The international integration of foreign exchange markets in the central and east European accession countries: speculative efficiency, transaction costs and exchange rate premiums

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Summary

A test of speculative efficiency on the foreign exchange markets of Poland, the Czech Republic, Hungary and the Slovak republic was unable to identify a cointegration relationship between forward and spot rates against the euro for the period between 1999 and mid-2002. Econometric studies confirm the existence of a time-variable exchange rate premium in all of the above countries. However, information and transaction costs also appear to be responsible for the observed deviations from speculative efficiency. The segmentation of the foreign exchange markets is likely to hamper the coordination of national monetary and foreign exchange policies within ERM II. In addition, this segmentation increases uncertainty in setting the central rate against the euro.

Zusammenfassung

Im Rahmen eines Tests der spekulativen Effizienz auf den Devisenmärkten Polens, der Tschechischen Repubik, Ungarns und der Slowakei kann für den Beobachtungszeitraum von 1999 bis Mitte 2002 keine Kointegrationsbeziehung zwischen Termin- und Kassakursen gegenüber dem Euro nachgewiesen werden. Ökonometrische Untersuchungen bestätigen die Existenz einer zeitvariablen Wechselkursprämie in allen genannten Ländern. Darüber hinaus scheinen aber auch Informations- und Transaktionskosten verantwortlich zu sein für die beobachteten Abweichungen von der spekulativen Effizienz. Die Segmentierung der Devisenmärkte dürfte die Koordinierung der nationalen Geld- und Währungspolitiken innerhalb des WKM II erschweren. Zusätzlich erhöht sie die Unsicherheit bei der Festlegung des Leitkurses gegenüber dem Euro.

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1 Introduction

The Copenhagen European Council decided in December 2002 to admit ten new members, mainly from central and eastern Europe, to the European Union on 1 May 2004. The complete liberalisation of external relationships associated with this move provides an opportunity, especially for the new members, to make significant improvements in efficiency throughout the economy. If this is to materialise, however, it is essential that the market participants actually respond to the changes in the underlying political framework and that the markets do not remain segmented for other reasons.

As part of a research project on the financial markets of the central and east European economies, the present paper examines the international foreign exchange market integration of four major accession countries. The foreign exchange markets are not only the interface for all cross-border transactions; they also play a dominant role in transmitting monetary policy impulses in central and eastern Europe.

In an empirical investigation into the real and financial integration of Europe in the 1990s Buch/Döpke (2000) came to the conclusion that, although the accession countries' degree of foreign exchange market integration with Germany was more advanced than the goods market integration, there were still substantial deficits. The paper on hand will not only determine the degree of segmentation at the beginning of the new millennium but will also look for causes of the incomplete integration and in this connection will examine in particular the efficiency of the central and east European foreign exchange markets.

In *Part II* of the paper the idea of speculative efficiency based on the interest parity theory will be presented as a measure of foreign exchange market integration. *Part III* will then examine the degree of integration between the foreign exchange markets of four selected accession countries (Poland, Hungary, the Czech Republic and the Slovak Republic) and the euro area. *Part IV* uses a theoretical model and empirical studies to ascertain whether and, if so, to what extent, the incomplete integration of the central and east European

* We wish to thank Martin Bohl, Zsolt Darvas, Jörg Döpke, Jens Hölscher, Jörg Breitung and the participants in the Friday seminar of the Deutsche Bundesbank for their valuable comments.

foreign exchange market is due to the existence of an exchange rate premium. *Part V* summarises the findings and draws conclusions relating to the future enlargement process of European monetary union.

2 Speculative efficiency as a measure of foreign exchange market integration

The notion of interest parity is used in this paper to quantify financial market integration.[1] A distinction has to be made between two variants - covered interest parity (CIP) and uncovered interest parity (UIP). These are based on different assumptions and capture different segments of the financial markets.[2]

Covered interest parity means that the yield on a domestic financial paper is equal to the yield on a foreign paper with a hedged exchange rate risk. Consequently, interest rate differentials between two economies are offset by the swap rate of the bilateral exchange rate:

$$(1)\qquad i_t - i_t{}^* = \frac{E^T_{t,t+k} - E_t}{E_t}$$

where i = domestic interest rate; i* = foreign interest rate; E = spot rate; E^T = forward rate.

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[1] The definition of integration on which this paper is based takes account not only of whether cross-border financial transactions are possible but also of the actual behaviour of investors. A comprehensive definition of this kind has already been provided by Scitovsky (1969, p 89), according to which "*the perfect integration of asset markets means ... that the assets must be transferable and the portfolio preferences of individual asset holders are regionally unbiased".* If the point of interest in this connection is not the actual transaction volume but primarily the structure and extent of the competition and the concomitant efficiency of the markets, then the law of one price is to be used. The interest parity theory applies the law of one price to fixed-interest and homogeneous financial paper, which means that assets with a comparable degree of risk have the same expected yield irrespective of the country in which they are traded. A number of other possible definitions are found in the literature. See, for example, Adam *et al* (2002), Jandura (2000), Shepherd (1994), Goldstein/Mussa (1993), Lemmen (1998) and Obstfeld (1986). For a rough breakdown of the various categories and a justification of the use of the "price approach" in the course of this research project see Herrmann/Jochem (2003).

[2] Both interest parities are based on the assumption of completely homogeneous, ie nominally risk-free, financial paper, which is perfectly interchangeable with respect to maturity, quality of the debtor etc. Regarding the debate on interest parities, see, among others, Jandura (2000), Lemmen/Eijffinger (1996), Kearney (1996), Fratzscher (2001) and Shepherd (1994). Owing to the different market practices in the various economies, however, this assumption can be applied only with qualifications. Studies in the east European economies, in particular, face this problem. Consequently, the informative value of the results may be impaired. For an account of different market conventions see J P Morgan (1998) and Bruns/Meyer-Bullerdiek (1996).

