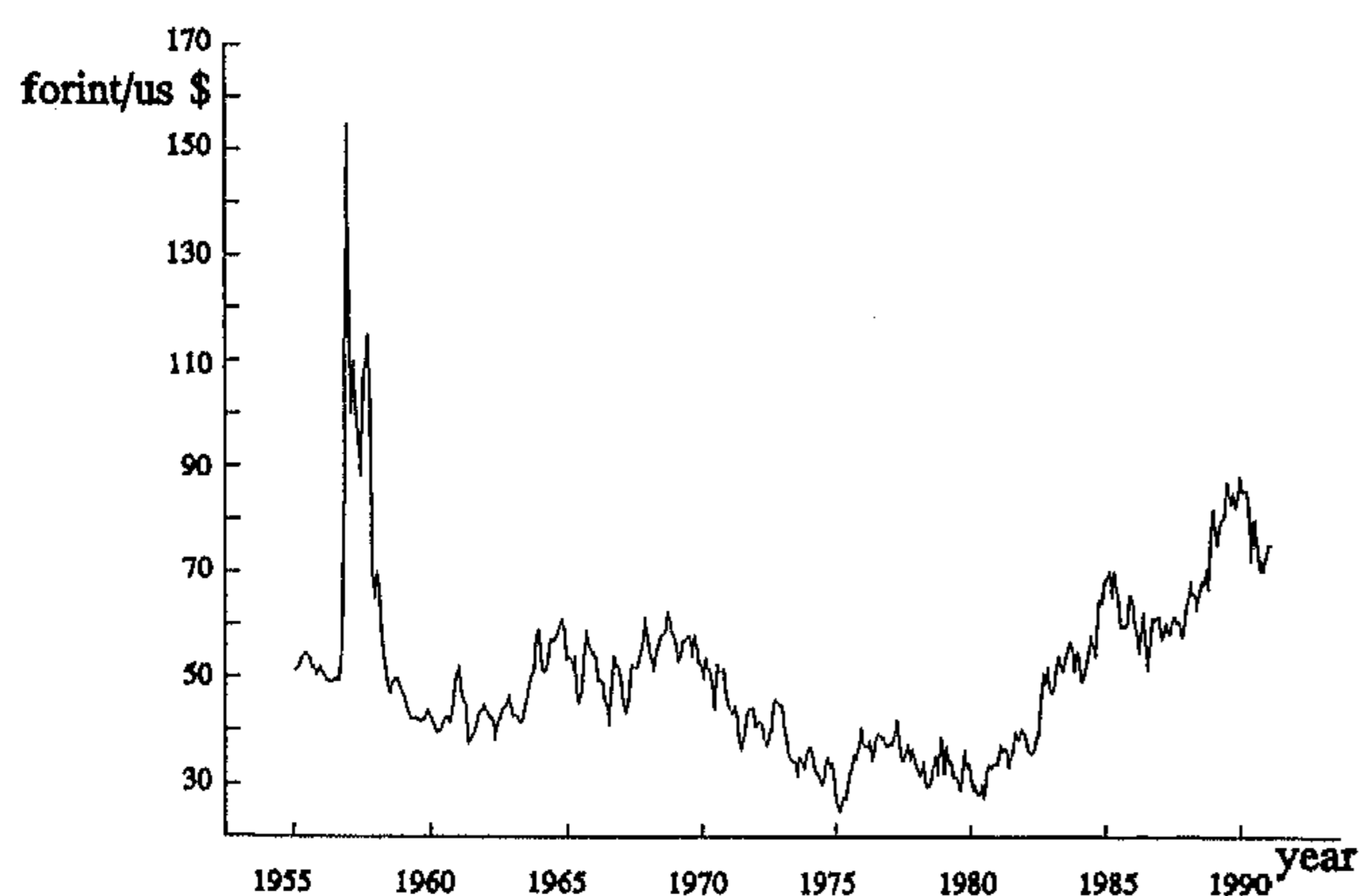


Figure 4. The Exchange Rate of the Hungarian Forint Expressed in U.S. Dollars, January 1955–December 1990.

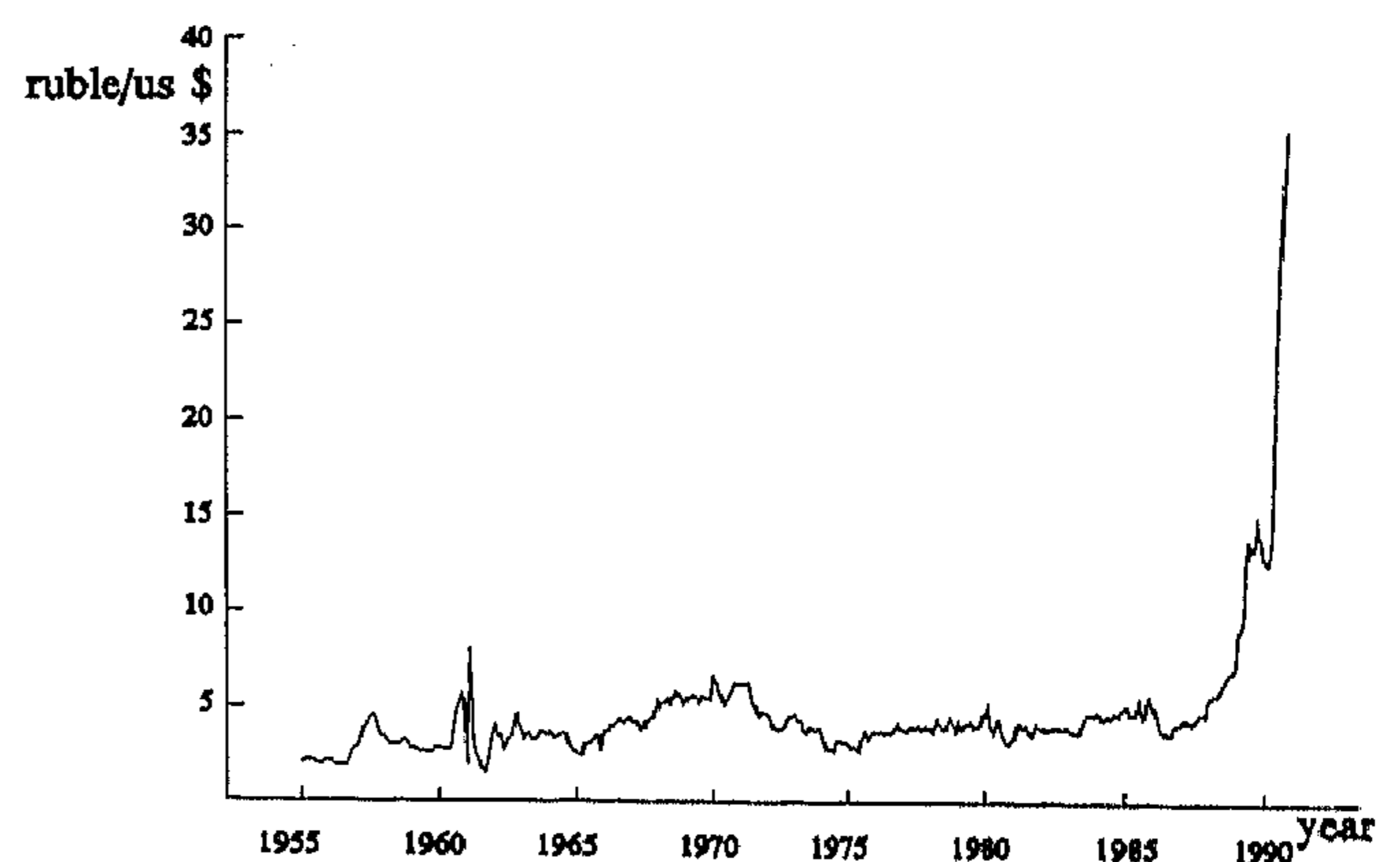


Figure 7. The Exchange Rate of the U.S.S.R. Ruble Expressed in U.S. Dollars, January 1955–December 1990.

U.S.S.R., the original data as given in the Appendix are used for the figures and our further empirical analysis. In Bulgaria and the U.S.S.R., however, currency reforms took place in December 1961 and January 1961, respectively. Both times, 1 new currency unit was set equal to 10 old ones. Although the Appendix contains the original data, we converted the exchange-rate ob-

servations prior to the time of currency reforms to new currency units and used these in our figures and analysis.

Generally, the figures show much variability in exchange rates. Outliers often can be assigned to specific political events. Examples are the Hungarian uprising of 1956 with the subsequent Russian intervention, the

building of the Berlin Wall in 1961, and the revolt in Czechoslovakia in 1968 with, again, Russian intervention. Each time a large (temporary) depreciation of the currency of the country concerned versus the dollar is observed.

A second phenomenon present in all countries except Russia is the continuing depreciation in the early eighties. This may to some extent be attributed to the worldwide rise of the dollar in this period. Especially in Poland, however, the home depreciation is too strong for this to be the whole story. Economic and political developments at home must have contributed to the rapid decline in home currency value. Similarly, the exponential depreciation in Poland, Bulgaria, Rumania, and the U.S.S.R. from 1988 onward no doubt is attributable to the "peaceful" economic and political reforms taking place at the time. Interestingly, the East German mark sharply appreciates after mid-1989, due, of course, to the increasing prospects of monetary and economic unification with West Germany.

In applied work with exchange rates from floating regimes, returns generally are preferred to levels. Where the logarithm of the spot rate is nonstationary and often strongly skewed, returns are stationary and exhibit little or no serial correlation. Sample moments of the empirical return distributions indicate absence of skewness. Table 1 presents the relevant summary statistics for the black-market exchange-rate returns used here. Returns are expressed as percentages per month.

Exchange-rate returns on East European black markets appear to display the same behavior as floating exchange-rate returns in general when evaluated according to the usual tests. The *S* test on skewness is not significant for any country at even the 10% level (critical value = 1.64). Symmetry thus cannot be rejected. The test on overall normality, on the other hand, points to significant deviations for all countries. All calculated *J* values considerably exceed the critical value of the $\chi^2(2)$ statistic at the 1% level of 9.21. In the absence of significant skewness, kurtosis—that is, fat tails—must be the source of the overall rejection of normality for each country.

