STATISTICAL PROPERTIES OF EXCHANGE RATES

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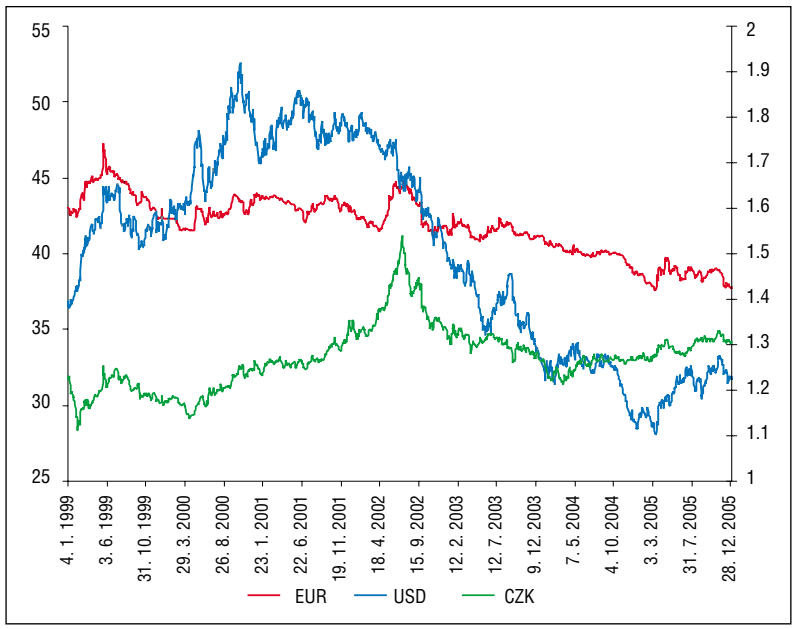
The Slovak koruna has undergone several changes during the 13 years of its existence. One of the most important took place on 1 January 1999 when the euro became its reference currency. Slovakia's entry into economic and monetary union and the subsequent introduction of the euro will bring to a close the brief history of the Slovak koruna, although this is not planned to happen before 2009. Until then, many companies will be exposed to exchange rate risk. Once the euro has been introduced, all exchange rate risks will in principle be confined to the risk of a change in the price of the euro against the dollar. For a few more years, however, Slovak companies active in the international payment system will have to track fluctuations in the exchange rates of the euro, dollar, Czech koruna, and possibly other currencies against the Slovak koruna. It will also be necessary to make forecasts and, when faced with unfavourable outlooks, to take measures to hedge the risk, for example, by using financial derivatives. To have some knowledge of the basic statistical properties of exchange rates is therefore very important. Methods such as Value-at-Risk (VaR) frequently assume particular distribution of risk factors. If these are not met, then the results may be incorrect and the subsequent decisions flawed. The purpose of this article is to analyse some of the key properties of the following exchange rates – the euro, dollar and Czech koruna against the Slovak koruna.

Chart 1 The EUR, USD and CZK exchange rates (left axis) against the SKK from 4 January 1999 to 30 December 2005.



The historical data covers a time period of 7 years (from 4 January 1999 to 30 December 2005), which represents 1,750 trading days. The development of the euro, dollar and Czech koruna exchange rates over the period under review is shown in Chart 1.

The values of the exchange rates are used to calculate the exchange rate returns. The main reason for using returns rather than prices (exchange rates) is that returns have more suitable statistical properties than rates (prices)[2]. Logarithmic returns (continuously compounded returns) are the most frequently used.

Daily logarithmic returns are calculated as follows:

$$r_t = \ln(P_t) - \ln(P_{t-1})$$

where: P_t is the exchange rate (SKK/EUR, SKK/USD, SKK/CZK)during the time t, and P_{t-1} is exchange rate during the time $t-1$.

Sample

The input data is the daily exchange rate of the euro (EUR), US dollar (USD) and Czech koruna (CZK) published by the National Bank of Slovakia. The currencies are selected on the grounds of their long-term prevalence in the balance of payments (together they account for 95% of both payments and receipts).