Equation (1) implies that full arbitrage between domestic and foreign financial paper is possible and that, as a result, there are no impediments due to transaction costs or default risks. In the case of fairly short maturities (one year or less) the validity of covered interest parity serves as a measure of integration of national *money markets* while eliminating exchange rate risks.

In the case of *uncovered interest parity*, by contrast, there is no hedging against exchange rate risks. Therefore, it is the expected exchange rate movements and not the swap rates that equal the national interest rate differentials:

(2) $$i_t - i_t{*} = \frac{E^e_{t,t+k} - E_t}{E_t}$$

where E^e = the expected exchange rate.

The uncovered interest parity can be broken down into two components, *covered interest parity* and *speculative efficiency*, which requires the forward rate to be the same as the expected exchange rate:[3]

(3) $$i_t - i_t{*} = \frac{E^T_{t,t+k} - E_t}{E_t} + \left\{ \frac{E^e_{t,t+k} - E_t}{E_t} - \frac{E^T_{t,t+k} - E_t}{E_t} \right\}$$

While the covered interest parity is a suitable means of measuring money market integration,[4] speculative efficiency requires perfectly integrated foreign exchange markets.

When checking speculative efficiency, however, one is faced with the problem that exchange rate expectations cannot be observed directly. Empirical work in this field therefore often draws on the hypothesis of rational exchange rate expectations:[5]

(4) $$E_{t+k} = E^e_{t,t+k} + u_{Dt}$$

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[3] This decomposition method goes back to an approach used by Frankel/McArthur (1988).

[4] See Herrmann/Jochem (2003).

[5] See Cumby/Obstfeld (1981). Alternatively, exchange rate expectations could also be modelled using ARIMA models, regression analyses or surveys (see Froot/Frankel 1989). However, none of these approaches is capable of completely ruling out systematic expectation errors. Tease *et al* (1991) assume that, although the choice of the method affects the results, long-term trends in the data are probably not seriously impaired.

Rational expectations result in the fact that the deviations (u_D) of the expected exchange rate from the actual rate show an expected value of zero. Furthermore, if the exchange rate follows a random walk, the expectation errors are serially uncorrelated. Rational expectations therefore imply that the actual exchange rate can be used as an unbiased estimator of the expected exchange rate.

This leads to the following test of speculative efficiency:[6]

$$(5) \qquad E^{T}_{t,t+k} = E^{e}_{t,t+k} = E_{t+k} - u_{Dt} \quad \text{or}$$

$$(5a) \qquad \frac{E^{T}_{t,t+k}}{E_{t+k}} - 1 = \rho_t$$

This approach involves a combined hypothesis test which links the hypothesis of rational exchange rate expectations (ie the actual rate is an unbiased estimator of the expected spot rate) with the hypothesis of efficient foreign exchange markets and the absence of exchange rate premiums (unbiased hypothesis, ie the forward rate is an unbiased estimator of the expected spot rate). Rejection of the null hypothesis, namely that the disturbance term ρ_t has the expected value of zero and is serially uncorrelated, has therefore to be interpreted with caution. It may be due both to inaccurate modelling of the exchange rate expectations and to the existence of transaction costs or of a risk premium.

Provided the exchange rate expectations are correctly modelled, the degree of segmentation on the foreign exchange markets is derived from the *average* value of the disturbance term:

$$(6) \qquad \frac{1}{N}\sum_{t}^{N} \frac{E^{T}_{t,t+k}}{E_{t+k}} - 1 = \overline{\rho}_t$$

All values of $\overline{\rho}_t > 0$ are an expression of a segmentation which reduces the volume of the cross-border transactions and increases the probability of asymmetric shocks or diverging economic developments. The possible causes of such integration deficits have to be interpreted in different ways, however. For example, risk premiums are a reflection of market participants' preferences and are therefore not inconsistent with the existence of perfect markets. All other reasons such as the use of market power entail transaction costs which impair efficient pricing.

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[6] See also Marston (1995).

3 The validity of speculative efficiency in central and eastern Europe

The present chapter examines whether the foreign exchange markets in central and eastern Europe are fully integrated with the markets in the euro area. Owing to a lack of data, only Poland, the Czech Republic, the Slovak Republic and Hungary were included in the study. The observation period begins on 31 December 1998, the day before the introduction of the euro (in the case of Poland and the Slovak Republic: January 1999), and ends on 30 June 2002. The study is based on three-month spot and forward rates.[7] The econometric test of the validity of speculative efficiency is based on the following regression model

$$(7) \qquad \frac{E^{T}_{t,t+3}}{E_t} = \alpha + \beta \frac{E_{t+3}}{E_t} + v_{Dt}$$

A necessary condition for foreign exchange market integration is a long-term equilibrium between the swap rate and the exchange rate movement. This means that the time series on the left-hand and right-hand side of (7) are either both stationary or are non-stationary and cointegrated. The sufficient condition for foreign exchange market efficiency is that α=0 and β=1 and that the residuals are serially uncorrelated (white noise). If the residuals are not white noise, inefficiencies will not be immediately corrected and the forward rate will not contain all the relevant information.[8]

The unit root tests were carried out on the basis of the Augmented Dickey-Fuller test (ADF), the Phillips-Perron test (PPT) and the Kwiatkowski-Phillips-Schmidt-Shin test (KPSS). It turned out that the time series $E^{T}_{t,t+3} / E_t$ is non-stationary and I(1) for all countries. By contrast, the time series E_{t+3}/E_t was stationary. As a long-term equilibrium between variables with different degrees of integration is impossible, the findings of the stationarity tests mean that in the case of all four accession candidates under review the *necessary* condition for fully integrated foreign exchange markets has to be rejected already at this stage.[9]

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[7] See information on data sources in the annex.