Of course, if the third and fourth moments of the underlying distributions are infinite, as suggested by

estimates of α presented later on, one may question the usefulness of the skewness and kurtosis statistics presented here. We nevertheless provide their values as preliminary evidence of nonnormality of exchange-rate returns.

The amount of serial correlation, as measured by ρ in the last column of Table 1, appears to be limited. The associated $\chi^2(1)$ statistic is significant at the 5% level for the Russian ruble only. We therefore assume that serial correlation poses no problem to our estimation procedure.

3. MONTE CARLO EXPERIMENTS: CHOOSING THE OPTIMAL *M* LEVEL

To determine the appropriate value of *m*, the number of tail observations to be used, we have performed a series of Monte Carlo experiments. Each Monte Carlo experiment consists of 200 replications of *n* draws from four different Student-*t* distributions with degrees of freedom ($=\alpha$) equal to 1, 2, 3, and 4. Separate experiments are conducted using the information in both tails or in the positive (right) tail only and for *n* = 431 and *n* = 215. Optimal *m* levels are selected by minimizing the mean squared error (MSE) across replications. This criterion is appropriate given the asymptotic normality of the estimator. Table 2 contains the simulation results.

A few points stand out. First, the optimal *m* levels are inversely related to α , as could be expected; with lower α and fatter tails more observations are clustered in the tails and carry information about the tail index. Second, the optimal *m* levels for *n* = 431 only using the right tail resemble those for *n* = 215—half the number of observations—using both tails. This exemplifies the gain in precision to be obtained when shifting from one to both tails.

The literature is ambiguous about the correct value of α , although values in the range 1–4 are most common (see, for example, Boothe and Glassman 1987). As our focus is on testing the existence of finite second moments—that is, on the issue of α smaller or larger than 2—we use the *m* levels associated with $\alpha = 2$ in the subsequent empirical analysis of exchange-rate returns.

Table 1. Empirical Distribution Characteristics of East European Exchange-Rate Returns, February 1955–December 1990 (*n* = 431)

| Currency | Mean | Variance | Skewness | Kurtosis | <i>S</i> test ^a | <i>J</i> test ^b | ρ^c |
|---------------------|------|----------|----------|----------|----------------------------|----------------------------|----------|
| Bulgarian lev | .41 | 57.72 | .96 | 7.18 | 1.11 | 378.93 | -.01 |
| Czechoslovak koruna | .02 | 33.79 | .55 | 4.97 | 1.49 | 91.65 | .03 |
| East German mark | -.24 | 55.34 | .50 | 10.31 | .43 | 978.55 | .05 |
| Hungarian forint | .09 | 54.54 | 1.25 | 14.47 | .82 | 2,475.12 | .08 |
| Polish zloty | 1.24 | 98.14 | .59 | 7.27 | 1.20 | 352.18 | -.01 |
| Rumanian lei | .46 | 56.50 | -2.82 | 4.73 | .14 | 53.96 | .02 |
| Soviet ruble | .66 | 134.84 | 2.68 | 56.31 | .72 | 51,551.57 | -.11 |

^a *S* test: $2(\# \text{ obs. below mean} - n/2)\sqrt{n} \sim N(0, 1)$ for $n \rightarrow \infty$.

^b *J* test: $n[\text{skewness}^2/6 + (\text{kurtosis}-3)^2/24] \sim \chi^2(2)$.

^c ρ : first-order serial correlation.

Table 2. Optimal Choice of m Through Monte Carlo Results

| | | α | | | |
|-----------|-----------------|----------|----|----|----|
| | | 1 | 2 | 3 | 4 |
| $n = 431$ | Right tail only | 51 | 33 | 13 | 15 |
| | Both tails | 114 | 52 | 28 | 19 |
| $n = 215$ | Right tail only | 34 | 20 | 9 | 6 |
| | Both tails | 68 | 31 | 17 | 11 |

4. EMPIRICAL RESULTS

In Table 3 we summarize the results with respect to the tail-index estimates for all countries over the whole sample. The first three columns contain the tail-index estimates for the right tail ($\hat{\alpha}^+$), the left tail ($\hat{\alpha}^-$), and for both tails together ($\hat{\alpha}^*$), respectively, with asymptotic standard errors given in parentheses below the estimates. In the next column, we test for equality of the tail indexes of the right and left tails of the return distributions, using the asymptotic normality of the tail-index estimates. The asymptotic variance of the difference ($\hat{\alpha}^+ - \hat{\alpha}^-$) is equal to the sum of the two individual variances, $[\sigma^2(\hat{\alpha}^+) + \sigma^2(\hat{\alpha}^-)]$, and may be calculated as $[(\hat{\alpha}^+)^2/33 + (\hat{\alpha}^-)^2/33]$ following the results in Section 1. In the last column, we test for $\hat{\alpha}^*$ smaller or larger than 2.

From the table, it appears that all exchange rates are characterized by point estimates for α in excess of 2. Equality of the left and right tail indexes is never rejected. In all cases, the test statistic is far below the 5% critical value of 1.96. This warrants simultaneous use of both tails in the further analysis. From now on, we will focus, therefore, on $\hat{\alpha}^*$.

The null hypothesis of $H_0: \alpha < 2$ against the alternative $H_1: \alpha \geq 2$ is rejected at the 5% level if the test statistic exceeds 1.64. For the alternative test of $H_0: \alpha \geq 2$ versus $H_1: \alpha < 2$, H_0 is rejected at the 5% level if

the test statistic is below -1.64 . Summarizing the results in the last column, we conclude that $H_0: \alpha \geq 2$ is never rejected, whereas $H_0: \alpha \leq 2$ is rejected for four out of seven currencies—the Bulgarian lev, the Czechoslovak koruna, the Hungarian forint, and the Rumanian lei. This suggests the existence of finite second moments for at least four currencies.

Note that for those currencies in which the null hypothesis of $\alpha \leq 2$ is rejected the sum-stable distribution is rejected as a potential generating distribution of exchange-rate returns. Similarly, Student- t distributions with less than 2 df are rejected for these currencies.

Since the choice of m may influence our empirical results, we now apply a sensitivity analysis and report tail-index estimates for various choices of m around the optimal m level of 52. The relevance of this exercise is also suggested by our Monte Carlo results. In some of the Monte Carlo experiments, the MSE criterion is approximately constant for a range of m values, with more than one local minimum. Table 4 contains the results of our sensitivity analysis.

The results show that the amount of variation in tail-index estimates across different choices of m , considerably differs between countries; for the zloty, the mark, and the ruble, the width of the range is at most .13, while the range is .67 for the Rumanian lei. There appears to be a tendency for currencies with relatively high α 's, such as the lei and the koruna, to be more sensitive to variation in m .

More formally, we have investigated whether different choices of m would have influenced our test results for $H_0: \alpha \leq 2$ or $H_0: \alpha \geq 2$. Only the results for the Hungarian forint and the Bulgarian lev are affected. For both currencies, the null hypothesis of $\alpha \leq 2$ was rejected when we used $m = 52$. Such rejection becomes impossible for the forint for m levels below 52 and for the lev for m levels in excess of 52. Note, however, that the 5% percent rejection for $m = 52$ was marginal for

Table 3. Tail-Index Estimates, February 1955–December 1990

| Currency | $\hat{\alpha}^+$ ($m = 33$) | $\hat{\alpha}^-$ ($m = 33$) | $\hat{\alpha}^*$ ($m = 52$) | Test statistics | |
|---------------------|----------------------------------|----------------------------------|----------------------------------|-----------------------------------|----------------------|
| | | | | $\hat{\alpha}^+ = \hat{\alpha}^-$ | $\hat{\alpha}^* = 2$ |
| Bulgarian lev | 2.16 (.38) | 2.78 (.48) | 2.66 (.37) | -1.01 | 1.79 |
| Czechoslovak koruna | 2.66 (.46) | 2.95 (.51) | 3.18 (.44) | -.42 | 2.68 |
| East German mark | 2.31 (.40) | 2.27 (.40) | 2.31 (.32) | .07 | .97 |
| Hungarian forint | 2.25 (.39) | 3.09 (.54) | 2.59 (.36) | -1.26 | 1.64 |
| Polish zloty | 2.10 (.37) | 2.31 (.40) | 2.39 (.33) | -.39 | 1.18 |
| Rumanian lei | 2.83 (.49) | 2.89 (.50) | 3.11 (.43) | -.09 | 2.57 |
| Soviet ruble | 2.25 (.39) | 2.15 (.37) | 2.10 (.29) | .18 | .34 |

NOTE: Asymptotic standard errors are below the tail-index estimates in parentheses.

Table 4. Tail-Index Estimates for Various m Levels: A Sensitivity Analysis, February 1955–December 1990 ($n = 431$)

| Currency | Point estimates of α | | | | | | |
|---------------------|-----------------------------|----------|----------|----------|----------|----------|----------|
| | $m = 40$ | $m = 44$ | $m = 48$ | $m = 52$ | $m = 56$ | $m = 60$ | $m = 64$ |
| Bulgarian lev | 2.76 | 2.85 | 2.72 | 2.66 | 2.54 | 2.53 | 2.38 |
| Czechoslovak koruna | 3.15 | 3.02 | 3.08 | 3.18 | 3.24 | 3.17 | 2.77 |
| East German mark | 3.32 | 2.27 | 2.36 | 2.31 | 2.39 | 2.34 | 2.24 |
| Hungarian forint | 2.39 | 2.46 | 2.46 | 2.59 | 2.69 | 2.69 | 2.63 |
| Polish zloty | 2.41 | 2.39 | 2.38 | 2.39 | 2.40 | 2.51 | 2.46 |
| Rumanian lei | 3.38 | 3.48 | 3.15 | 3.11 | 2.84 | 2.92 | 2.81 |
| Soviet ruble | 2.14 | 2.08 | 2.13 | 2.10 | 2.10 | 2.17 | 2.19 |

precisely these two currencies. In short, we conclude that our tail-index estimates are indeed somewhat sensitive to the particular choice of m , but that our test results appear quite robust. A different choice of m may change the verdict only in borderline cases in which calculated test statistics are quite close to the applied critical values.

Next, we investigate the stability of α over time for each country. We estimate the tail indexes for two subperiods of equal length, February 1955–December 1972 ($n_1 = 215$) and January 1973–December 1990 ($n_2 = 216$), using the appropriate m level of 31, as shown in Table 2. We formally test for equality of the α 's using the asymptotic normality of $\hat{\alpha}_1$ and $\hat{\alpha}_2$ and thus of the difference between them. We also test $H_0: \alpha \leq 2$ and $H_0: \alpha \geq 2$, respectively. The results are shown in Table 5.