Table 1 Descriptive statistics of logarithmic returns

Currency	Mean	Median	Minimum	Maximum	Standard deviation	Skewness	Kurtosis
CZK	0.00004	0	-0.02841	0.02015	0.00386	-0.14502	3.82000
EUR	-0.00007	-0.00012	-0.01490	0.02322	0.00299	0.88692	7.52121
USD	-0.00008	-0.00007	-0.03723	0.02668	0.00722	-0.06634	0.74553

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[2] Campbell, J. Y. – Lo, A. W. – Mackinley, A. C.: The Econometrics of Financial Markets, manuscript, 1995, p. 22.

Descriptive statistics of exchange rate returns

Table 1 shows the basic descriptive statistics of the logarithmic returns of the CZK, EUR and USD exchange rates against the SKK.

Measures of central tendency (arithmetic mean and median) are very close to zero, and despite the large sample, they are not significantly different from zero (using the t-test, Wilcoxon test, and Sign test). Thus the standard assumption that the expected value of daily returns equals zero is met[3]. The most substantial day-to-day change in an exchange rate was recorded by the USD (it fell by more than 3.7%, though it also posted the highest daily increase of 2.6%). As for the standard deviation, the EUR had the lowest (0.3%) and the USD the highest (0.7%), more than double the EUR's. In order to assess the normality of returns, which is a fundamental assumption of many financial models, the measures of shape – skewness and kurtosis – are of interest. The results show that out of the three currencies, the USD deviates the least from symmetric distribution and the EUR deviates the most (distribution is positively skewed). Also with kurtosis, the EUR had the highest and the USD the lowest (close to the kurtosis of normal distribution). The results suggest a non-normal distribution of the logarithmic returns of the CZK, EUR and USD against the SKK. The Shapiro-Wilk test rejected normality for all three currencies ($P<0.001$), mainly due to more frequent occurrence of extreme values than expected by normal distribution. Charts 2 and 3 compare the real values of distribution (x-axis) with the expected values (y-axis).

CZK and EUR returns show systematic deviation from the normal distribution, with the deviation depicted on the graphs by points lying away from the straight line. USD returns display the least deviation from the normal distribution since the points, except for some outliers, are found next to the straight line.

Stationarity of time series

None of assessed currencies returns passed the Dickey-Fuller test ($P<0.001$), which means that the time series of returns (CZK, EUR and USD against the SKK) are not stationary.

Independence of returns in time

By assessing the values of the autocorrelation coefficients, partial autocorrelation coefficients and the tests of their significance, we come to the conclusion that CZK and USD returns may be considered independent in time. EUR returns show a first-lag positive autocorrelation (AC = 0.1 $P<0.001$).

[3] Figlewski, S.: Forecasting Volatility Using Historical Data, New York University Working Paper no. 13, 1994, p. 5.

