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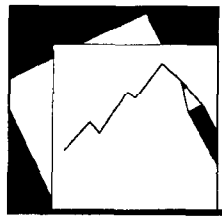

IMF Working Paper

Czech Koruna and Polish Zloty: Spot and Currency Option Volatility Patterns

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Monetary and Exchange Affairs Department

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Abstract

Exchange rate flexibility has facilitated an impressively fast insertion of the Czech koruna and the Polish zloty into the global currency market. However, exchange rate volatility patterns differ: Lower volatility is observed for the koruna against the euro relative to the U.S. dollar, while the opposite is true for the zloty, apparently related to earlier financial integration of the Czech Republic with Europe and early dollarization in Poland as a result of initial higher inflation rates. By contrast, the currency options market shows enhanced information content of both currencies against the euro reflected in the behavior of their implied volatility.

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I. INTRODUCTION

The evolution of Eastern European currencies in the last decade has been one of the most impressive features of their transition to become market economies. After a brief period of limited convertibility, these currencies have become increasingly traded in international markets to the point that cross-border investors and market-makers have developed up-to-date financial instruments to separate risks in their financial operations in these markets, allowing for a more effective hedging and the design of tailor-made financial investment alternatives.

In the case of the Czech Republic and Poland, first-wave candidates to join the EU, a relatively flexible exchange rate has increasingly facilitated the incorporation of market expectations in interest rate and exchange rate changes. However, there have been important differences in the path toward market liberalization for these two countries, in particular for foreign exchange markets, which may have affected not only the market infrastructure, but also the perception of risks by cross-border investors.

Important differences already existed at the inception of the transition process:

- Poland was on the verge of hyperinflation with average consumer price inflation of 600 percent in 1990 compared with 10 percent in the former Czech and Slovak Federal Republic;

- As a result, Poland showed a larger share of foreign currency deposits, equivalent to 38 percent of total private deposits, particularly in U.S. dollars. This compares with about 10 percent in the Czech and Slovak Federal Republic;

- Poland had also accumulated a more severe debt problem with an external debt of US$47 billion (70 percent of GDP) compared to US$8 billion in the Czech and Slovak Federal Republic (about 30 percent of GDP); and

- Poland was a relatively closed economy relative to the Czech and Slovak Federal Republic, with exports equivalent to 19 percent of GDP against 33 percent of GDP in the Czech and Slovak Federal Republic. This compromised debt sustainability even further.

These factors also affected the evolution of foreign exchange markets in different ways: First, a peg to the U.S. dollar in the context of sizable dollarized deposits strengthened the link of the Polish zloty with that currency. Second, hyperinflation and dollarization may have made agents operating in Poland more sensitive to changes in relative returns in the first stages of transition. Third, doubts concerning debt sustainability in Poland may have prevented the participation of cross-border investors until the debt problem was resolved. Fourth, however, once agreements with main creditors were reached, the substantial stock of debt facilitated the rapid consolidation of a relatively liquid government debt market.

This paper compares exchange rate volatility patterns in the Czech Republic and Poland, especially in the last years of the 1990s when both countries took more decisive steps toward exchange rate flexibility. The main question that it addresses is how the main features of the foreign exchange market and of foreign exchange policy reflect on differences in volatility patterns, in particular relative to the U.S. dollar and the euro. Other subordinated questions are how differences between the foreign exchange markets in these countries reflect expectations of currency option users and how they are reflected in the transmission of information from more informed investors into the foreign exchange spot market.

The paper is organized as follows: section I analyzes the highlights of the evolution of foreign exchange markets in both countries including policy and market developments in the last decade and an overview of exchange rate volatility patterns. Section II describes the market infrastructure of the currency derivatives market, in particular in relation to cross-border transactions, with emphasis on the influence of foreign exchange policy and market developments in the configuration of the market for such instruments. It then analyzes currency option implied volatility indicators. Section III deals with the information content of currency option implied volatilities, including application of a GARCH model to measure the incorporation of information implicit in changes of daily implied volatility on spot exchange rate volatility, for both currencies relative to the U.S. dollar and the euro for the period end-1997 to end-2000. [2] Conclusions are summarized in the final section of the paper.

II. Foreign Exchange Policy, Regulation and Market Developments[3]

A. Evolution of the Foreign Exchange Market and Macroeconomic Background

The Czech and Slovak Federal Republic (CSFR) started the transition with an average inflation of 5 percent in the 1980s, lower than for other transition economies. By contrast, transition in Poland started with a stabilization program that aimed at quickly bringing down inflation from 600 percent in 1990. The limited external debt in the CSFR (only about 115 percent of exports in convertible currencies) provided less uncertainty for foreign counterparts, while the debt problem in Poland conditioned significantly the prospects of the stabilization program.