Table 5 clearly shows that tail-index estimates for the koruna, forint, and ruble have substantially risen from the first to the second period so that equality across periods has to be rejected. For these three currencies, $H_0: \alpha \leq 2$ has to be rejected for the second period but not for the first one. The rejection of $H_0: \alpha \leq 2$ for the forint and koruna over the whole period, as displayed

in Table 3, thus appears largely due to the tail behavior of returns in the second part of the sample. For the whole period, we could also reject the hypothesis $\alpha \leq 2$ for the Bulgarian lev and the Rumanian lei; this is not possible for each of the two subperiods. With respect to the lev, this appears to be caused primarily by the increase in precision when using the whole sample. For the Rumanian lei, however, the tail index for the whole sample is also substantially higher than in each of the two subperiods, leading to rejection of the hypothesis. The Russian ruble is a special case because its tail index is below 2, though not significantly so, in the first subperiod and significantly higher than 2 in the second one. For the whole sample, some compensation appears to occur, leading to a tail index close to 2. At this point we have no explanation to offer for the puzzling results observed in Table 5. The difference in the tail behavior of exchange-rate returns across the two subperiods warrants further investigation.

Comparing our results with the existing empirical literature on the distributional properties of exchange-rate returns is hazardous because results have generally been obtained through the use of methods requiring a maintained hypothesis about the underlying distribu-

Table 5. Stability of Tail Indexes Across Subperiods

| Currency | $\hat{\alpha}_1$ ($m = 31$) | $\hat{\alpha}_2$ ($m = 31$) | Test statistics | | |
|---------------------|----------------------------------|----------------------------------|-----------------------------------|----------------------|----------------------|
| | | | $\hat{\alpha}_1 = \hat{\alpha}_2$ | $\hat{\alpha}_1 = 2$ | $\hat{\alpha}_2 = 2$ |
| Bulgarian lev | 2.08 (.37) | 2.60 (.47) | -.87 | .21 | 1.28 |
| Czechoslovak koruna | 2.20 (.40) | 4.20 (.75) | -2.35 | .51 | 2.92 |
| East German mark | 2.03 (.36) | 2.57 (.46) | -.92 | .08 | 1.23 |
| Hungarian forint | 2.08 (.37) | 3.41 (.61) | -1.85 | .21 | 2.30 |
| Polish zloty | 2.64 (.47) | 2.34 (.42) | .47 | 1.35 | .81 |
| Rumanian lei | 2.68 (.48) | 2.50 (.45) | .27 | 1.41 | 1.11 |
| Soviet ruble | 1.61 (.29) | 3.11 (.56) | -2.38 | -1.35 | 1.99 |

NOTE: Asymptotic standard errors are below the tail-index estimates in parentheses.

tion. Boothe and Glassman (1987), for example, reported a characteristic exponent—comparable to the tail-index estimate—significantly below 2 under the assumption that a sum-stable distribution is the appropriate one. Using the same data, they also estimated the number of degrees of freedom of an underlying Student- t distribution to equal 3–4, however. Based on goodness-of-fits tests, Boothe and Glassman then concluded that the Student- t distribution is more appropriate in general than the sum-stable one in describing floating exchange-rate returns.

Akgiray et al. (1988) studied Latin American black-market rates and found considerable skewness for most countries considered. Their estimates of the characteristic exponent of the hypothesized stable distribution centered on 1.0. They also performed a tail-shape analysis somewhat similar to ours using a maximum likelihood procedure, yielding estimates of α between .5 and 7. Moreover, the reported confidence intervals were rather large. These findings are in contrast with our results. Using the same technique that we do, Koedijk et al. (1990) documented tail-index estimates around 2 for European Monetary System (EMS) countries both before and after the start of the EMS in 1979.

5. CONCLUSION

In this article, we provide new insights into the empirical distribution of East European black-market exchange-rate returns by focusing on the information in the tails of the distribution. We investigate the amount of tail fatness and the stability of the distribution's tail behavior across time using a tail-index estimator α that is based on extreme-value theory. It appears possible to estimate α directly by simply manipulating some of the higher order statistics. We modify and extend the estimator proposed in the literature to be able to take the information in both tails into account simultaneously.

For a distribution with tail index α , only moments of order smaller than or equal to α exist. We explicitly test for the existence of finite second moments in exchange-rate returns, using the asymptotic normality of $\hat{\alpha}$.

Because α also characterizes the main alternative classes of distribution functions of exchange-rate returns that have been advanced in the literature—that is, the sum-stable and the Student- t distributions—our test results may also allow us to reject some of these classes of distributions. This is facilitated by the fact that estimation of α is independent of a maintained hypothesis about any of these nonnested distributions.

We find no skewness but considerable kurtosis for all empirical exchange-rate distributions considered. Serial correlation is only present in the returns of the Russian ruble. Point estimates of the tail index α are above 2 for all countries over the whole sample period from February 1955 to December 1990. For four out of seven currencies, $H_0: \alpha \leq 2$ can be rejected—the lei, the lev, the forint, and the koruna. For those currencies the sum-stable distribution must be rejected as potential generating distribution. Overall, modest support for the existence of finite second moments is found. This conclusion is quite robust against alternative choices of the number of tail observations used.

We also estimated the tail indexes for two subperiods and found that equality of the tail indexes should be rejected for three of the East European currencies—the forint, the ruble, and the koruna. This evidence points to significant changes in the underlying distributions generating exchange-rate returns over time and warrants further investigation.

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APPENDIX: EAST EUROPEAN BLACK-MARKET EXCHANGE RATES

| <i>Period</i> | <i>Polish zloty</i> | <i>Rumanian lei</i> | <i>Hungarian forint</i> | <i>Bulgarian lev</i> | <i>Czechoslovak koruna</i> | <i>Russian ruble</i> | <i>East German mark</i> | |
|---------------|-------------------------|-------------------------|-----------------------------|--------------------------|--------------------------------|--------------------------|---------------------------------|-------|
| 1955 | 1 | 48.50 | 27.00 | 51.25 | 37.25 | 41.00 | 20.50 | 19.85 |
| | 2 | 49.00 | 27.25 | 51.50 | 37.50 | 41.50 | 20.75 | 20.15 |
| | 3 | 53.50 | 28.50 | 52.00 | 38.50 | 42.75 | 21.25 | 23.50 |
| | 4 | 65.00 | 29.00 | 53.00 | 38.75 | 43.75 | 21.50 | 23.25 |
| | 5 | 66.00 | 29.00 | 54.00 | 39.00 | 43.00 | 21.25 | 23.35 |
| | 6 | 68.50 | 29.50 | 54.50 | 38.50 | 43.50 | 21.00 | 23.45 |
| | 7 | 79.50 | 29.25 | 54.00 | 38.00 | 44.50 | 20.50 | 23.40 |
| | 8 | 90.00 | 29.50 | 53.50 | 38.50 | 45.50 | 19.75 | 23.00 |
| | 9 | 82.50 | 29.00 | 52.00 | 37.50 | 44.25 | 19.50 | 22.00 |
| | 10 | 81.50 | 28.50 | 51.75 | 37.00 | 44.00 | 19.00 | 21.75 |
| | 11 | 82.50 | 28.75 | 50.50 | 37.50 | 43.75 | 20.00 | 22.00 |
| | 12 | 84.00 | 29.00 | 52.00 | 38.50 | 45.50 | 21.50 | 23.00 |
| 1956 | 1 | 81.50 | 28.00 | 51.25 | 37.25 | 44.00 | 21.75 | 21.00 |
| | 2 | 80.00 | 28.00 | 50.75 | 37.00 | 43.00 | 21.00 | 20.50 |
| | 3 | 76.50 | 26.75 | 49.75 | 36.00 | 41.50 | 20.00 | 20.00 |
| | 4 | 74.25 | 26.00 | 49.25 | 35.00 | 40.25 | 19.00 | 19.40 |
| | 5 | 72.50 | 25.50 | 49.00 | 34.50 | 40.00 | 18.75 | 18.75 |
| | 6 | 71.50 | 26.00 | 49.25 | 34.00 | 40.00 | 18.50 | 17.70 |
| | 7 | 76.00 | 25.50 | 49.50 | 34.25 | 40.50 | 19.00 | 17.00 |
| | 8 | 79.00 | 26.00 | 50.00 | 34.25 | 40.00 | 19.25 | 17.25 |
| | 9 | 74.00 | 26.15 | 49.50 | 34.00 | 39.75 | 19.00 | 17.30 |
| | 10 | 82.00 | 28.75 | 56.50 | 36.50 | 43.00 | 23.00 | 18.50 |
| | 11 | 110.00 | 32.75 | 88.00 | 40.50 | 50.50 | 26.50 | 19.35 |
| | 12 | 135.00 | 35.50 | 155.00 | 43.00 | 53.00 | 27.50 | 18.75 |
| 1957 | 1 | 125.00 | 36.00 | 117.50 | 43.50 | 54.25 | 28.75 | 19.00 |
| | 2 | 125.00 | 36.50 | 100.00 | 44.00 | 54.50 | 28.50 | 18.60 |
| | 3 | 125.00 | 36.00 | 110.00 | 44.50 | 52.50 | 33.00 | 18.50 |
| | 4 | 115.00 | 36.50 | 100.00 | 45.00 | 54.00 | 37.50 | 18.70 |
| | 5 | 110.00 | 36.00 | 95.00 | 45.00 | 53.50 | 39.50 | 18.65 |
| | 6 | 115.00 | 35.00 | 88.00 | 44.00 | 52.00 | 41.00 | 18.00 |
| | 7 | 130.00 | 36.75 | 105.00 | 46.50 | 53.50 | 44.00 | 17.86 |
| | 8 | 135.00 | 37.00 | 110.00 | 46.00 | 54.00 | 45.00 | 17.90 |
| | 9 | 170.00 | 36.50 | 115.00 | 45.00 | 53.00 | 44.50 | 18.00 |
| | 10 | 180.00 | 36.00 | 100.00 | 44.00 | 52.50 | 41.50 | 16.50 |
| | 11 | 175.00 | 34.25 | 70.00 | 40.00 | 51.25 | 37.00 | 16.25 |
| | 12 | 170.00 | 34.00 | 65.00 | 38.50 | 50.50 | 35.00 | 16.35 |
| 1958 | 1 | 185.00 | 33.00 | 70.00 | 37.50 | 49.50 | 33.75 | 16.40 |
| | 2 | 170.00 | 33.50 | 67.50 | 38.00 | 50.00 | 33.50 | 16.50 |
| | 3 | 140.00 | 32.00 | 59.00 | 36.50 | 48.00 | 31.50 | 16.35 |
| | 4 | 115.00 | 31.00 | 55.00 | 35.00 | 47.00 | 30.00 | 16.25 |
| | 5 | 120.00 | 29.75 | 51.50 | 33.00 | 44.50 | 29.00 | 16.20 |
| | 6 | 110.00 | 31.50 | 48.50 | 33.50 | 42.50 | 30.00 | 16.20 |
| | 7 | 115.00 | 32.00 | 47.00 | 33.00 | 41.25 | 29.00 | 16.15 |
| | 8 | 120.00 | 33.75 | 49.00 | 34.50 | 43.00 | 30.00 | 16.30 |
| | 9 | 125.00 | 34.50 | 49.50 | 35.00 | 44.50 | 31.00 | 16.35 |
| | 10 | 135.00 | 36.00 | 49.75 | 36.75 | 44.25 | 31.75 | 16.75 |
| | 11 | 125.00 | 35.25 | 48.00 | 35.50 | 42.75 | 31.00 | 16.85 |
| | 12 | 115.00 | 33.50 | 47.50 | 34.00 | 41.50 | 30.00 | 16.90 |
| 1959 | 1 | 110.00 | 33.00 | 46.50 | 33.50 | 40.50 | 28.00 | 16.25 |
| | 2 | 105.00 | 31.00 | 45.00 | 32.00 | 39.25 | 27.50 | 16.10 |
| | 3 | 102.00 | 30.50 | 43.25 | 31.75 | 39.00 | 27.00 | 16.15 |
| | 4 | 100.00 | 30.25 | 42.15 | 31.25 | 38.50 | 26.75 | 16.20 |
| | 5 | 96.00 | 29.50 | 42.00 | 31.00 | 37.50 | 26.50 | 16.00 |
| | 6 | 95.00 | 29.75 | 42.50 | 31.25 | 37.75 | 27.00 | 15.90 |
| | 7 | 94.00 | 29.50 | 42.00 | 31.00 | 38.00 | 26.50 | 15.80 |
| | 8 | 93.00 | 29.50 | 41.85 | 31.00 | 37.50 | 26.25 | 15.75 |
| | 9 | 100.00 | 29.25 | 42.00 | 30.75 | 37.20 | 25.50 | 15.60 |
| | 10 | 115.00 | 28.00 | 43.00 | 31.00 | 36.50 | 27.00 | 15.25 |
| | 11 | 120.00 | 28.50 | 44.00 | 31.25 | 37.00 | 28.00 | 15.00 |
| | 12 | 115.00 | 28.75 | 43.00 | 31.50 | 37.00 | 28.50 | 14.75 |
| 1960 | 1 | 110.00 | 28.00 | 42.00 | 32.00 | 36.50 | 28.00 | 14.80 |
| | 2 | 105.00 | 27.50 | 41.00 | 31.25 | 36.00 | 27.50 | 14.25 |
| | 3 | 100.00 | 27.00 | 39.50 | 31.75 | 35.50 | 27.00 | 14.15 |
| | 4 | 100.00 | 28.00 | 40.25 | 31.50 | 36.00 | 27.50 | 14.10 |
| | 5 | 97.00 | 27.50 | 40.00 | 31.00 | 35.75 | 27.50 | 14.00 |
| | 6 | 96.00 | 28.50 | 41.25 | 31.50 | 36.00 | 28.00 | 14.50 |
| | 7 | 105.00 | 29.50 | 42.50 | 32.00 | 37.50 | 40.00 | 15.25 |