[8] However, speculative efficiency can also be rejected for econometric reasons. If monthly data are used, the three-month exchange rate movements are not stochastically independent of each other. The OLS estimator could then be inefficient. See Boothe/Longworth (1986). Siegel (1972) also shows that a rejection of speculative efficiency is possible on purely formal grounds. However, the empirical relevance of the Siegel paradox is refuted by McCulloch (1975).

[9] In view of the brevity of the observation period, however, it is possible that the non-stationarity of the swap rates is only a temporary phenomenon. Even so, in a test of uncovered interest parity Buch/Döpke (2000) come to the conclusion that in four out of five accession candidate countries there is no cointegration relationship between domestic and foreign money market rates and exchange rate movements.

By contrast, the foreign exchange markets of the EMS countries displayed long-term equilibrium between swap rates and exchange rate movements in the 1990s. According to a study by Nieuwland/Verschoor/Wolff (2000) on the existence of exchange rate premiums in the EMS, both variables were stationary. Almost all empirical studies on the speculative efficiency between the currencies of major industrial nations also suggest that spot rates and forward rates are integrated from the first degree and are also cointegrated. However, the restrictions $\alpha=0$ and $\beta=1$ are frequently rejected, with the result that the sufficient condition for foreign exchange market efficiency is not fulfilled and, consequently, the unbiased hypothesis, according to which the forward rate is an unbiased means of estimating the expected spot rate, must be rejected with respect to the international foreign exchange markets.[10]

The results make it clear that perfect integration of the foreign exchange markets cannot be assumed in either the EMS or the central and eastern European economies. Even so, the countries participating in EMS are more highly integrated than the former transition countries. The reason for this is that the cointegration of spot and forward rates in the EMS reflects a long-term equilibrium in both variables, with the result that the swap rates allow conclusions to be drawn regarding the expected course and the expected extent of exchange rate movements. In Poland, the Slovak Republic, the Czech Republic and Hungary, by contrast, such an interrelationship cannot be proved.

Regarding the ongoing enlargement process of European monetary union to include the east European economies, it is not only interesting to note that the degree of integration so far reached by the east European foreign exchange markets is still incomplete and is less than that of the EMS economies; what is more important is the ability to identify the underlying reasons for this. This is the subject of the following part of this paper.

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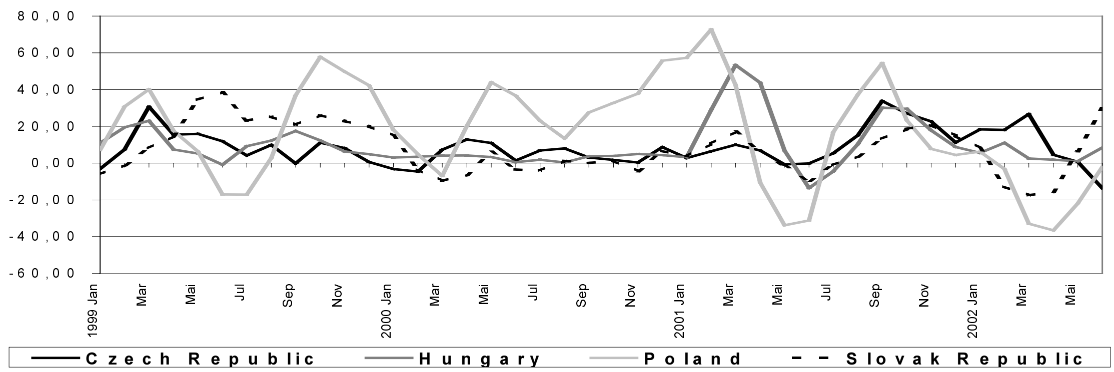
[10] Hakkio/Rush (1989), Barnhart/Szakmary (1991), Sosvilla-Rivero/Park (1992), Luintel/Paudyal, K. (1998) and Jandura (2000) find that the necessary condition for most currencies has been met but reject the sufficient condition. By contrast, some more recent studies do not reject the sufficient condition (for example, those of Naka/Whitney 1995 and Norbin/Reffett 1996).

4 Reasons for an incomplete integration of foreign exchange markets in central and eastern Europe

4.1 Evaluation of possible reasons using a graphical presentation

The deviations from speculative efficiency are shown in *Chart 1*. The forecasting errors of the forward rate for the actual subsequent spot rate are evidently greatest in Poland, followed by Hungary. By contrast, the discrepancies arising in the Czech and Slovak republics seem to be somewhat less pronounced. However, this in itself does not enable to draw conclusions about the existing integration of the foreign exchange markets. At least *stochastic* deviations could be due to irrational expectations as well. Yet in that case there would be speculative efficiency. In line with the results of the econometric study, however, the graphical presentation gives the impression that the deviations were not randomly distributed during the observation period but, instead, were in the positive range for the most part. That implies that financial assets in the central and east European countries have generally shown a higher yield than comparable assets in the euro area. As already mentioned, there are, in principle, a number of possible factors causing yields in the accession countries to lead those in the euro area.[11]

Chart 1. Deviation from speculative efficiency [a)]



a) according to equation (5a), in percentage points per annum

i) Incorrect modelling of exchange rate expectations

Systematic divergences between exchange rate expectations and the actual exchange rate can also be observed if the hypothesis of rational expectations applies. The "peso problem"

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11 Engel (1996) provides a systematic overview.

arises if the fundamental factors indicate an overvaluation of the currency that may last for some time and will be corrected at an undefined date, possibly outside the observation period. This can cause the actual exchange rate to deviate from the expected exchange rate over a lengthy period.[12] A similar situation arises if the central bank intervenes in support of the domestic currency *after* the forward rate has been established. This is likely in cases where the central bank explicitly or implicitly pursues an exchange rate target and uses the forward rate as an indicator of market expectations.