A transition toward a liberal foreign exchange regime took place in the years preceding the dissolution of the currency union with the Slovak Republic (1993), with the unofficial parallel market converging toward the official rate. A less orderly process took place in Poland, where a crawling peg to a currency basket was introduced in October 1991 after the exchange rate became unsustainable. Both countries accelerated the liberalization of their foreign exchange market, accompanied in Poland by negotiations with external creditors, with monetary policy aiming at building up foreign exchange reserves to meet debt obligations.

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[2] Information on currency option prices is available since November 1997.

[3] Information on Tables 1 and 2 is based mainly on several issues of IMF Staff Reports and Selected Issues Documents.

The dissolution of the currency union with the Slovak Republic on February 8, 1993 led to the creation of the Czech koruna as the legal tender of the Czech Republic and somehow delayed further foreign exchange liberalization. In Poland, commercial banks were allowed to transact directly in the foreign exchange market, and the obligation to sell excess foreign exchange to the central bank was removed in 1993. By contrast, the development of the Czech domestic financial market was significant, as domestic banks offered modern financial products including operations in the futures market. Poland experienced initial difficulties, with the central bank and the government having problems placing securities in the money market. Since 1994, borrowing in foreign currency by Czech enterprises increased, including short-term borrowing by banks, encouraged by interest rate differentials, expectations of currency appreciation, and some expectations of controls. In Poland, completion of negotiations with creditors in 1994 improved credibility in government policies, encouraging additional capital inflows.

Concerns about speculative capital flows started in 1995. In the Czech Republic, a limit on net short-term borrowing by banks was set on August 1, 1995. Capital inflows and persistent exchange rate appreciation pressures continued nonetheless, as increased derivatives and speculative trading related to koruna-denominated securities issued took place mainly in London through NDFs, attracted by the domestic-foreign interest rate differential of 8.5 percent. Commercial banks covered short positions in the spot market through forward transactions, and proprietary trading by banks had increased much more than client-driven transactions. Forward and swaps foreign exchange transactions in the Czech koruna were twice as much as in the Polish zloty.[4] Poland rebased the zloty in January 1995, with 1 Zl equal to 10,000 old Zl. In May 1995 a crawling band was set at +/- 7 percent, with the central rate continuing to crawl at the rate of 1.2 percent per month. In the Czech Republic, the exchange rate band was widened from +/-0.5 percent to +/-7.5 percent around a central rate in February 1996.

Poland issued its first eurobond in June 1995, while the euro-koruna bond market was established in September 1995. German commercial banks issued debt to on-lend the koruna through subsidiaries in the Czech Republic (allowing Czech entities to refinance their external liabilities in domestic currency). Other supranational and sovereign issuers used their strong credit rating to swap koruna receipts into other currencies at lower cost. London swap houses, counterparties to such transactions, often placed the koruna receipts in Czech bonds in order to hedge their obligations. In Poland, a new eurobond issue for DM 250 million attracted new investors. The share of foreign holdings of treasury bills increased from almost zero in 1994 to more than 20 percent in the first quarter of 1996, encouraged by interest differentials and expectations of exchange rate appreciation. Poland's central bank cut its headline rates by a total of 3-4 percentage points in 1996 to counteract exchange rate pressures.

Some US$2 billon of euro-koruna bond issues were expected to mature in early 1997 while the exchange rate reached a level 6 percent above its central parity.[5] The Czech central bank tried

[4] And larger at the time than for any Latin American country.

[5] Issuers of Euro-Koruna bonds had raised US$4 billion until 1997 in the offshore market, compared with total issue of Euro-zlotys of US$614 million.

unsuccessfully to "talk the rate down." On May 15, 1997, after 10 days of unsustainable foreign exchange intervention, intensive short-selling and steep increases in interest rates, [6] the Czech koruna dropped to 4.8 percent below parity. On May 26 1997, the central bank adopted a managed floating regime, with the Deutsche Mark as the reference currency.

In 1998, foreign currency denominated debt of enterprises in the Czech Republic had reached 31 percent of GDP or 57 percent of exports of goods and nonfactor services, and net portfolio outflows were recorded for the first time, as households and enterprises readjusted their portfolios in reaction to lower domestic returns relative to those abroad. In Poland, lower inflation encouraged capital inflows further, with US$12 billion in 1998, twice the level of 1997. Nonresidents accounted for half of all sales at primary auctions of government securities in the first half of the year. The authorities responded initially with further sterilization policies and higher reserve requirements. On February 26, 1998 the exchange rate band was widened to 10 percent, and again on October 29, 1998, to 12.5 percent. Foreign currency lending increased significantly toward the end of 1998, with a share of 24 percent of total lending up from 17 percent at the end of 1997. Banks circumvented outstanding restrictions through currency swaps or re-denominating financial credits as commercial credit. In January 1999, the authorities removed the daily fixing by the central bank, [7] and issued a new Foreign Exchange Law that made the zloty almost fully convertible and allowed off-shore accounts, with some limitations on investments in securities and transactions in derivatives.[8]

In Poland, the currency basket was redefined to EUR 55 percent and USD 45 percent with the introduction of the euro, and on March 1, 1999, the Zloty's trading band was widened to 15 percent and the rate of crawl was lowered to 0.3 percent per month. The exchange rate was finally allowed to float on April 11, 2000, to facilitate a full-fledged inflation-targeting framework. In 2000, a downgrade by Standard and Poor to A- reflected the prospects of a protracted slowdown in the Czech Republic. By contrast, upward pressures on the Czech koruna resulted from strong inflows of foreign direct investment, mainly from privatizations of financial institutions.