| | | | | | | | | |
|------|----|--------|-------|-------|-------|-------|-------|-------|
| | 8 | 100.00 | 29.00 | 42.75 | 32.00 | 37.00 | 48.50 | 15.75 |
| | 9 | 100.00 | 29.50 | 41.50 | 33.00 | 36.00 | 50.00 | 16.00 |
| | 10 | 95.00 | 30.50 | 44.00 | 34.00 | 37.50 | 55.00 | 17.00 |
| | 11 | 85.00 | 32.50 | 48.00 | 36.00 | 38.50 | 57.50 | 18.00 |
| | 12 | 95.00 | 31.50 | 51.00 | 35.00 | 38.00 | 45.00 | 19.00 |
| 1961 | 1 | 98.00 | 32.00 | 52.25 | 36.00 | 37.50 | 20.00 | 19.25 |
| | 2 | 87.50 | 30.00 | 47.00 | 31.25 | 34.00 | 8.00 | 19.37 |
| | 3 | 82.50 | 28.50 | 45.75 | 33.00 | 30.00 | 6.00 | 18.50 |
| | 4 | 82.00 | 26.50 | 45.00 | 31.00 | 29.50 | 3.00 | 18.00 |
| | 5 | 75.00 | 23.50 | 37.65 | 29.00 | 27.75 | 2.40 | 17.60 |
| | 6 | 68.00 | 23.00 | 38.00 | 28.00 | 25.00 | 2.25 | 17.75 |
| | 7 | 70.00 | 23.00 | 39.40 | 28.50 | 26.00 | 1.83 | 18.00 |
| | 8 | 80.00 | 23.50 | 39.75 | 29.00 | 28.00 | 1.66 | 30.00 |
| | 9 | 82.00 | 24.00 | 42.00 | 29.75 | 29.50 | 1.50 | 25.00 |
| | 10 | 85.00 | 24.50 | 43.75 | 31.00 | 30.00 | 2.00 | 19.00 |
| | 11 | 88.00 | 25.50 | 43.80 | 31.00 | 30.50 | 2.60 | 18.00 |
| | 12 | 90.00 | 25.75 | 44.90 | 31.50 | 31.00 | 3.25 | 17.00 |
| 1962 | 1 | 89.00 | 26.50 | 43.80 | 4.32 | 30.25 | 3.75 | 16.00 |
| | 2 | 95.00 | 26.85 | 43.25 | 4.40 | 33.25 | 4.00 | 17.50 |
| | 3 | 100.00 | 27.25 | 42.35 | 4.38 | 31.00 | 3.30 | 19.60 |
| | 4 | 105.00 | 27.00 | 42.00 | 4.42 | 30.00 | 3.50 | 19.70 |
| | 5 | 95.00 | 25.50 | 38.25 | 4.00 | 28.00 | 2.75 | 16.00 |
| | 6 | 94.00 | 25.00 | 41.50 | 4.10 | 27.00 | 2.85 | 14.00 |
| | 7 | 98.50 | 28.00 | 42.25 | 4.15 | 28.00 | 3.25 | 13.75 |
| | 8 | 100.00 | 30.00 | 43.50 | 4.20 | 28.50 | 3.35 | 14.25 |
| | 9 | 110.00 | 32.00 | 44.50 | 4.25 | 30.00 | 3.50 | 12.25 |
| | 10 | 115.00 | 33.00 | 44.50 | 4.50 | 33.00 | 4.00 | 16.25 |
| | 11 | 118.00 | 35.00 | 47.00 | 4.75 | 39.00 | 4.60 | 16.75 |
| | 12 | 105.00 | 33.00 | 44.75 | 4.50 | 37.50 | 4.00 | 16.60 |
| 1963 | 1 | 99.00 | 34.50 | 42.60 | 4.60 | 40.00 | 3.75 | 16.25 |
| | 2 | 95.00 | 33.50 | 43.00 | 4.50 | 38.50 | 3.30 | 15.75 |
| | 3 | 100.00 | 34.50 | 42.50 | 4.65 | 38.75 | 3.50 | 15.60 |
| | 4 | 100.00 | 34.00 | 41.60 | 4.60 | 38.50 | 3.60 | 15.35 |
| | 5 | 98.00 | 34.50 | 42.00 | 4.50 | 38.75 | 3.40 | 16.00 |
| | 6 | 100.00 | 34.60 | 44.35 | 4.50 | 38.50 | 3.30 | 15.25 |
| | 7 | 105.00 | 32.00 | 46.20 | 4.00 | 34.50 | 3.30 | 13.00 |
| | 8 | 110.00 | 31.75 | 49.00 | 4.00 | 34.25 | 3.35 | 12.25 |
| | 9 | 105.00 | 30.25 | 50.40 | 3.90 | 34.50 | 3.65 | 12.50 |
| | 10 | 108.00 | 29.00 | 50.85 | 3.50 | 36.00 | 3.60 | 11.90 |
| | 11 | 107.50 | 30.00 | 58.00 | 3.60 | 36.50 | 3.60 | 14.25 |
| | 12 | 105.00 | 29.75 | 59.00 | 3.60 | 36.75 | 3.50 | 14.50 |
| 1964 | 1 | 110.00 | 30.00 | 53.60 | 3.70 | 35.00 | 3.60 | 13.50 |
| | 2 | 110.00 | 30.00 | 51.00 | 3.80 | 33.50 | 3.60 | 13.40 |
| | 3 | 105.00 | 30.50 | 51.20 | 3.70 | 33.75 | 3.30 | 13.25 |
| | 4 | 100.00 | 33.00 | 52.65 | 3.50 | 32.00 | 3.40 | 12.00 |
| | 5 | 100.00 | 34.00 | 57.50 | 3.35 | 36.00 | 3.40 | 11.00 |
| | 6 | 100.00 | 35.00 | 56.75 | 3.30 | 39.00 | 3.50 | 10.75 |
| | 7 | 105.00 | 38.00 | 57.40 | 3.45 | 50.00 | 3.60 | 9.00 |
| | 8 | 110.00 | 38.50 | 58.20 | 3.50 | 48.00 | 3.60 | 8.75 |
| | 9 | 108.00 | 37.50 | 59.90 | 3.00 | 45.00 | 3.20 | 11.00 |
| | 10 | 112.50 | 37.15 | 61.00 | 3.15 | 41.00 | 2.90 | 12.25 |
| | 11 | 110.00 | 40.00 | 58.85 | 3.15 | 41.50 | 2.70 | 13.35 |
| | 12 | 105.00 | 36.00 | 53.25 | 3.08 | 38.50 | 2.60 | 13.25 |
| 1965 | 1 | 107.00 | 38.50 | 54.00 | 3.10 | 39.50 | 2.55 | 14.40 |
| | 2 | 105.00 | 34.50 | 53.50 | 2.90 | 34.50 | 2.50 | 12.50 |
| | 3 | 100.00 | 30.00 | 51.00 | 2.85 | 32.25 | 2.50 | 13.25 |
| | 4 | 100.00 | 28.50 | 54.15 | 3.05 | 32.00 | 3.00 | 13.00 |
| | 5 | 105.00 | 25.00 | 45.40 | 2.80 | 34.50 | 2.95 | 13.75 |
| | 6 | 110.00 | 23.50 | 45.45 | 2.60 | 33.50 | 3.10 | 13.50 |
| | 7 | 105.00 | 23.25 | 47.50 | 2.75 | 34.50 | 3.15 | 13.25 |
| | 8 | 115.00 | 28.00 | 55.70 | 3.15 | 36.50 | 3.30 | 14.35 |
| | 9 | 120.00 | 32.00 | 59.00 | 3.90 | 39.00 | 3.50 | 14.90 |
| | 10 | 115.00 | 33.00 | 55.75 | 3.50 | 37.50 | 3.40 | 14.80 |
| | 11 | 110.00 | 32.25 | 55.00 | 3.65 | 37.25 | 2.70 | 13.50 |
| | 12 | 105.00 | 29.75 | 54.60 | 3.50 | 37.50 | 3.65 | 15.10 |
| 1966 | 1 | 110.00 | 28.00 | 53.50 | 3.50 | 36.50 | 3.70 | 14.15 |
| | 2 | 112.50 | 27.25 | 49.25 | 3.30 | 35.00 | 3.65 | 13.50 |
| | 3 | 115.00 | 25.50 | 49.50 | 3.45 | 32.50 | 3.95 | 13.00 |
| | 4 | 110.00 | 25.40 | 49.00 | 3.25 | 31.75 | 3.90 | 12.70 |
| | 5 | 98.00 | 27.50 | 46.00 | 3.10 | 34.50 | 4.00 | 11.75 |
| | 6 | 90.00 | 26.50 | 44.75 | 3.08 | 34.00 | 4.15 | 11.55 |
| | 7 | 91.50 | 26.80 | 41.00 | 2.98 | 35.50 | 4.30 | 11.35 |
| | 8 | 95.00 | 31.00 | 49.25 | 2.92 | 36.25 | 4.10 | 11.60 |