In the period from January 1999 to June 2002 the forward rate in all accession countries under review was mostly above the subsequent actual exchange rate. If it had coincided with the expectations of the market participants during this period, that would imply that the currencies of the accession countries showed persistent depreciation tendencies whereas these tendencies did not materialise or did not materialise fully during the observation period. However, the exchange rates of the Polish zloty and the Hungarian forint remained at the floor of the permissible target corridor, ie the currencies displayed a significant tendency to appreciate. After the Polish central bank had adopted inflation targeting in April 2000 and refrained from intervening on the foreign exchange market the zloty rose within two months by approximately 12% against the euro. The forint also appreciated after the target bands were extended to ±15% at the beginning of May 2001, rising by 10% within a month. Following losses during the initial months of the observation period the Czech koruna and the Slovak koruna also recorded prolonged value gains against the euro. Therefore, the existence of a "peso effect" or deliberate central bank intervention to support the domestic currency against market forces seem not to be plausible in the case of the four countries during the period concerned.

Furthermore, the assumption of rational expectations is an assumption that is not empirically founded and even theoretically is not incontestable.[13] Even so, nominal exchange rate developments in the accession countries during the past few years were fully within the bounds of the typical real appreciation trends that occur in an economic catching-up process.[14] At all events, the recent developments cannot be regarded as speculative bubbles which are generally encouraged by irrational expectations.

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[12] See, for example, Evans (1996), Deutsche Bundesbank (1998).

[13] See Frankel/Rose (1995).

[14] See Fischer (2002) for developments in the real exchange rates of the accession countries and the underlying causes.

ii) Transaction costs

The scope that investors have to optimise their portfolios in line with their yield and exchange rate expectations is limited by the level of the transaction costs which they face in the form of bid-ask spreads, ie differences between the buying and selling rate, on the spot and forward markets. However, only part of these transaction costs are due to the actual costs of market trading. They are also a reflection of competition on the financial markets. A small number of banks in their capacity as active "market makers" are able to achieve monopoly profits. If, for example, a greater number of importers who wish to eliminate their exchange rate risks by buying foreign exchange are active on the forward market, this enables the "market makers", due to the imperfect competition, to raise the forward rate above the expected exchange rate.[15]

The concentration in the banking sector of the accession countries, measured in terms of the share of the five largest banks in total banking assets, is roughly equal to the EU average. Owing to the ongoing process of consolidation, however, it shows an upward tendency.[16] During the observation period the extent of the bid-ask spreads on the foreign exchange markets of the countries under review generally amounted to less than 1% of the bid rate and therefore cannot be seen as the main reason for the differences observed between the forward rate and the actual subsequent spot rate. During the period under review the average differences ranged from 9% in the Czech Republic to 29% in Poland.

iii) Exchange rate premiums

A far more significant reason for deviations from speculative efficiency could be the fact that in the markets a risk premium is charged on assets denominated in the currencies of the central and east European countries. Such premiums arise, firstly, as a result of market participants' risk aversion and, secondly, as a result of the impact that a volatile market environment has on yield expectations. In spite of the resultant segmentation, they are unproblematical insofar as they are consistent with an efficient allocation of capital.

In addition to this initial evaluation of determinant variables their empirical relevance is also of interest. It is important to make a distinction between the exchange rate premium and transaction costs when ascertaining the causes of any remaining segmentation because the implications associated with these two aspects are different. Firstly, exchange rate

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[15] As the banks' purchasing rate for foreign exchange is below their selling rate, the swap rate can fluctuate within the spread around the expected exchange rate without creating speculation.

[16] See Reininger/Schardax/Summer (2001), p 9 f.

premiums are consistent with efficient markets. Secondly, events in the present euro-area countries have shown that the anchoring of exchange rate expectations and a concomitant decline in the exchange rate premium were successful in dismantling the existing foreign exchange market segmentation in the run-up to the introduction of the euro. Such *endogenous developments* are also to be expected in the east European economies when the market participants are certain that there are no further obstacles to accession. By contrast, inefficiencies which stem, for example, from large transaction and information costs are much more problematical. As they may actually impede the smooth functioning of ERM II in extreme cases, they should be reduced as far as possible prior to monetary integration into the exchange rate mechanism of the Eurosystem. To that extent, it seems reasonable to ascertain the impact of an exchange rate premium on foreign exchange market segmentation and in this way to be able to draw conclusions regarding the extent of existing transaction costs. The following section contains a detailed examination of the empirical relevance of exchange rate premiums in the foreign exchange markets of central and eastern Europe.

4.2 Identifying exchange rate premiums by means of an econometric study

Proving the existence of the exchange rate premium which is paid on the foreign exchange markets for the hedge against exchange rate fluctuations and explaining their justification have appeared in the literature since the beginning of the 1980s. The theoretical considerations are based on the general asset price model developed by Lucas (1982). It states that the level of the risk premium depends on the concavity of the utility function and the probability distribution of the exogenous variables monetary growth and consumption. It was empirically tested by Hodrick/Srivastava (1986) and Hodrick (1989).

The studies by Kaminsky/Peruga (1990) and Backus/Gregory/Telmer (1993) retain the theoretical justification of the risk premium but assume the existence of the stochastic process of capital income and forgo a general equilibrium approach, which would also explain these variables.[17] None of the studies mentioned is ultimately able to explain the risk premium solely on the basis of the variables derived from the Lucas asset pricing model.

A simplified test of the existence of a risk premium is to be found in the work of Domowitz/Hakkio (1985). They use the conditional variance of the logarithmic difference between the forward rate and the expected exchange rate as explanatory variables. Using

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[17] See Dumas (1993).

the same method and the results of surveys on the expected exchange rates within the EMS, Nieuwland/Verschoor/Wolff (2000) were able to prove the existence of a risk premium on the foreign exchange markets. Studies by Wolff (1987), Cheung (1993) and Alexius/Sellin (1999) point in the same direction. They confirm the existence of an exchange rate premium in state-space models using the Kalman filter to identify latent factors. Although this procedure significantly improves the empirical identification of the exchange rate premium, its drawback is that the exchange rate premium can be explained only in the light of its own past trend.