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[6] To 75 percent for the central bank 2-week repo and to 35 percent for the 3-month PRIBOR.

[7] "Fixing" consisted on the central bank practice of setting "official market rates" once a day relative to the U.S. dollar.

[8] A commercial bank cannot conduct derivative transactions in zloty if its global foreign exchange position exceeds 30 percent of its own funds.

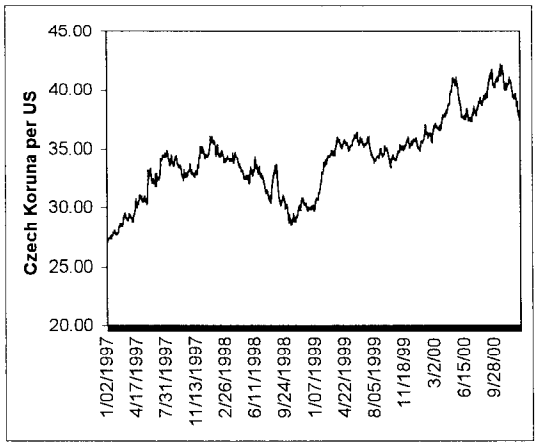
Table 1. Czech Republic: Foreign Exchange Policy, Regulation and Market Developments

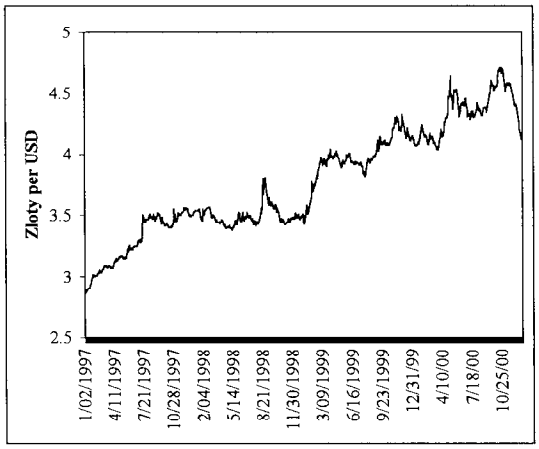
Periods	Background	Foreign Exchange Policy	Foreign Exchange Regulation	Market Developments
Velvet Revolution (From November 1989)	-Average inflation of 5 percent in the 1980s. -External debt only 115 percent of exports in convertible currencies.	-Initial 50 percent devaluation, subsequent peg to a basket of currencies of main trading partners, and unification.	-Foreign exchange freely available for most current account transactions (except for oil, gas narcotics, and arms and ammunition).	-Increasing convergence of parallel exchange rate toward the official rate.
Break up with Slovak Republic (From February 1993)	-Exports-imports equivalent to 34-31 percent of total with Germany and 2-4 percent of total with US.	-Creation of the Czech koruna. In May 1993, peg to basket comprised of the DM and the U.S. dollar (65 and 35 percent respectively).	-Delay of envisaged removal of restrictions, including on the availability of foreign exchange for payments and transfers of invisibles.	
Liberalization of foreign exchange market (1994)	-Acceptance of IMF Article VIII obligations in October 1995.	-Czech koruna fully convertible for current transactions and further liberalization of the capital account.	-Enterprises allowed to open foreign-currency denominated accounts in domestic commercial banks. -Residents allowed to engage in foreign direct investment and related lending.	-Investors attracted by privatization opportunities increase presence in financial and currency market. -Significant development of domestic financial market.
Intensification of cross-border flows (1995-1996)	-Forward and swaps foreign exchange transactions twice as much as in the Polish Zloty.	- Exchange rate band widened from ±0.5 percent to ±7.5 percent around a central rate in February 1996.	-Limit set on net short-term borrowing in August 1995.	-Significant capital inflows and persistent exchange rate appreciation. -Annual 8.5 percent domestic-foreign interest rate differential. -German commercial banks issued debt in Koruna to on-lend through subsidiaries.
Financial crisis (1997)	-External current account deficit of.. and maturing US$2 billion of euro-koruna bond issues.	-Central bank tries unsuccessfully to "talk the exchange rate down." -Unsustainable central bank intervention (exchange rate dropped to 4.8 percent below parity). -Exchange rate band substituted by managed floating with DM as a reference currency.	- Restrictions to non-resident access to domestic liquidity (never enforced).	-Intensive short-selling and steep increases in interest rates. -Residents shifted domestic currency holdings into foreign exchange. - After floating was decided, the Czech koruna depreciated by 12 percent below parity. After that,, speculative positions unwinded.
Post crisis (1998-)	-Gross external debt of US$22.5 billion, about 40 percent of GDP (one third short-term). - Slowdown in activity.	-Keeping a relatively stable exchange rate vis-à-vis the DM resulted in increasing interbank interest rates.		-Foreign currency denominated corporate debt reached 31 percent of GDP. -Net portfolio outflows resulted in exchange rate depreciation.