(continued)

APPENDIX: EAST EUROPEAN BLACK-MARKET EXCHANGE RATES (Continued)

| Period | Polish zloty | Rumanian lei | Hungarian forint | Bulgarian lev | Czechoslovak koruna | Russian ruble | East German mark | |
|--------|-----------------|-----------------|---------------------|------------------|------------------------|------------------|------------------------|-------|
| | 9 | 98.50 | 33.00 | 54.00 | 3.10 | 37.50 | 4.15 | 11.65 |
| | 10 | 102.50 | 35.00 | 52.00 | 3.25 | 37.75 | 4.30 | 11.50 |
| | 11 | 115.00 | 36.50 | 51.95 | 3.40 | 39.25 | 4.35 | 13.50 |
| | 12 | 117.00 | 36.50 | 50.00 | 3.30 | 39.00 | 4.35 | 13.30 |
| 1967 | 1 | 102.50 | 33.75 | 46.50 | 3.00 | 34.00 | 4.15 | 12.50 |
| | 2 | 100.00 | 34.75 | 43.50 | 2.85 | 34.65 | 4.20 | 12.20 |
| | 3 | 98.00 | 35.70 | 43.40 | 2.70 | 36.30 | 4.15 | 12.25 |
| | 4 | 94.00 | 38.90 | 47.15 | 2.75 | 37.25 | 3.75 | 12.50 |
| | 5 | 100.00 | 40.00 | 52.50 | 2.72 | 37.00 | 3.85 | 12.00 |
| | 6 | 110.00 | 39.50 | 52.00 | 2.78 | 38.00 | 4.25 | 12.25 |
| | 7 | 110.00 | 33.00 | 51.75 | 2.90 | 41.50 | 3.80 | 12.00 |
| | 8 | 117.00 | 38.00 | 52.50 | 3.50 | 40.75 | 4.30 | 11.75 |
| | 9 | 122.00 | 44.00 | 54.50 | 3.55 | 42.50 | 4.30 | 12.00 |
| | 10 | 133.00 | 50.00 | 56.00 | 3.70 | 41.50 | 4.40 | 13.00 |
| | 11 | 115.00 | 52.00 | 61.50 | 3.88 | 40.65 | 4.85 | 14.00 |
| | 12 | 124.00 | 61.00 | 58.00 | 4.00 | 38.75 | 5.40 | 17.50 |
| 1968 | 1 | 115.00 | 47.50 | 55.00 | 3.50 | 37.00 | 4.85 | 15.75 |
| | 2 | 115.75 | 46.00 | 53.50 | 3.40 | 38.25 | 5.20 | 13.35 |
| | 3 | 120.00 | 44.00 | 51.40 | 3.30 | 36.50 | 5.25 | 13.30 |
| | 4 | 125.00 | 45.35 | 54.57 | 3.43 | 37.50 | 5.20 | 11.75 |
| | 5 | 137.00 | 40.00 | 56.12 | 3.60 | 38.80 | 5.45 | 13.50 |
| | 6 | 140.00 | 34.75 | 57.75 | 3.70 | 39.50 | 5.15 | 13.80 |
| | 7 | 132.00 | 32.25 | 58.00 | 3.39 | 42.00 | 5.45 | 15.25 |
| | 8 | 140.00 | 34.50 | 58.00 | 3.60 | 44.00 | 5.90 | 16.15 |
| | 9 | 155.00 | 42.00 | 62.50 | 4.20 | 57.25 | 5.50 | 15.60 |
| | 10 | 149.00 | 40.30 | 60.90 | 4.10 | 58.25 | 5.75 | 16.15 |
| | 11 | 140.00 | 45.00 | 58.00 | 4.16 | 57.50 | 5.40 | 16.90 |
| | 12 | 145.00 | 40.15 | 58.00 | 4.08 | 61.00 | 5.15 | 15.65 |
| 1969 | 1 | 140.00 | 35.15 | 55.40 | 3.92 | 62.50 | 5.45 | 15.55 |
| | 2 | 140.00 | 33.35 | 53.00 | 3.57 | 60.25 | 5.38 | 14.60 |
| | 3 | 145.00 | 36.50 | 54.10 | 3.70 | 61.00 | 5.50 | 14.50 |
| | 4 | 144.00 | 37.25 | 57.10 | 3.65 | 59.00 | 5.65 | 14.65 |
| | 5 | 125.00 | 36.90 | 56.70 | 3.67 | 55.00 | 5.55 | 14.80 |
| | 6 | 115.00 | 33.90 | 57.75 | 3.38 | 67.50 | 5.40 | 15.10 |
| | 7 | 115.00 | 32.25 | 57.75 | 3.01 | 59.00 | 5.20 | 14.50 |
| | 8 | 120.00 | 39.00 | 54.05 | 3.25 | 70.00 | 5.50 | 15.15 |
| | 9 | 143.00 | 47.60 | 58.00 | 3.90 | 70.00 | 5.40 | 16.50 |
| | 10 | 147.50 | 48.25 | 56.85 | 3.95 | 72.50 | 5.41 | 15.70 |
| | 11 | 138.00 | 42.55 | 52.65 | 3.77 | 60.00 | 5.41 | 13.90 |
| | 12 | 143.50 | 42.20 | 52.50 | 3.83 | 55.00 | 5.40 | 13.50 |
| 1970 | 1 | 132.50 | 40.00 | 49.75 | 3.82 | 50.00 | 6.60 | 13.65 |
| | 2 | 134.00 | 39.00 | 53.70 | 3.45 | 47.00 | 6.30 | 12.75 |
| | 3 | 130.00 | 37.25 | 51.90 | 3.05 | 45.00 | 6.35 | 11.80 |
| | 4 | 120.00 | 37.75 | 51.25 | 3.12 | 40.00 | 5.65 | 12.30 |
| | 5 | 135.00 | 37.00 | 47.75 | 3.17 | 42.00 | 5.50 | 13.00 |
| | 6 | 118.00 | 31.75 | 44.00 | 3.03 | 45.00 | 5.14 | 12.50 |
| | 7 | 122.50 | 35.45 | 52.65 | 3.13 | 42.25 | 5.33 | 12.30 |
| | 8 | 128.00 | 40.00 | 51.00 | 3.55 | 43.00 | 5.55 | 13.00 |
| | 9 | 127.50 | 41.30 | 51.00 | 3.51 | 40.00 | 5.71 | 14.35 |
| | 10 | 129.00 | 43.50 | 51.75 | 3.60 | 39.00 | 6.10 | 14.00 |
| | 11 | 125.00 | 44.10 | 46.95 | 3.66 | 42.50 | 6.25 | 13.80 |
| | 12 | 180.00 | 41.20 | 45.00 | 3.55 | 39.00 | 6.15 | 14.40 |
| 1971 | 1 | 145.00 | 38.20 | 44.00 | 3.30 | 39.00 | 6.15 | 14.10 |
| | 2 | 140.00 | 37.65 | 43.00 | 3.12 | 38.00 | 6.25 | 13.85 |
| | 3 | 127.50 | 37.75 | 44.75 | 2.92 | 36.50 | 6.15 | 13.55 |
| | 4 | 110.00 | 39.00 | 43.00 | 2.85 | 36.00 | 6.20 | 13.70 |
| | 5 | 100.00 | 37.50 | 38.00 | 2.74 | 34.60 | 6.20 | 13.40 |
| | 6 | 90.00 | 35.35 | 36.50 | 2.74 | 30.50 | 5.50 | 13.30 |
| | 7 | 100.00 | 37.75 | 38.85 | 3.14 | 32.90 | 5.15 | 12.25 |
| | 8 | 95.00 | 41.60 | 43.20 | 3.26 | 33.30 | 4.90 | 12.70 |
| | 9 | 100.00 | 43.00 | 44.00 | 3.30 | 32.50 | 4.50 | 13.50 |
| | 10 | 100.00 | 45.10 | 43.90 | 3.26 | 32.85 | 4.65 | 14.05 |
| | 11 | 99.00 | 42.55 | 44.35 | 3.17 | 33.30 | 4.60 | 13.00 |
| | 12 | 85.00 | 41.50 | 40.70 | 3.06 | 32.75 | 4.60 | 12.40 |
| 1972 | 1 | 88.00 | 37.35 | 41.55 | 2.86 | 30.65 | 4.55 | 12.00 |
| | 2 | 83.00 | 38.10 | 41.40 | 2.83 | 28.65 | 4.50 | 11.30 |
| | 3 | 83.00 | 38.10 | 41.30 | 2.61 | 27.70 | 4.00 | 10.50 |