Chiang (1991) und Jiang/Chiang (2000) took a different approach. Here, the determinants arising out of the asset price model of Lucas (1982) are replaced by the conditional variances of the share prices or are augmented by these. The use of a broader spectrum of yields than the basic model provides for is particularly advisable owing to the close relationship that is observed between share price movements and exchange rate movements.

The inclusion of other financial market segments also appears prudent when considering the international integration of the foreign exchange markets in central and eastern Europe. In the annex the underlying regression equation used in the following is derived by means of a theoretic model. In the end the exchange rate premium is explained by the conditional variances of monetary growth, industrial output (as a proxy for consumption) and share price movements, both in the domestic market and abroad:

$$(8) \qquad e_t^T - e_{t+3} = c + \beta_1 hm_{i,t} + \beta_2 hm_{EMU,t} + \beta_3 hy_{i,t} + \beta_4 hy_{EWU,t} + \beta_5 hk_{i,t} + \beta_6 hk_{EMU,t} + \varepsilon_t$$

where hm = conditional variance of monetary growth, hy = conditional variance of the growth in industrial output as a proxy for consumption, hk = conditional variance of the relative changes in the share price index, ε = disturbance term, i = country index for accession candidates and EMU = index for European monetary union.

The endogenous element in equation (8) is defined in such a way that positive deviations indicate a yield advantage and therefore a possible exchange rate premium to the detriment of investment in central and eastern Europe. In the regression the expected signs of the parameters of the domestic variables (β_1, β_3, β_5) are negative, and of the parameters of the euro-area variables (β_2, β_4, β_6) positive.[18]

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[18] See annex.

The estimates are made on the basis of monthly data. In the case of the Czech Republic and Hungary the observation period is from December 1998 to June 2002 and for Poland and the Slovak Republic from January 1999 to June 2002. The sample per country therefore consists of only 43 and 42 observations respectively. To that extent, the results are to be interpreted with caution.

As the conditional variance of the exogenous variables, ie money stock, industrial output and share market index or their respective growth rates, cannot be observed directly, in a first step it is necessary to estimate them. The conditional variance of the relevant time series z_t is established by means of the following GARCH equation system:**19**

(9) $$z_t = c + \sum_{j=1}^{r} \gamma_j z_{t-j} + \varepsilon_t$$

(10) $$h_t = \omega + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-1}^2 + \sum_{i=1}^{p} \beta_i h_{t-1}$$

Equation (9) is the mean equation, which in the present approach models the relevant time series z_t as an AR process. In equation (10) the conditional variance h_t is calculated by a GARCH process as a function of past information, ie from the squared residuals of the mean equation and the conditional variance of the previous period.**20**

The specification of the exogenous univariate time series of monetary growth, growth in industrial output and relative changes in the share price index as AR models is based on the Box-Jenkins method of modelling time series. This comprises the *identification of the model*, the *estimation of the parameters* and the *diagnosis of the residuals*. The process of model formation is iterative until a simple though statistically adequate model is found.**21**

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19 For the underlying principles of the ARCH and GARCH models see Engle (1982) and Bollerslev (1986). As it is not possible to include the causes of a high degree of volatility in the estimate, the *estimated* volatility and the *forecast* volatility of the previous period are used as determinants of the current volatility. Consequently, a measurement of the degree of volatility in the form of the conditional variance is derived for each period. See also Frömmel (2002) and Abberger (1997).

20 It is advisable to specify the GARCH model as such in order to be able to model special characteristics of financial market series such as the inherent heteroscedasticity and the leptokurtic distribution, ie a much higher peak in the density function than in a normal distribution. Thus, account can be taken of the fact that both the trend and the volatility of financial market variables are influenced by perpetually changing institutional and economic factors and that the financial markets have periods of high volatility and periods of extreme calm (volatility clusters). See Domowitz/Hakkio (1985).

21 See Box-Jenkins (1976).

Checking the series for stationarity is essential for the identification of the models. The Augmented Dickey-Fuller test (ADF), the Phillips-Perron test (PPT) or the Kwiatkowski-Phillips-Schmidt-Shin test (KPSS) are used for this. In all times series the null hypothesis of a unit root could be rejected at the 5% significance level and the null hypothesis of stationarity could not be rejected at the 5% significance level.[22]

By checking the correlograms, the autocorrelation function and the partial autocorrelation function, the Q statistic and the Breusch-Godfrey serial correlation LM tests, the AR model with the best goodness of fit in terms of the Akaike information criterion (AIC) is identified and the parameters are estimated. The model can be accepted only if the residuals of the model are white noise; otherwise, the process of model formation is repeated. In an *initial* step seasonally adjusted data were used. In a *second* step this procedure was varied by modelling the non-seasonally adjusted time series in the course of seasonal AR processes. As the results of both procedures are comparable, only the results of the time series that were already seasonally adjusted were shown. In most cases these show a slightly greater significance of the parameters. The estimated parameters of the autoregressive terms and their z-values are shown in *Table 1*.

The identified AR model was tested for the presence of ARCH effects by means of an ARCH LM test. Significant GARCH effects are maintained in the model. The autocorrelation coefficients and partial autocorrelation coefficients of the squared residuals show whether a suitable GARCH model could be implemented along the lines of the procedure used by Bollerslev (1986). The constant of the GARCH equation, the coefficients of the ARCH and GARCH terms as well as their z-statistics likewise appear in *Table 1*. Both the AR specification and the GARCH models show very little common ground between the individual countries or the time series. It must be emphasised, however, that the z-values of the GARCH components are highly significant. Therefore, the volatility in earlier periods seems to be of great importance for the current variance.

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[22] However, the stationarity of $e^{T}_{t,t+3} - e_{t+3}$ is inconsistent with the results in Part 3, according to which the time series $E^{T}_{t,t+3} / E_t$ and E_{t+3} / E_t display different degrees of integration. This contradiction can ultimately be explained only by the insufficient ability to distinguish between stationary and non-stationary time series or by the low power of the available stationarity tests.