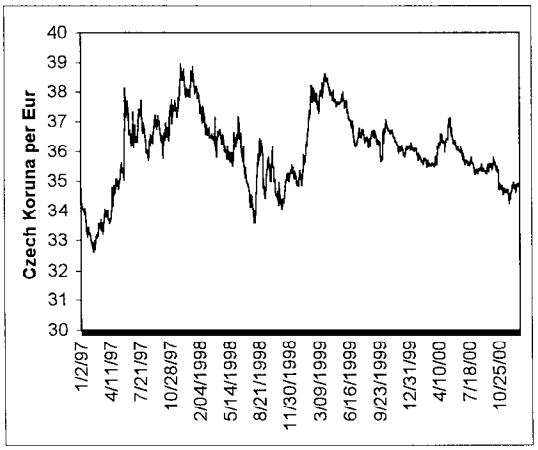
Table 2. Poland: Foreign Exchange Policy, Regulation and Market Developments

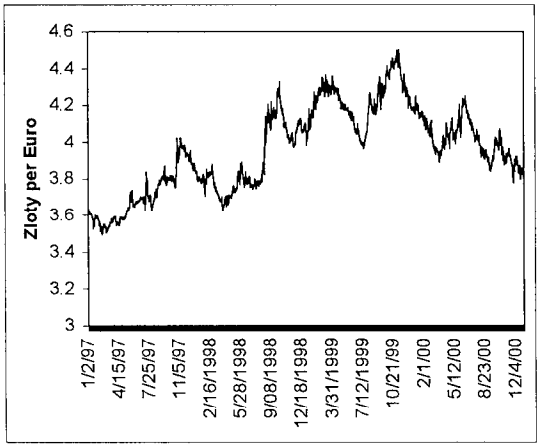
Periods	Background	Foreign Exchange Policy	Foreign Exchange Regulation	Market Developments
Initial Adjustment program (1990-mid-91)	-Inflation of 600 percent in 1990. -Multiple instruments: Money wage, money supply, interest rate, direct credit limits.	-Fixed exchange rate as a nominal anchor. -Crawling peg to currency basket introduced in October 1991 (45 percent U.S. dollar, 35 percent DM, 10 percent Pounds, 10 percent French Franc).		-Excess liquidity, not effectively wiped out by reverse repos. -Government could not place most of bonds issues.
Agreements with foreign creditors (mid-1991-October 1994)	-Agreement with Paris Club (April 1991) provided for a reduction in two stages of creditors' claims by 50 percent in present value terms. -Completion of negotiations with London Club creditors improved credibility in government policies.	-Increase in the rate of crawl accompanied by occasional step devaluations. -Increased sterilization operations (stock of securities increased 14 times expressed in Zloties in 1994-95.) -Households allowed to deposit directly in the central bank to avoid additional stimulus to capital inflows.	-Elimination of most restrictions on the availability of foreign exchange for current account transactions were largely eliminated. -Removal of limits on the transfer of profits for FDI and salary remittances. -Foreign investment law implemented in July 1991 eliminates authorization for FDI and repatriation of capital. -In 1993, Free interbank market, removal of obligation to sell excess foreign exchange to central bank.	-Financial inflows increased, including "unclassified" current account transactions.
Introduction of an exchange rate band (1995)	-First eurobond issued in June 1995 for US$250 million, followed by a DM issue in November 1996. -Headline central bank rate cut three times in 1996 by 3-4 percentage points. - Higher reserve requirements are set in 1998.	-Zloty is rebased in January 1995 (1 Zl equal to 10,000 old Zl). - A crawling band was set at ±7 percent, with a crawling central rate. -Zloty allowed to revalue in December 1995.	-Foreign exchange law implemented in January 1995 allowed for unrestricted accounts for non-residents, with transfer limited by the origin. -Poland accepted Article VIII obligations on June 1, 1995). -In October 1995, enterprises allowed to hold foreign exchange in bank accounts.	-Share of foreign holdings of treasury bills increased from almost zero in 1994 to 20 percent at the beginning of 1996, encouraged by interest rate differentials and expectations of exchange rate appreciation. They accounted for half of all sales in the first half of 1998 - Capital inflows doubled in 1998, to US$12 billion.
Exchange rate flexibilization, switch to inflation targeting (1998-99)	-Inflation targeting is adopted in 1999. -Inflation targets were overshot in 1999 and 2000.	-Exchange rate band widened to 10 percent on February 26, 1998; and again to 12.5 percent on October 29. -With the introduction of the euro, currency basket is redefined to EUR 55 percent and USD 45 percent. -Zloty band widened to 15 percent. Rate of crawl reduced to 0.3 percent a month. -Floating was introduced on April 11, 2000.	-"Fixing" by the central bank is abandoned. -Foreign Exchange Law made the Zloty almost fully convertible.	-Foreign currency lending increased to 24 percent of total in 1998. Banks circumvented outstanding restrictions through currency swaps.