| | | | | | | | | |
|------|----|--------|-------|-------|------|-------|------|-------|
| | 4 | 84.00 | 38.80 | 38.50 | 2.66 | 29.75 | 3.87 | 11.45 |
| | 5 | 88.00 | 36.30 | 37.05 | 2.61 | 28.80 | 3.81 | 11.90 |
| | 6 | 90.00 | 36.65 | 39.30 | 2.58 | 32.80 | 3.77 | 13.25 |
| | 7 | 85.00 | 40.10 | 40.25 | 2.74 | 32.25 | 3.86 | 12.80 |
| | 8 | 82.00 | 40.35 | 44.15 | 2.82 | 33.10 | 3.93 | 13.25 |
| | 9 | 79.00 | 43.05 | 45.95 | 3.03 | 33.40 | 4.12 | 14.50 |
| | 10 | 85.00 | 40.15 | 45.20 | 3.00 | 32.85 | 4.46 | 13.20 |
| | 11 | 82.00 | 38.70 | 44.60 | 2.92 | 32.55 | 4.44 | 13.75 |
| | 12 | 88.00 | 38.15 | 44.75 | 2.90 | 32.80 | 4.58 | 13.05 |
| 1973 | 1 | 87.50 | 35.65 | 41.00 | 2.86 | 30.50 | 4.56 | 11.55 |
| | 2 | 80.00 | 33.90 | 38.30 | 2.78 | 29.55 | 4.25 | 10.10 |
| | 3 | 80.00 | 33.50 | 35.75 | 2.45 | 28.15 | 4.28 | 9.85 |
| | 4 | 71.00 | 33.35 | 34.70 | 2.45 | 26.75 | 4.21 | 9.75 |
| | 5 | 68.00 | 25.70 | 33.90 | 2.24 | 25.55 | 3.72 | 9.05 |
| | 6 | 68.00 | 24.80 | 34.40 | 2.17 | 24.25 | 3.68 | 8.80 |
| | 7 | 77.50 | 24.25 | 31.60 | 2.11 | 23.05 | 3.65 | 7.60 |
| | 8 | 83.00 | 28.50 | 35.35 | 2.54 | 25.95 | 3.97 | 8.55 |
| | 9 | 80.50 | 31.40 | 34.15 | 2.46 | 24.10 | 3.84 | 9.80 |
| | 10 | 70.50 | 28.65 | 32.85 | 2.45 | 23.05 | 3.71 | 9.70 |
| | 11 | 78.00 | 31.10 | 35.65 | 2.65 | 25.20 | 3.78 | 10.80 |
| | 12 | 83.00 | 31.50 | 37.00 | 2.62 | 26.20 | 3.83 | 11.00 |
| 1974 | 1 | 82.00 | 33.45 | 36.65 | 2.59 | 24.10 | 3.70 | 10.50 |
| | 2 | 82.25 | 30.80 | 34.55 | 2.47 | 22.30 | 3.25 | 9.50 |
| | 3 | 75.50 | 27.20 | 32.15 | 2.30 | 21.50 | 2.85 | 9.15 |
| | 4 | 79.60 | 27.40 | 31.90 | 2.29 | 21.25 | 2.82 | 8.80 |
| | 5 | 87.80 | 25.10 | 31.40 | 2.27 | 22.95 | 2.78 | 9.00 |
| | 6 | 85.85 | 26.15 | 30.00 | 2.39 | 23.85 | 2.72 | 9.70 |
| | 7 | 90.30 | 27.15 | 30.10 | 2.45 | 25.50 | 2.72 | 9.65 |
| | 8 | 92.50 | 30.20 | 34.15 | 2.72 | 26.95 | 3.28 | 10.20 |
| | 9 | 87.50 | 29.15 | 35.20 | 2.70 | 25.65 | 3.15 | 10.70 |
| | 10 | 82.00 | 29.75 | 33.00 | 2.57 | 25.75 | 3.10 | 10.30 |
| | 11 | 92.00 | 29.05 | 34.15 | 2.49 | 24.90 | 3.16 | 9.10 |
| | 12 | 88.00 | 28.90 | 31.70 | 2.41 | 23.40 | 3.06 | 9.00 |
| 1975 | 1 | 87.50 | 27.50 | 27.10 | 2.22 | 21.90 | 3.10 | 8.45 |
| | 2 | 96.00 | 27.40 | 25.55 | 2.10 | 21.25 | 2.87 | 7.75 |
| | 3 | 94.50 | 26.70 | 24.90 | 2.09 | 21.55 | 2.88 | 7.25 |
| | 4 | 103.00 | 27.65 | 27.40 | 2.21 | 21.65 | 2.94 | 7.65 |
| | 5 | 87.00 | 25.95 | 27.15 | 2.13 | 20.50 | 2.78 | 7.60 |
| | 6 | 92.50 | 26.20 | 29.85 | 2.12 | 22.00 | 2.70 | 8.10 |
| | 7 | 115.00 | 32.40 | 32.20 | 2.36 | 23.85 | 3.18 | 8.70 |
| | 8 | 93.50 | 31.00 | 32.80 | 2.37 | 24.55 | 3.44 | 8.95 |
| | 9 | 95.50 | 32.45 | 35.85 | 2.48 | 25.00 | 3.76 | 9.90 |
| | 10 | 112.50 | 31.65 | 34.65 | 2.47 | 24.85 | 3.30 | 9.85 |
| | 11 | 113.50 | 33.05 | 37.45 | 2.57 | 25.65 | 3.48 | 9.70 |
| | 12 | 129.00 | 34.60 | 40.60 | 2.67 | 26.65 | 3.67 | 10.30 |
| 1976 | 1 | 118.50 | 32.40 | 37.30 | 2.58 | 25.10 | 3.70 | 9.30 |
| | 2 | 100.50 | 33.70 | 37.25 | 2.47 | 25.30 | 3.63 | 9.40 |
| | 3 | 106.75 | 34.40 | 37.00 | 2.47 | 24.75 | 3.75 | 9.30 |
| | 4 | 115.00 | 37.30 | 38.25 | 2.38 | 25.05 | 3.62 | 9.40 |
| | 5 | 116.75 | 34.00 | 34.20 | 2.07 | 24.50 | 3.57 | 9.50 |
| | 6 | 135.00 | 36.50 | 35.85 | 2.01 | 25.00 | 3.56 | 9.50 |
| | 7 | 123.00 | 38.20 | 38.75 | 2.80 | 27.25 | 3.63 | 9.90 |
| | 8 | 130.00 | 37.95 | 39.45 | 2.66 | 27.40 | 3.60 | 10.65 |
| | 9 | 129.00 | 38.95 | 38.95 | 2.54 | 26.70 | 3.75 | 10.50 |
| | 10 | 128.00 | 38.65 | 38.65 | 2.58 | 26.45 | 3.90 | 10.00 |
| | 11 | 122.50 | 37.60 | 37.60 | 2.59 | 25.75 | 4.15 | 9.65 |
| | 12 | 128.50 | 34.00 | 37.05 | 2.45 | 25.35 | 3.80 | 9.95 |
| 1977 | 1 | 133.00 | 33.60 | 37.60 | 2.45 | 26.50 | 3.88 | 10.00 |
| | 2 | 132.00 | 32.10 | 37.40 | 2.39 | 25.80 | 3.85 | 9.25 |
| | 3 | 127.25 | 34.40 | 39.15 | 2.04 | 23.15 | 3.69 | 9.10 |
| | 4 | 126.75 | 35.70 | 42.25 | 2.06 | 23.45 | 3.78 | 9.35 |
| | 5 | 120.25 | 35.55 | 38.85 | 2.07 | 23.15 | 4.01 | 9.30 |
| | 6 | 121.00 | 35.50 | 34.85 | 2.42 | 24.85 | 3.82 | 9.60 |
| | 7 | 119.00 | 35.25 | 34.50 | 2.51 | 25.05 | 3.97 | 9.15 |
| | 8 | 126.50 | 35.70 | 35.95 | 2.76 | 26.70 | 4.02 | 9.95 |
| | 9 | 130.00 | 33.90 | 37.45 | 2.94 | 26.75 | 3.84 | 10.20 |
| | 10 | 136.00 | 35.00 | 34.45 | 2.80 | 25.60 | 3.80 | 10.05 |
| | 11 | 133.00 | 35.70 | 36.60 | 3.30 | 27.45 | 3.99 | 9.50 |
| | 12 | 116.00 | 32.50 | 33.85 | 2.80 | 26.60 | 3.75 | 9.20 |
| 1978 | 1 | 107.50 | 32.10 | 33.15 | 2.67 | 26.55 | 3.98 | 9.00 |
| | 2 | 116.25 | 30.50 | 31.85 | 2.71 | 25.40 | 3.66 | 8.45 |
| | 3 | 119.00 | 30.40 | 31.65 | 2.53 | 24.50 | 3.95 | 8.00 |
| | 4 | 127.00 | 35.20 | 34.25 | 2.81 | 26.25 | 4.38 | 8.30 |

(continued)