Table 1. Univariate time series models for calculating conditional variances

	AR model specification				GARCH model specification		
Time series	**Constant**	**AR(1)**	**AR(2)**	**AR(j)**	**Constant**	**ARCH**	**GARCH**
POM	0.01 *(3.52)*	0.50 *(4.64)*			0.00 *(4.12)*	-0.27 *(-4.01)*	
POY		-0.45 *(-1.91)*			0.00 *(0.75)*	0.42 *(1.11)*	0.55 *(1.94)*
POS		0.26 *(2.48)*		-0.36 [AR(3)] *(-3.42)*	0.00 *(0.62)*	-0.26 *(-1.46)*	0.97 *(2.06)*
CZM	0.01 *(3.73)*			0.45 [AR(12)] *(3.42)*	0.00 *(0.67)*	-0.20 *(-0.93)*	1.09 *(3.37)*
CZY	0.00 *(2.34)*	-0.28 *(-2.33)*			0.00 *(1.39)*	-0.22 *(-3.14)*	1.13 *(37.80)*
CZS		0.49 *(9.46)*	-0.26 *(-3.47)*		0.00 *(16.19)*	-0.35 *(-7.23)*	1.07 *(20.14)*
HUM	0.01 *(21.34)*	0.31 *(3.26)*			0.00 *(0.28)*	-0.12 *(-1.54)*	1.10 *(5.54)*
HUY	0.01 *(2.26)*			0.34 [AR(3)] *(3.70)*	0.00 *(0.24)*	-0.17 *(-3.35)*	1.13 *(5.77)*
HUS					0.00 *(2.56)*	-0.11 *(-0.43)*	
SLM	0.01 *(2.54)*	0.56 *(2.78)*	-0.28 *(-1.97)*	0.37 [AR(3)] *(3.32)*	0.00 *(2.42)*	-0.12 *(-0.98)*	0.86 *(17.77)*
SLY	0.00 *(4.15)*	-0.21 *(-1.91)*		-0.14 [AR(3)] *(-3.33)* 0.11 [AR(5)] *(3.12)*	0.00 *(2.66)*	-0.14 *(-0.62)*	1.20 *(5.24)*
SLS					0.00 *(0.64)*	-0.18 *(-1.25)*	1.08 *(7.67)*
EUM	0.01 *(5.83)*	0.46 *(2.68)*	-0.28 *(-2.06)*		-0.00 *(-0.41)*	-0.03 *(-0.43)*	1.04 *(8.93)*
EUY					0.00 *(1.08)*	-0.32 *(-2.77)*	1.05 *(3.60)*
EUS					0.00 *(0.00)*	-0.17 *(-32.87)*	1.15 *(6.88)*

Once the conditional variances for the individual times series have been quantified, the parameters for identifying the exchange rate premiums can be estimated using an OLS regression model. The process of model formation goes from "general to specific".[23] The estimate is consistent if the conditional variances were consistently estimated. In each case, however, it reveals standard errors of the estimated parameters that are too low, and therefore the t-values are too high. This error of the first order stems from the fact that the regressors are not exogenously given but were previously estimated.[24] To that extent, one is inclined, wrongly, to reject the null hypothesis, ie the absence of a risk premium.

[23] See Hendry (1995).

[24] See Pagan (1984).

Consequently, when interpreting the results particularly strict standards have to be set with respect to the level of significance of the estimate. The results of the regression are summarised in *Table 2*.

Table 2. Coefficients and t-values of the regression model for explaining the existence of risk premiums on central and east European foreign exchange markets

	C	Var DMI	Var DME	Var DYI	Var DYE	Var DSI	Var DSE	R^2
Poland	-0.09 *(-812.08)***	-220.84 *(-3.94)***	3625.72 *(5.77)***	-62.61 *(-7.05)***	738.81 *(6.05)***	5.21 *(1.27)*	27.42 *(8.80)***	0.7
Czech Republic	0,01 *(12.43)***	-273.72 *(-7.09)***	1640.15 *(3.64)***	75.19 *(10.30)***	-62.24 *(-1.31)*	-3.95 *(-3.15)***	1.59 *(0.75)*	0.7
Slovak Republic	0.13 *(78.30)***	-240.88 *(-1.19)*	1931.34 *(3.00)***	-158.60 *(-7.22)***	-774.11 *(-11.10)***	-11.73 *(-5.64)***	-1.54 *(-0.64)*	0.5
Hungary	0.04 *(5.11)***	-1022.73 *(-10.17) ***	2301.16 *(10.86)***	-16.24 *(-2.43)***	43.25 *(2.18)**	-10.81 *(-4.24)***	10.13 *(6.30)***	0.6

* Variable is significant at the 5% level / ** Variable is significant at the 1% level.

There are signs that a risk premium exists in all the economies studied. The variables of the theoretical model are mostly significant and have the expected sign. There is no need for concern about the above-mentioned error of the first order, which implies that the actual standard errors are greater than shown, insofar that most of the parameters are significant at the 1% level. That appears sufficiently informative for an empirical investigation of the model.

Despite that, systematic differences between the individual variables do exist. For example, the volatility of monetary growth is significant both for the country concerned and for the reference country in all economies and has the expected sign. The volatility of the share markets is likewise very informative. It is true that the conditional variances in the share market indices are not significant in some cases, but none of the samples has significantly wrong signs. By contrast, the forecast contribution made by the conditional variance of industrial output cannot be confirmed. In two instances a significantly wrong sign appears (Czech Republic: domestic industrial output; Slovak Republic: foreign industrial output).[25]

Moreover, substantial differences between the individual countries can also be identified. If the results are examined one by one, it emerges that in Hungary all variables are significant *and* have the correct sign. In Poland all significant variables also have the correct sign although one variable is not significant. By contrast, there is one significantly wrong sign in both the Czech Republic and the Slovak Republic.