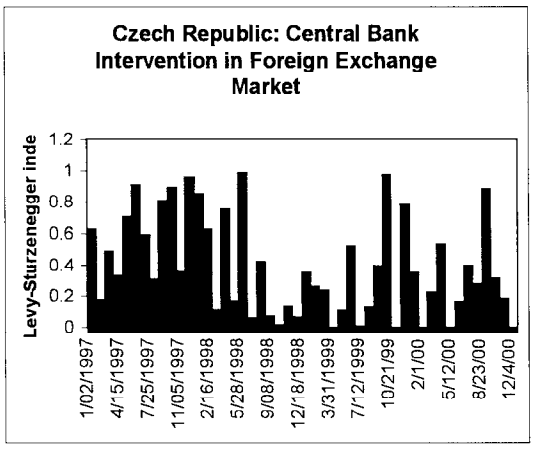
Chart 1. Czech Republic and Poland: Exchange Rates Relative to the U.S. Dollar and the Euro

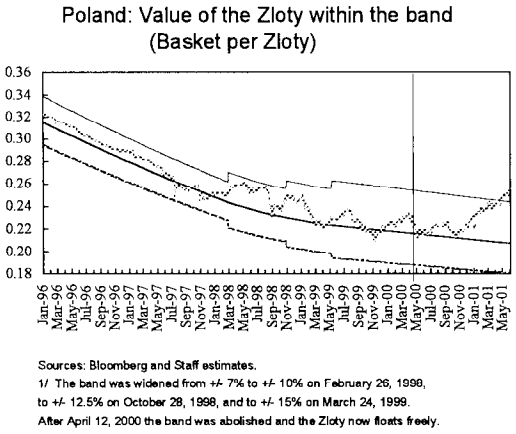












Sources: Bloomberg and Staff estimates.

1/ The band was widened from +/- 7% to +/- 10% on February 26, 1996, to +/- 12.5% on October 28, 1998, and to +/- 15% on March 24, 1999. After April 12, 2000 the band was abolished and the Zloty now floats freely.

B. Exchange Rate Volatility Patterns

Domestic and external factors are reflected in the evolution of the exchange rate. [9] The 1997 crisis in the Czech Republic is clearly reflected in substantial exchange rate depreciation followed by appreciation in 1998 against both the U.S. dollar and the euro. Exchange rate depreciation resumes in 1999 after the Russian crisis, and the Czech koruna shows different paths against the U.S. dollar and the euro from then onward, reflecting the euro depreciation against the U.S. dollar. Intervention in the foreign exchange market under the prevailing managed floating regime became less intensive after 1997, and the Czech koruna appreciates against the euro the two years toward the end of 2000 while it depreciates against the U.S. dollar in the same period. [10]

In the case of the zloty, some depreciation during 1997 was followed by certain stability against the U.S. dollar but not against the euro. The Russian crisis of 1998 resulted in a short-lived exchange rate depreciation, in general following the euro afterwards although with much more fluctuations than in the case of the Czech koruna. The widening of the exchange rate band against the reference currency basket resulted in exchange rate appreciation.

Chart 2 allows a visual inspection of one-month and three-month exchange rate volatility. It is apparent that the Czech koruna shows less volatility fluctuations than the Polish zloty against both currencies, and a tendency to remain above a higher volatility plateau with respect to the U.S. dollar relative to the euro. The Polish zloty shows more fluctuations against the euro, especially looking at one-month volatility, and a salient feature: Exchange rate volatility remains on average lower against the U.S. dollar relative to the euro. The opposite trend is observed in the Czech koruna which reflects traditional linkages of the foreign exchange markets in Poland to the U.S. dollar because of early dollarization, and in the Czech Republic to the euro (following with the DM) because of early financial links with Europe following a faster process of financial development at the beginning of the transition period.

Mean exchange rate daily returns are very close to zero (Table 3), but normality is rejected as the skewness indicator is significantly larger than zero and the Kurtosis indicator significantly larger than three, which is confirmed by the large value of the Jarque-Berra coefficient. Table 4 confirms that less exchange rate volatility is observed for the Czech koruna against the euro and

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[9] The evolution of the exchange rate is shown in Chart 1, for both the Czech Koruna and the Polish Zloty against the U.S. dollar and the Euro for 1997-2000. The series for the Euro are extended before 1999 the basket formula for the period before its inception on January 1, 1999.