APPENDIX: EAST EUROPEAN BLACK-MARKET EXCHANGE RATES (Continued)

| Period | Polish zloty | Rumanian lei | Hungarian forint | Bulgarian lev | Czechoslovak koruna | Russian ruble | East German mark | |
|--------|-----------------|-----------------|---------------------|------------------|------------------------|------------------|------------------------|-------|
| | 5 | 121.00 | 31.80 | 29.40 | 2.73 | 25.85 | 4.04 | 9.05 |
| | 6 | 145.75 | 33.55 | 29.60 | 2.71 | 26.30 | 4.03 | 8.55 |
| | 7 | 115.00 | 27.90 | 29.75 | 2.75 | 27.45 | 3.80 | 9.25 |
| | 8 | 117.50 | 29.00 | 32.45 | 3.10 | 29.00 | 3.83 | 8.85 |
| | 9 | 115.75 | 31.70 | 35.40 | 3.20 | 26.15 | 4.30 | 9.15 |
| | 10 | 104.00 | 33.20 | 31.80 | 2.90 | 23.60 | 4.45 | 8.15 |
| | 11 | 116.50 | 33.65 | 38.90 | 2.92 | 27.15 | 4.12 | 8.25 |
| | 12 | 113.50 | 34.45 | 37.90 | 2.99 | 27.00 | 4.05 | 8.15 |
| 1979 | 1 | 111.50 | 31.90 | 31.90 | 2.58 | 26.60 | 3.64 | 7.80 |
| | 2 | 104.75 | 30.45 | 37.20 | 2.43 | 24.30 | 4.29 | 7.80 |
| | 3 | 104.50 | 29.90 | 33.50 | 2.33 | 24.65 | 3.85 | 7.80 |
| | 4 | 108.00 | 32.10 | 34.50 | 2.52 | 25.35 | 3.97 | 8.05 |
| | 5 | 108.50 | 29.40 | 31.55 | 2.38 | 25.50 | 4.13 | 8.05 |
| | 6 | 107.25 | 27.00 | 31.20 | 2.10 | 25.25 | 4.08 | 8.25 |
| | 7 | 103.00 | 26.75 | 31.35 | 2.02 | 26.10 | 4.27 | 8.05 |
| | 8 | 100.00 | 25.85 | 28.80 | 2.08 | 26.25 | 3.94 | 8.95 |
| | 9 | 100.00 | 28.25 | 30.95 | 2.50 | 26.40 | 4.01 | 8.55 |
| | 10 | 101.00 | 31.25 | 36.45 | 2.60 | 26.65 | 3.95 | 8.65 |
| | 11 | 102.00 | 31.45 | 33.00 | 2.50 | 26.40 | 3.98 | 8.70 |
| | 12 | 111.75 | 29.45 | 34.10 | 2.57 | 27.00 | 4.50 | 8.75 |
| 1980 | 1 | 121.50 | 28.50 | 31.60 | 2.38 | 27.00 | 4.79 | 8.80 |
| | 2 | 114.50 | 25.35 | 28.85 | 1.91 | 24.60 | 4.49 | 8.10 |
| | 3 | 119.00 | 26.15 | 29.85 | 1.99 | 23.70 | 5.19 | 8.35 |
| | 4 | 120.00 | 25.65 | 28.00 | 2.07 | 25.25 | 3.95 | 8.40 |
| | 5 | 110.50 | 25.75 | 27.90 | 2.21 | 23.20 | 3.82 | 8.50 |
| | 6 | 116.50 | 26.95 | 29.90 | 2.31 | 25.65 | 3.58 | 11.00 |
| | 7 | 114.00 | 30.50 | 27.30 | 2.21 | 25.60 | 4.26 | 10.00 |
| | 8 | 125.00 | 33.35 | 32.20 | 2.28 | 25.85 | 4.34 | 9.70 |
| | 9 | 117.00 | 31.25 | 33.80 | 2.58 | 26.20 | 3.60 | 9.50 |
| | 10 | 123.00 | 34.60 | 32.85 | 2.66 | 26.15 | 3.50 | 9.75 |
| | 11 | 125.00 | 32.55 | 33.50 | 2.67 | 26.55 | 3.11 | 8.80 |
| | 12 | 123.00 | 32.55 | 33.50 | 2.67 | 26.55 | 3.10 | 8.40 |
| 1981 | 1 | 112.00 | 36.20 | 33.85 | 2.84 | 25.65 | 3.08 | 9.25 |
| | 2 | 128.00 | 38.60 | 37.50 | 2.73 | 28.40 | 3.41 | 10.00 |
| | 3 | 148.00 | 36.40 | 35.85 | 2.58 | 26.85 | 3.34 | 8.75 |
| | 4 | 165.00 | 38.00 | 37.00 | 2.89 | 25.55 | 4.10 | 9.00 |
| | 5 | 154.00 | 39.65 | 36.15 | 2.85 | 24.65 | 4.20 | 9.90 |
| | 6 | 213.00 | 34.55 | 33.00 | 2.31 | 28.65 | 3.85 | 10.10 |
| | 7 | 245.00 | 37.45 | 34.55 | 2.43 | 28.40 | 3.95 | 10.60 |
| | 8 | 367.00 | 42.00 | 36.00 | 2.98 | 30.40 | 4.05 | 10.90 |
| | 9 | 330.00 | 43.30 | 40.00 | 2.46 | 28.35 | 3.61 | 10.50 |
| | 10 | 375.00 | 43.10 | 38.25 | 2.88 | 26.60 | 3.55 | 9.75 |
| | 11 | 507.00 | 43.80 | 38.35 | 2.80 | 26.90 | 3.62 | 9.35 |
| | 12 | 525.00 | 45.00 | 40.50 | 2.87 | 27.90 | 4.20 | 9.75 |
| 1982 | 1 | 800.00 | 46.15 | 39.90 | 2.91 | 28.60 | 3.93 | 10.00 |
| | 2 | 500.00 | 43.55 | 37.90 | 2.77 | 27.10 | 3.91 | 9.50 |
| | 3 | 475.00 | 43.60 | 36.10 | 2.77 | 27.10 | 3.91 | 9.95 |
| | 4 | 450.00 | 47.35 | 35.75 | 2.87 | 28.10 | 3.85 | 10.35 |
| | 5 | 445.00 | 57.60 | 35.90 | 2.88 | 27.25 | 3.75 | 10.40 |
| | 6 | 475.00 | 43.80 | 38.50 | 2.95 | 29.75 | 3.86 | 11.35 |
| | 7 | 470.00 | 43.50 | 39.00 | 2.87 | 28.85 | 3.90 | 11.40 |
| | 8 | 430.00 | 52.25 | 44.50 | 3.13 | 31.35 | 3.92 | 11.05 |
| | 9 | 400.00 | 49.75 | 51.00 | 3.20 | 30.90 | 3.90 | 12.20 |
| | 10 | 375.00 | 48.35 | 48.50 | 3.22 | 30.00 | 3.92 | 12.10 |
| | 11 | 480.00 | 53.35 | 51.90 | 3.30 | 29.60 | 3.82 | 11.95 |
| | 12 | 450.00 | 48.00 | 48.00 | 3.19 | 28.75 | 3.89 | 11.35 |
| 1983 | 1 | 440.00 | 49.15 | 47.00 | 3.02 | 29.70 | 3.94 | 10.35 |
| | 2 | 450.00 | 49.00 | 48.00 | 2.86 | 28.60 | 3.80 | 10.15 |
| | 3 | 460.00 | 52.40 | 52.00 | 2.84 | 28.75 | 3.70 | 10.10 |
| | 4 | 540.00 | 49.65 | 54.00 | 2.90 | 28.60 | 3.68 | 10.70 |
| | 5 | 555.00 | 51.35 | 52.00 | 2.97 | 29.70 | 3.65 | 11.10 |
| | 6 | 700.00 | 51.60 | 51.00 | 2.79 | 28.65 | 3.63 | 11.95 |
| | 7 | 610.00 | 55.00 | 53.00 | 3.25 | 32.00 | 4.00 | 12.65 |
| | 8 | 540.00 | 66.50 | 55.00 | 3.66 | 34.30 | 4.30 | 13.30 |
| | 9 | 510.00 | 69.50 | 57.00 | 3.88 | 34.50 | 4.49 | 13.70 |
| | 10 | 575.00 | 77.25 | 56.00 | 3.66 | 33.20 | 4.62 | 13.50 |
| | 11 | 775.00 | 67.00 | 51.00 | 3.92 | 33.50 | 4.53 | 13.20 |
| | 12 | 900.00 | 60.55 | 55.00 | 3.88 | 34.00 | 4.60 | 14.05 |