The significance of the individual variables is not the only point of interest. It is also important to know the extent to which the risk premium can explain the existing differences between the forward rate and the spot rate. This ratio varies considerably between the economies under review. In Hungary, for example, only 20% of the total deviations can be explained by the risk premium, in Poland 30%, in the Czech Republic 40% and in the Slovak Republic as much as 50%. This may be interpreted to mean that the Czech Republic and the Slovak Republic, where the lack of progress in integration is due to a greater extent to the existence of an exchange rate premium, are better prepared for membership of ERM II than Poland and Hungary. The reason is that, while the exchange rate premium is consistent with efficient foreign exchange markets and, in addition, will probably be substantially reduced through endogenous developments in connection with accession to the EU, segmentation in Poland and Hungary is based to a greater extent on information and transaction costs, irrational expectations and other market inefficiencies. In addition the graphical presentation in Part 4.1 has already indicated that these two economies also have the greater deviations from speculative efficiency.

In addition to the conditional variances AR terms were included in the regression equation.[26] They reflect adjustments towards a longer-term equilibrium and can therefore be interpreted as an indicator of delayed information processing or market inefficiency. The fit of the estimate can be improved by this dynamic modelling. In Poland R^2 rises from 0.3 to 0.7, in the Czech Republic from 0.4 to 0.7 and in Hungary from 0.2 to 0.6. Only in the case of the Slovak Republic was it possible to do without AR terms, that additionally confirms the comparatively high degree of efficiency of its foreign exchange markets. By contrast, the adjustment process in the Czech Republic, Poland and Hungary are much

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[25] The explanation might lie in the generally low level of volatility of this variable and the possibility that it is an insufficient proxy for the adequate, though only quarterly available, "consumption" variable in the theoretical model; see Alexius/Sellin (1999).

[26] The residuals are serially uncorrelated and represent expectation errors which also occur when expectations are rational. For all countries a significant heteroscedasticity of the residuals was identified and modelled by means of a GARCH (1.1) process.

more extensive and have a greater impact on the segmentation of the markets. It is still obvious that in all economies the constant of the regression equation is extremely significant. It can represent other distortions on the foreign exchange markets or indicate that the risk premium not only has a component which varies over time but one which is independent of time and which cannot be explained by the exchange rate model used.

5 Conclusion

In summary, it can be said that the foreign exchange markets of the central and east European accession countries are not yet fully integrated internationally. Furthermore, the absence of proof that there is a long-term equilibrium between swap rates and actual exchange rate movements is a clear indication of systematic infringements of the law of one price and points to a lower degree of integration in the accession candidates than in the euro-area countries in the 1990s.

Systematic expectation errors which may arise as the result of the peso problem or the existence of speculative bubbles offer no satisfactory explanation for the discrepancies observed in these samples. Even so, the failure to achieve speculative efficiency is not necessarily a reflection of imperfect markets. Instead, there are signs that the remaining segmentation in all four countries is due to some extent to exchange rate premiums which vary over time and which are fully consistent with efficient pricing on the foreign exchange markets. Yet adjustment to long-term equilibrium after a disturbance does not seem to occur immediately but, instead, requires some time (except in the Slovak Republic), a phenomenon which may be due to additional information costs. There is a further factor in all countries, namely a constant component which is independent of time and which persistently hinders complete adjustment of the expected yields at home and abroad. It indicates further distortions or a fixed component of the exchange rate premium which cannot be explained by variables included in the model.

The segmentation of the foreign exchange markets, especially where it is not reduced endogenously through EU accession, can be expected to impair the coordination of national money and exchange rate policies within ERM II. Furthermore, it raises the uncertainties with respect to defining the parity vis-à-vis the euro. Owing to the participation of the accession countries in ERM II, a further reduction in transaction and information costs on the central and east European foreign exchange markets as well as an improvement in the way markets process information seems thoroughly desirable.

A Annex

A.1 Sources

Money market rates, three-month	
all countries	End-of-period, Datastream (IR)
Foreign exchange spot rates	
Slovak Republic, Czech Republic, Hungary	End-of-period, Datastream (WMR)
Poland	Bloomberg
Foreign exchange forward rates, three-month	
Slovak Republic, Czech Republic, Hungary	End-of-period, Datastream (WMR)
Poland	Bloomberg

A.2 Modelling the exchange rate premium along the lines of Lucas (1982)

Two countries, the United Kingdom (country 1) and the United States (country 2), each have a basket of goods (x_1 and x_2 respectively). The purchasing power of the pound in terms of x_1 is

(A1a) $\Pi_1 = 1/P_1$;

the purchasing power of the US dollar in terms of x_1 is

(A1b) $\Pi_2 = E/P_1$

where Π_i = purchasing power of the currency of country i, P_i = price level in country i and E = exchange rate [£/$].

The US terms of trade are given by

(A2) $$TOT = \frac{E \cdot P_2}{P_1} = \frac{u'(x_2)}{u'(x_1)}.$$

where $u'(x_i)$ = marginal utility of x_i.

Using a cash-in-advance model and assuming that goods markets are completely cleared:

$$(A3a)\quad \Pi_1 = \frac{x_1}{M_1} \qquad \text{and} \qquad (3b) \quad \Pi_2 = \frac{TOT \cdot x_2}{M_2}$$

where M_i = the money stock in country i.