[10] As measured by the Levy-Sturzenegger Index in Levy-Sturzenegger (2000).

Table 3. Czech Republic and Poland: Exchange Rate Returns Unconditional Distribution Statistics

(In percent)

	Koruna/USD	Zloty/USD	Koruna/Euro	Zloty/Euro
Mean	0.031	0.035	0.000	0.005
Median	0.036	0.000	-0.028	0.014
Maximum	8.02	3.489	7.777	4.584
Minimum	-3.27	-3.733	-3.163	-3.388
Standard deviation	0.811	0.645	0.642	0.789
Skewness	0.9628	0.2224	1.8839	0.2521
Kurtosis	12.6588	8.2888	25.5439	5.7493
Jarque-Berra (test for normality)	4207.443	1221.820	22660.11	338.89

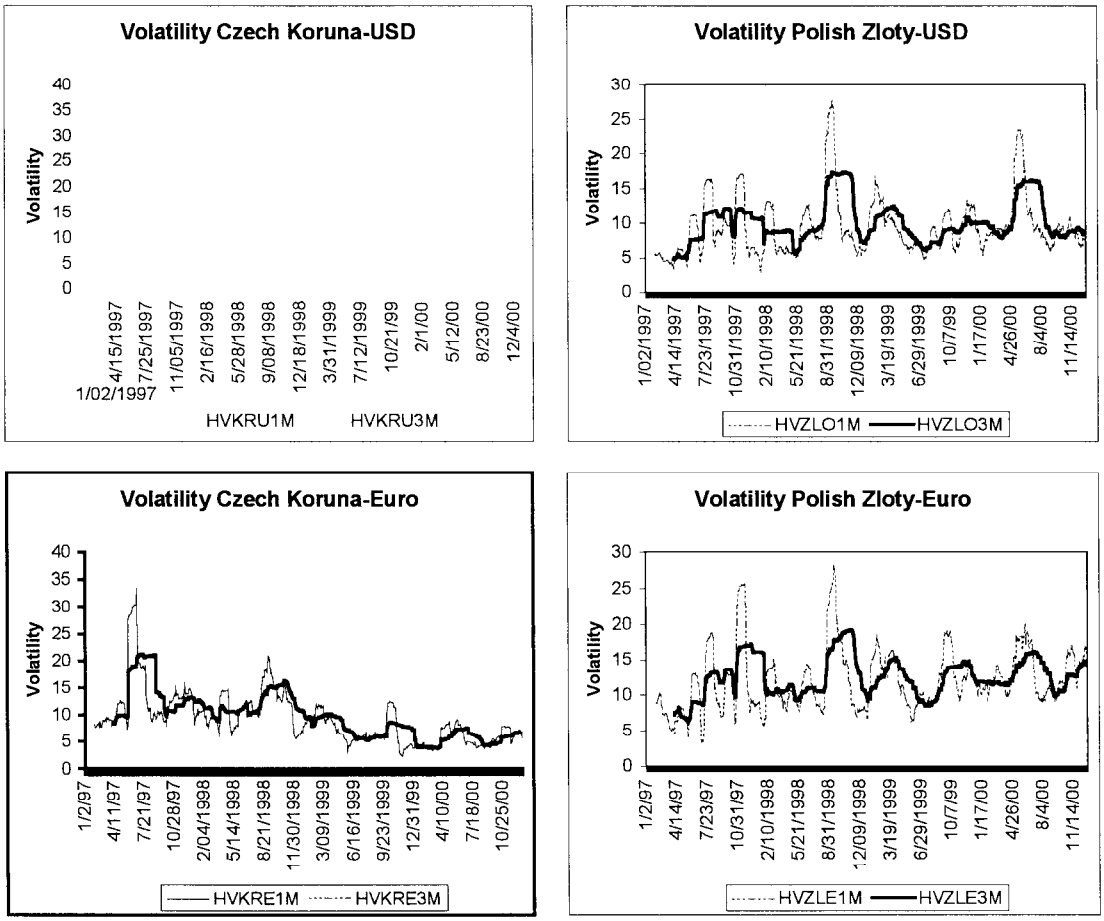
Source: Staff calculations.

Table 4. Czech Republic and Poland: Historical Exchange Rate Volatility Indicators

	1 month	2 month	3 month	6 month
Czech Koruna/USD				
Average volatility	12.42501	12.6728	12.7979	12.85528
Standard deviation	4.22157	3.620767	3.292255	2.615012
Czech Koruna/Euro				
Average volatility	9.30712	9.519622	9.667135	9.830213
Standard deviation	4.863281	4.463099	4.214118	3.622285
Polish Zloty/USD				
Average volatility	9.528677	9.899215	10.14525	10.58502
Standard deviation	4.274281	3.500193	2.974821	1.918823
Polish Zloty/Euro				
Average volatility	12.12793	12.38333	12.55182	12.87933
Standard deviation	4.387676	3.386011	2.738734	1.557886

Source: Bloomberg and staff calculations.