| | | | | | | | | |
|------|----|----------|--------|-------|-------|-------|-------|-------|
| 1984 | 1 | 700.00 | 52.60 | 54.00 | 3.66 | 33.10 | 4.50 | 14.20 |
| | 2 | 800.00 | 54.75 | 49.00 | 3.50 | 32.50 | 4.75 | 13.75 |
| | 3 | 850.00 | 50.00 | 50.00 | 3.55 | 33.00 | 4.65 | 14.00 |
| | 4 | 700.00 | 45.50 | 53.00 | 3.35 | 33.50 | 4.40 | 14.25 |
| | 5 | 600.00 | 49.50 | 54.50 | 3.50 | 31.00 | 4.35 | 14.45 |
| | 6 | 550.00 | 59.00 | 57.90 | 3.75 | 32.25 | 4.58 | 14.50 |
| | 7 | 560.00 | 61.75 | 55.85 | 4.10 | 33.85 | 4.50 | 14.40 |
| | 8 | 535.00 | 68.60 | 53.95 | 4.35 | 37.05 | 4.45 | 13.75 |
| | 9 | 532.00 | 67.50 | 64.50 | 4.46 | 39.20 | 4.75 | 15.00 |
| | 10 | 545.00 | 60.95 | 64.55 | 4.24 | 39.18 | 4.65 | 14.80 |
| | 11 | 680.00 | 55.15 | 63.75 | 4.18 | 36.45 | 4.55 | 15.35 |
| | 12 | 660.00 | 57.10 | 68.15 | 4.40 | 37.70 | 4.90 | 15.98 |
| 1985 | 1 | 666.25 | 54.65 | 68.35 | 4.45 | 37.25 | 4.95 | 16.05 |
| | 2 | 722.50 | 52.55 | 70.05 | 4.45 | 37.75 | 5.15 | 16.30 |
| | 3 | 582.20 | 58.88 | 65.10 | 4.03 | 33.00 | 4.60 | 14.50 |
| | 4 | 580.00 | 67.80 | 70.10 | 5.25 | 32.45 | 4.66 | 15.35 |
| | 5 | 575.00 | 63.70 | 66.60 | 4.10 | 32.50 | 4.61 | 15.18 |
| | 6 | 565.00 | 69.60 | 65.55 | 4.03 | 36.05 | 4.70 | 15.07 |
| | 7 | 577.50 | 63.30 | 59.25 | 3.85 | 34.25 | 5.50 | 13.40 |
| | 8 | 665.70 | 67.55 | 59.75 | 4.24 | 35.85 | 4.65 | 13.50 |
| | 9 | 547.50 | 63.50 | 59.20 | 3.98 | 33.69 | 4.40 | 13.48 |
| | 10 | 620.00 | 64.75 | 60.30 | 4.35 | 34.15 | 4.85 | 13.35 |
| | 11 | 595.75 | 58.75 | 65.20 | 4.20 | 33.65 | 5.56 | 13.05 |
| | 12 | 592.85 | 60.15 | 64.85 | 5.19 | 33.50 | 5.53 | 12.80 |
| 1986 | 1 | 676.70 | 60.60 | 59.70 | 4.51 | 32.25 | 4.78 | 13.30 |
| | 2 | 534.50 | 53.35 | 58.45 | 3.75 | 30.65 | 4.99 | 12.25 |
| | 3 | 545.70 | 58.75 | 54.60 | 3.85 | 27.30 | 4.50 | 12.15 |
| | 4 | 610.00 | 58.70 | 58.70 | 3.65 | 28.00 | 3.90 | 12.75 |
| | 5 | 551.50 | 63.28 | 62.25 | 3.85 | 29.70 | 3.68 | 13.10 |
| | 6 | 600.00 | 61.00 | 56.25 | 4.00 | 29.50 | 3.79 | 11.80 |
| | 7 | 686.00 | 63.50 | 51.20 | 3.81 | 28.60 | 3.61 | 11.65 |
| | 8 | 654.00 | 62.90 | 56.40 | 4.09 | 30.00 | 3.67 | 11.45 |
| | 9 | 735.00 | 63.00 | 61.30 | 3.85 | 29.55 | 3.55 | 12.25 |
| | 10 | 755.00 | 64.60 | 60.55 | 3.95 | 31.40 | 4.00 | 12.75 |
| | 11 | 800.00 | 61.90 | 61.35 | 3.80 | 27.10 | 4.10 | 12.30 |
| | 12 | 875.00 | 60.20 | 61.40 | 3.78 | 27.55 | 4.15 | 12.05 |
| 1987 | 1 | 900.00 | 63.00 | 57.25 | 3.50 | 26.20 | 4.10 | 13.45 |
| | 2 | 975.00 | 62.25 | 57.90 | 3.45 | 25.60 | 4.39 | 10.60 |
| | 3 | 1000.00 | 65.85 | 60.60 | 3.56 | 26.60 | 4.33 | 9.95 |
| | 4 | 1010.00 | 63.50 | 58.50 | 3.45 | 25.65 | 4.25 | 10.05 |
| | 5 | 1050.00 | 60.50 | 58.00 | 3.85 | 26.35 | 4.20 | 10.55 |
| | 6 | 1100.00 | 63.75 | 61.20 | 4.08 | 27.80 | 4.30 | 13.00 |
| | 7 | 1250.00 | 71.65 | 61.60 | 4.11 | 29.05 | 4.32 | 13.11 |
| | 8 | 1175.00 | 71.40 | 60.00 | 4.05 | 28.30 | 4.60 | 12.90 |
| | 9 | 1200.00 | 72.15 | 60.60 | 4.65 | 30.30 | 4.65 | 13.45 |
| | 10 | 1250.00 | 70.00 | 57.50 | 4.40 | 28.70 | 4.63 | 13.35 |
| | 11 | 1300.00 | 66.10 | 57.65 | 4.17 | 28.25 | 4.52 | 12.60 |
| | 12 | 1300.00 | 67.25 | 62.55 | 4.30 | 28.60 | 5.35 | 12.50 |
| 1988 | 1 | 1325.00 | 72.90 | 64.50 | 4.26 | 29.50 | 5.55 | 12.90 |
| | 2 | 1300.00 | 73.50 | 68.05 | 4.29 | 30.35 | 5.60 | 13.00 |
| | 3 | 1295.00 | 72.10 | 65.50 | 5.10 | 26.50 | 5.65 | 11.00 |
| | 4 | 1350.00 | 72.25 | 65.75 | 5.12 | 28.10 | 5.70 | 10.50 |
| | 5 | 1475.00 | 74.50 | 62.80 | 4.45 | 30.10 | 5.80 | 10.60 |
| | 6 | 1500.00 | 86.50 | 65.65 | 4.65 | 31.80 | 6.05 | 11.05 |
| | 7 | 1750.00 | 95.25 | 68.25 | 5.05 | 34.85 | 6.30 | 12.90 |
| | 8 | 1900.00 | 95.80 | 67.30 | 5.75 | 35.95 | 6.50 | 14.00 |
| | 9 | 2250.00 | 96.50 | 70.75 | 5.80 | 34.75 | 6.75 | 14.20 |
| | 10 | 2700.00 | 82.70 | 66.50 | 5.90 | 38.80 | 6.80 | 14.00 |
| | 11 | 3000.00 | 72.90 | 78.80 | 6.10 | 39.50 | 6.90 | 15.25 |
| | 12 | 3200.00 | 95.00 | 82.00 | 6.50 | 45.75 | 7.25 | 16.00 |
| 1989 | 1 | 3000.00 | 90.00 | 77.00 | 6.55 | 42.00 | 9.00 | 15.50 |
| | 2 | 2800.00 | 89.00 | 75.00 | 5.98 | 38.50 | 8.90 | 16.00 |
| | 3 | 3000.00 | 94.50 | 78.90 | 6.05 | 41.50 | 9.20 | 16.15 |
| | 4 | 3200.00 | 98.50 | 80.00 | 6.35 | 39.50 | 9.90 | 16.50 |
| | 5 | 3800.00 | 107.80 | 80.25 | 6.50 | 43.15 | 12.50 | 16.85 |
| | 6 | 4100.00 | 120.00 | 87.00 | 9.25 | 47.20 | 13.75 | 17.80 |
| | 7 | 6890.00 | 115.00 | 85.00 | 9.20 | 46.75 | 13.00 | 18.50 |
| | 8 | 7000.00 | 125.10 | 82.50 | 10.25 | 49.00 | 13.50 | 19.50 |
| | 9 | 6900.00 | 129.00 | 85.00 | 10.10 | 44.50 | 13.25 | 17.50 |
| | 10 | 7200.00 | 131.00 | 82.00 | 10.20 | 42.50 | 15.00 | 17.00 |
| | 11 | 9000.00 | 128.00 | 84.00 | 10.00 | 40.00 | 14.00 | 16.70 |
| | 12 | 12700.00 | 120.00 | 88.00 | 12.50 | 43.00 | 13.75 | 16.50 |

(continued)

APPENDIX: EAST EUROPEAN BLACK-MARKET EXCHANGE RATES (Continued)

| Period | | Polish zloty | Rumanian lei | Hungarian forint | Bulgarian lev | Czechoslovak koruna | Russian ruble | East German mark |
|--------|----|-----------------|-----------------|---------------------|------------------|------------------------|------------------|------------------------|
| 1990 | 1 | 10000.00 | 90.00 | 85.00 | 11.00 | 41.00 | 12.80 | 13.50 |
| | 2 | 9850.00 | 120.00 | 85.25 | 10.00 | 41.00 | 12.75 | 10.00 |
| | 3 | 9800.00 | 110.00 | 85.45 | 10.00 | 40.00 | 12.45 | 12.00 |
| | 4 | 9825.00 | 125.00 | 82.00 | 8.90 | 38.00 | 13.00 | 9.00 |
| | 5 | 9825.00 | 135.00 | 72.00 | 10.00 | 37.00 | 13.90 | 7.00 |
| | 6 | 10250.00 | 140.00 | 80.00 | 9.00 | 35.00 | 17.00 | — |
| | 7 | 9900.00 | 150.00 | 74.00 | 9.15 | 33.00 | 22.00 | — |
| | 8 | 9500.00 | 165.00 | 70.00 | 13.50 | 32.00 | 25.00 | — |
| | 9 | 9600.00 | 170.00 | 72.00 | 15.00 | 34.00 | 28.00 | — |
| | 10 | 10300.00 | 177.00 | 70.00 | 17.00 | 40.00 | 30.00 | — |
| | 11 | 10300.00 | 185.00 | 73.00 | 20.00 | 45.00 | 32.00 | — |
| | 12 | 10350.00 | 200.00 | 75.00 | 21.50 | 45.00 | 35.00 | — |

NOTE: Rates are in number of foreign currency units per U.S. dollar.

Source: Various issues of *Pick's Currency Yearbook* and *World Currency Yearbook*.

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REFERENCES

- Akgiray, V., Booth, G. G., and Seifert, B. (1988), "Distribution Properties of Latin American Black Market Exchange Rates," *Journal of International Money and Finance*, 7, 37-48.
- Boothe, P., and Glassman, D. (1987), "The Statistical Distribution of Exchange Rates: Empirical Evidence and Economic Implications," *Journal of International Economics*, 22, 297-320.
- Goldie, C. M., and Smith, R. L. (1987), "Slow Variation With Remainder: Theory and Applications," *Quarterly Journal of Mathematics*, 38, 45-71.
- Hill, B. M. (1975), "A Simple Approach to Inference About the Tail of a Distribution," *The Annals of Statistics*, 3, 1163-1174.
- Koedijk, K. G., Schafgans, M. M. A., and De Vries, C. G. (1990), "The Tail Index of Exchange Rate Returns," *Journal of International Economics*, 29, 93-108.
- Leadbetter, M. R., Lindgren, M. R. G., and Rootzen, H. (1983), *Extremes and Related Properties of Random Sequences and Processes*, New York: Springer-Verlag.
- Mason, D. M. (1982), "Laws of Large Numbers for Sums of Extreme Values," *Annals of Probability*, 10, 754-764.
- Mood, A. M., Graybill, T. A., and Boes, D. C. (1974), *Introduction to the Theory of Statistics*, New York: McGraw-Hill.
- Westerfield, J. M. (1977), "An Examination of Foreign Exchange Risk Under Fixed and Floating Exchange Rate Regimes," *Journal of International Economics*, 7, 181-200.