The exchange rate is determined by the purchasing power parity on the goods markets:

$$(A4)\quad E = \frac{\Pi_2}{\Pi_1} = \frac{TOT \cdot x_2 / M_2}{x_1 / M_1} = \frac{u'(x_2)}{u'(x_1)} \cdot \frac{x_2 / M_2}{x_1 / M_1}$$

The forward rate is determined by the covered interest parity:

$$(A5)\quad E^T = E \cdot \frac{1 + i_1}{1 + i_2}$$

Interest rates arise from the optimisation of the intertemporal consumption function. Let W_t represent the wealth of a representative consumer in the United Kingdom, measured in terms of x_1. He may consume part of this wealth in the current period. He invests the rest at interest rate i and uses it to meet his consumption requirements in the second period.

$$(A6)\quad L = \in \left[U(X_t, X_{t+1}) + \lambda \left\{ W_t - X_t - \frac{X_{t+1}}{1 + i_1} \frac{\Pi_{1,t}}{\Pi_{1,t+1}} \right\} \right]$$

where $\in[...]$ = the expectation operator, $X_t = x_{1t} + TOT_t \cdot x_{2t}$ = consumption in units of x_1.

Maximisation for $x_{1,t}$ and $x_{1,t+1}$ results in:

$$(A7)\quad \frac{1}{1 + i_1} = \in \left[\frac{\beta \cdot u'(x_{1,t+1})}{u'(x_{1,t})} \cdot \frac{\Pi_{1,t+1}}{\Pi_{1,t}} \right]$$

where $U(X_t, X_{t+1}) = u(X_t) + \beta \cdot u(X_{t+1})$.

Taking account of (A3a), one obtains:

$$(A8)\quad \frac{1}{1 + i_1} = \in \left[\frac{\beta \cdot u'(x_{1,t+1})}{u'(x_{1,t})} \cdot \frac{x_{1,t+1} / M_{1,t+1}}{x_{1,t} / M_{1,t}} \right]$$

Substituting (A8) and the analogous expression for $1+i_2$ in equation (A5) results in:

$$(A9)\quad E_t^T = E_t \frac{\in\left[\frac{\beta \cdot u'(x_{2,t+1})}{u'(x_{2,t})} \cdot \frac{x_{2,t+1}/M_{2,t+1}}{x_{2,t}/M_{2,t}}\right]}{\in\left[\frac{\beta \cdot u'(x_{1,t+1})}{u'(x_{1,t})} \cdot \frac{x_{1,t+1}/M_{1,t+1}}{x_{1,t}/M_{1,t}}\right]}$$

The utility function is specified as follows:[27]

$$(A10)\quad u(x_1, x_2) = \left[\frac{1}{1-\gamma}\right] x_1^{1-\gamma} + \left[\frac{1}{1-\delta}\right] x_2^{1-\delta}$$

If this utility function is used, (A9) becomes

$$(A11)\quad E_t^T = E_t \frac{\in\left[\beta \frac{x_{2,t+1}^{1-\delta}}{x_{2,t}^{1-\delta}} \cdot \frac{M_{2,t}}{M_{2,t+1}}\right]}{\in\left[\beta \frac{x_{1,t+1}^{1-\gamma}}{x_{1,t}^{1-\gamma}} \cdot \frac{M_{1,t}}{M_{1,t+1}}\right]}$$

If the growth rates of the random variables x_1, x_2, M_1 and M_2 are distributed normally, (A11) can be written logarithmically as:[28]

$$(A12)\quad \begin{aligned} e_t^T &= e_t + (1-\delta)\in[\hat{x}_2] - \in[\hat{M}_2] - (1-\gamma)\in[\hat{x}_1] + \in[\hat{M}_1] \\ &+ \frac{1}{2}(1-\delta)^2 h_{\hat{x}2}^2 + \frac{1}{2} h_{\hat{M}2}^2 - \frac{1}{2}(1-\gamma)^2 h_{\hat{x}1}^2 - \frac{1}{2} h_{\hat{M}1}^2 \end{aligned}$$

where h_i = conditional variance of variable i.

If (A10) is integrated into (A4), the expected spot rate is obtained for t+1. This rate in logarithmic form amounts to:

$$(A13)\quad \in[e_{t+1}] = e_t + (1-\delta)\in[\hat{x}_2] - \in[\hat{M}_2] - (1-\gamma)\in[\hat{x}_1] + \in[\hat{M}_1]$$

Consequently, the premium for exchange rate risk is given by:

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27 The utility function is also used by, for example, Hodrick (1989) and implies a constant relative risk aversion (γ for good x_1 and δ for good x_2).

28 If $\hat{x}$ is distributed normally, x_{t+1}/x_t is log-normally distributed. Where an incidental variable (z) is distributed log-normally: $\in\left[e^{\ln z}\right] = e^{\in[\ln z] + 1/2\sigma_z^2}$.

(A14) $\in\left[e_{t+1}\right]-e_t^T=\frac{1}{2}(1-\gamma)^2 h_{\hat{x}1}^2+\frac{1}{2}h_{\hat{M}1}^2-\frac{1}{2}(1-\delta)^2 h_{\hat{x}2}^2-\frac{1}{2}h_{\hat{M}2}^2$

The risk premium demanded for the holding of foreign currency assets therefore depends on the conditional variances of the domestic and foreign variables. An increase in the degree of volatility at home increases the expected purchasing power of the domestic currency ($1/P_i$). Accordingly, the expected yield on foreign assets increases to compensate investors. However, this effect is partly offset by the risk aversion of market participants (γ and δ as measures of the constant relative risk aversion).

Jiang/Chiang (2000) explicitely take account of the volatility of asset price developments analogously to the volatility of changes in the endowment with consumer goods. This is done by integrating the volatility of stock markets, which are highly correlated with foreign exchange markets, into the model. The difference between the expected exchange rate and the forward rate is then given by

(A15) $\in\left[e_{t+1}\right]-e_t^T=\frac{1}{2}(1-\gamma)^2 h_{\hat{x}1}^2+\frac{1}{2}h_{\hat{M}1}^2+\frac{1}{2}\kappa_1 h_{\hat{K}1}^2-\frac{1}{2}(1-\delta)^2 h_{\hat{x}2}^2-\frac{1}{2}h_{\hat{M}2}^2-\frac{1}{2}\kappa_2 h_{\hat{K}2}^2$

where = κ_1, κ_2 parameter to be estimated for the impact of stock market volatility.

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