Chart 2. Czech Republic and Poland: One-Month and Three-Month Exchange Rate Volatility



the Polish zloty against the U.S. dollar. By contrast, exchange rate volatility lies above 12 percent for the Czech koruna against the U.S. dollar and the Polish zloty against the euro. Exchange rate volatility tends to be lower for shorter periods, while volatility fluctuations (measured by the standard deviations) are smaller for longer periods with higher volatility standard deviations of the Czech koruna/euro exchange rate and the Polish zloty/euro exchange rate. [11]

[11] Except for the one-month volatility in the case of the Polish Zloty.

III. Market Infrastructure and Information from Currency Options

A. Overview of Market Infrastructure

More than 75 percent of daily turnover in foreign exchange transactions in Eastern European currencies are conducted mainly in the London market (except for Hungary). [12] Consistent with exchange rate volatility patterns, the Czech koruna has long been in the zone of influence of the euro, closely related to the Deutsche Mark, with main transactions conducted by domestic currency units within the major investment banks' trading groups. More market diversification is observed for the Polish zloty, with more transactions taking place in the U.S. dollar market.

Derivatives market

Interest rate swap and forward rate agreements (FRA) have developed strongly in the Czech koruna. In Poland, the Non-Deliverable Forwards (NDF) market survived because of some controls, although they were not binding.[13] Other derivative instruments tend to focus on transactions with corporates rather than between market players.

The currency option market started to operate in 1995. The typical transaction size is small relative to developed markets, larger for the Czech koruna for foreign exchange forwards, options and swaps (Table 5). Benchmark quotes for the Czech koruna are against the euro, while for the Polish zloty are against the U.S. dollar. Currency options are traded basically at the money, as liquidity in both currencies for trading options at strike prices other than at the money is low.

In the Czech Republic and Poland, quotes in the deposit market and FRAs are basically at the same price level, with bid-offer spreads of 15 basis points. The swap market in the Czech Republic extends to 15 years, and it is more liquid than in Poland where it extends to 10 years, difference related to earlier financial development. The Czech swap market is the most liquid swap market in the region, with bid-offer spreads of less than 10 basis points. Few repo transactions take place in the Czech Republic and Poland, although there are no legal restrictions that prevent domestic and foreign investors from operating in this market.

While market makers could hedge through currency derivatives, foreign investors in general do not hedge domestic currency exposure except when market conditions are extremely uncertain. Some investors prefer only to hedge the euro exposure, hedging the approximate correlation

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[12] Cohrs, Thomas and Dahmer, William. Fx and Derivatives; Euromoney, September 2000.

[13] Some restrictions on short-term capital flows still exist for operations in Polish Zloty. Specifically, transactions in derivative instruments not quoted on one of the country's exchanges require the explicit approval of the Polish National Bank.

with the domestic currencies (approximately 80 percent for the Czech koruna and 60 percent for the Polish zloty in recent years) by financing positions through a combination of euro and U.S. dollar funding. Generally, lack of liquidity in the market for forward and swaps at long maturities make prices out of any reasonable expectation making hedging unduly costly. Zloty forward foreign exchange transactions for periods longer than six months are made difficult by lack of bank interest rates quotes for more than six months.

Bond market

Given the close relation between currency and bond markets, features of bond markets help illustrate differences in the market infrastructure where currency derivative operations are conducted. Currency-linked eurobonds exist for both the Czech koruna and the Polish zloty, denominated in domestic currencies and issued by high-rated issuers. The zloty-linked market is the largest (also the largest in Eastern Europe) with an outstanding notional amount equivalent to USD 5.2 billion compared to USD 1.3 billion for the Czech koruna in 2000. Previous leadership of koruna-denominated bonds reversed after the financial crisis of 1997 in the Czech Republic. Other differences between the two markets are (Table 6):

Table 5. Czech Koruna and Polish Zloty: Typical Transaction Size for Selected Cross-Border Financial Transactions

(In millions of U.S. dollars)

	Czech koruna	Polish zloty
Foreign exchange spot	10	5
Foreign exchange forwards	10	5
Foreign exchange options	10	5
Swaps	5	1
Domestic debt	1	3
Currency-linked eurobond	0.3	1.5

Source: Deutsche Bank.

Availability of zloty-denominated bonds is larger, at USD 33 billion. Actually, the Polish bond market is the largest in Eastern Europe, while that for Czech bonds is one of the smallest at USD 6 billion. [14] Both are however smaller than other comparable markets such as South Africa

[14] Information available for Poland is at nominal value, while that for the Czech Republic is at market value.