Chart 2 Probability plot of CZK returns

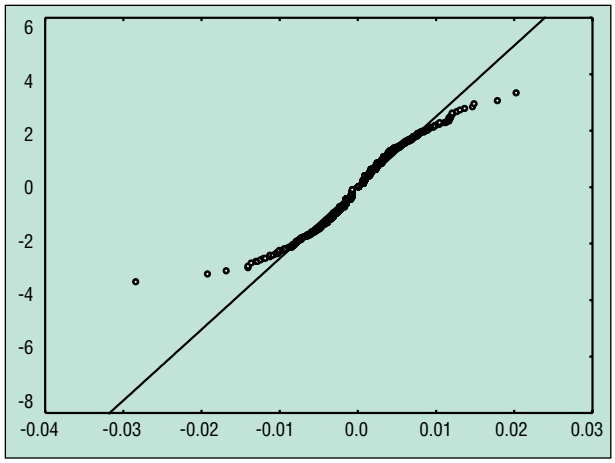


Chart 3 Probability plot of EUR returns

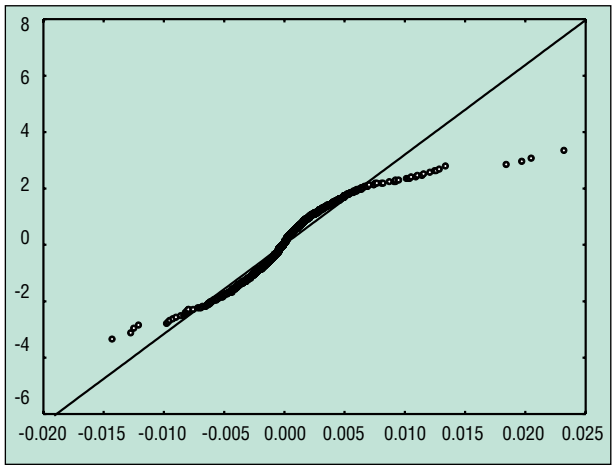
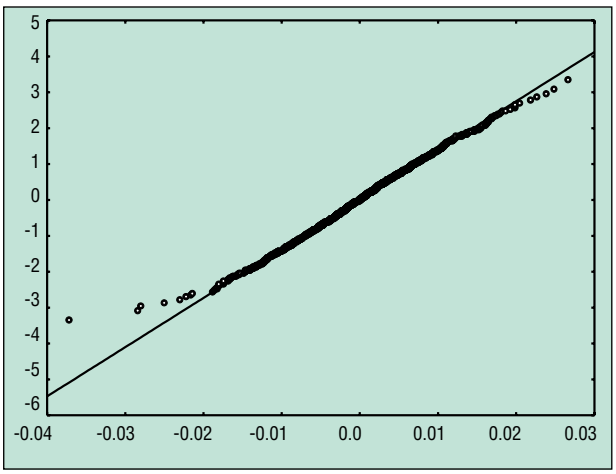


Chart 4 Probability plot of USD returns



Independence and identical distribution of returns

Using the BDS test[4], we checked the fulfilment of

[4] Brock, W. A. – Dechert, W. D. – Scheinkman, J. A. – Lebaron, B.: A Test for Independence Based on the Correlation Dimension; Econometric Reviews 15 August 1996, pp. 197-235.

another standard assumption – Independence and identical distribution (IID). This is, for example, an assumption of the use of the rule for standard deviation scaling when making the conversion from 1-day to k-day standard deviation.

RiskMetrics methodology uses this assumption for VaR estimation (e.g., the VaR for a 5-day horizon is defined as 1-day VaR, estimated using daily returns, multiplied by the square root of five).

The results of the BDS test (using a methodology of the proportion of pairs and $\varepsilon = 0.7$, and with 6 as the maximum number of dimensions) indicate that only the USD meets the assumption of independent and identically distributed returns (all P-values are greater than 0.01). The EUR and CZK returns cannot be considered independent and identically distributed ($P<0.001$).

In summing up the BDS tests and autocorrelations, we find that USD returns are independent and identically distributed, CZK returns are independent but not identically distributed, and EUR returns are not independent.

Correlations between returns of the examined currencies

The values of all three Pearson correlation coefficients of the logarithmic returns are positive. As expected, the lowest correlation is between the USD and CZK returns (0.25), the middle one is between the USD and EUR returns (0.39), and the highest between EUR and CZK returns (0.45). All the correlations are statistically highly significant ($P<0.001$). As far as exchange rate management is concerned, this information is very important in relation to the options for the diversification of risks.

Summary

In this article, we have focused on certain statistical properties of logarithmic returns of the three most significant currencies for Slovakia: the euro, dollar, and Czech koruna.

Expected value of all three returns equals zero. None of the three currencies shows a normal distribution of returns, although the SKK/USD returns have an almost normal distribution. All three return time series are non-stationary. Returns of the SKK/EUR show positive autocorrelation. Only SKK/USD returns are independent and identically distributed. All three correlations between the returns are positive. Examination of the statistical properties of exchange rate returns is not an end in itself, but provides a practical benefit in the field of exchange rate risk management. The findings show that SKK/USD returns come closest to the theoretical assumptions of many simpler financial models, while SKK/EUR returns are furthest from them. For exchange rate risk management, this means that simple parametric methods (such as the RiskMetrics methodology for VaR estimation) are reliable for the SKK/USD exchange rate. Conversely, exchange rate risk management for the CZK and EUR demands the use of more sophisticated methods, not reliant on assumptions that, as we have shown, these two currencies simply do not meet. Ignorance of such facts would lead to systematic underestimation of the existing exchange rate risk and the real losses would exceed estimates.

[5] Gazda, V. – Kožený, K. – Výrost, T.: O zlyhaní tradičného škálovania štandardnej odchýlky výnosností kapitálových aktív (On the failure of traditional scaling for standard deviation of the profitability of capital assets); Finance a Úver (Finance and Credit), 2004, volume 54, no. 8-9, pp. 325-334.

[6] Quantitative Micro Software: EViews 5 help, 2004.

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