(USD 80 billion) and Turkey (USD 50 billion). Demand for bonds in coming years is ensured by expectation of convergence to a low yield environment. A comparison of swap spreads to EU interest rates suggests that faster convergence is expected for the Czech Republic compared to Poland (about 2 years vs. 4 years, respectively, based on DB estimates).[15]

- Maturity ranges for both Czech Koruna and Polish zloty bonds extend to 10 years. A larger share of domestic-bond holders in the Czech Republic relative to Poland results from a requirement on banks to hold a proportion of reserve deposits in treasury bills (which according to market participants tends to drive bond prices upwards). Participation of foreign investors at 12-13 percent is within the range observed in other emerging markets. This estimate may be biased downwards because of an increasing number of foreign investors trading through domestic institutions.

- Liquidity for Czech bonds is limited, even for benchmark bonds, with the liquidity premium reflected on the upward-slope yield curve. Polish bonds are more liquid at the 3-5 year range, but Czech bonds could be more liquid at times for longer maturities. In Poland, on-the-run benchmark issues are normally the most liquid of each bond series. A swap market against the Warsaw interbank rate (WIBOR) exists for maturities up to 10 years, and against the Prague interbank rate (PRIBOR) for maturities up to 15 years. Downward-slope yield curves for Czech and Polish bonds reflects convergence expectations, and for the latter also higher interest rates for short end maturities relative to the former.

Relatively lower activity by foreign investors in the Czech Republic concentrates in buy-and-hold transactions. By contrast, foreign investors embark on more active proprietary trading in the Polish market relative to the rest of Eastern Europe, more important for 3-6 month transactions. European investors (particularly from Germany) are more likely to buy and hold bonds and hedge currency risk in periods of uncertainty (mainly by rolling short-term forwards). Non-European investors (particularly from the US) engage in cross-over transactions.

Concerning prospects, several developments are worth noting: First, the increased incorporation of bond prices from the Czech Republic and Poland in international bond price indices will likely increase the involvement of foreign investors. Second, the increasing participation of private pension funds, especially in Poland, will expand liquidity in the domestic bond markets especially for longer maturities. Last, intensified convergence plays in the near future will result from both the Czech Republic and Poland having been identified as frontrunners among 10 Central and Eastern European for EU accession, together with Hungary, Estonia and Slovenia.

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[15] Estimates are based on Deutsche Bank calculations using five-year forward swap spreads over Euribor.

Table 6. Czech Republic and Poland: Domestic Debt Main Characteristics

	Czech koruna	Polish zloty
Outstanding bond issue	USD 6 billion. (Kor 200 billion)	USD 33 billion. (Zlo 145 billion).
Share of:		
Foreign investors	13	12
Domestic financial institutions	83	38
Domestic non-bank investors	4	38
Central bank	0	12
Maturity longer than one year	43	78
Treasury bills' maturities	20 issues up to 11-month.	13-week, 26-week, 52-week. (51 issues).
Fixed-coupon bonds	18 outstanding issues out to 10 years.	21 outstanding issues out to 10 years.
CPI-linked bonds	Issued in 1997 to finance flood damage.	No longer issued.
Outstanding currency-linked Eurobonds	USD 1.3 billion. (Kor 50 billion).	USD 5.2 billion. (Zlo 22 billion).

Source: Deutsche Bank

B. Currency Options Implied Volatility Patterns

This section introduces information on implied volatility, as reported by Reuters on at the money call options, quoted by Cantor Fitzgerald International and compiled by the Deutsche Bank, London. Currency option quotes are expressed in implied-volatility units.[16] Implied volatilities are used to determine option prices based on any pricing model, but generally the Black-Scholes-Garman-Kohlhagen model is used by investment banks operating in these currencies. The Garman-Kohlhagen adaptation of Black and Scholes treats currencies like dividend-paying stocks with a yield equal to the risk-free interest rate in the foreign currency. In terms of Black-Scholes, implied volatility is the term σ in the following expression:

$$c = Se^{-r(T-t)}N(d_1) - Xe^{-r(T-t)}N(d_2)$$

[16] Reported lack of liquidity in the Koruna/U.S. dollar and the Zloty/Euro option market, led to infrequent quotes. The series for the Koruna/U.S. dollar stopped at June 30, 2000 and the series for the Zloty/Euro on September 8, 2000.

Where:

$$d_1 = [\ln (S_1/X) + (r + \tfrac{1}{2}\sigma^2)(T-t)]/[\sigma \, SQR(T-t)]$$
$$d_2 = d_1 - \sigma \, SQR(T-t)$$

For:

c	:	Price of call option
S	:	Spot price
r	:	Free interest rate
T	:	Maturity
t	:	Current period
X	:	Strike price
d_1, d_2	:	Terms from a normal distribution

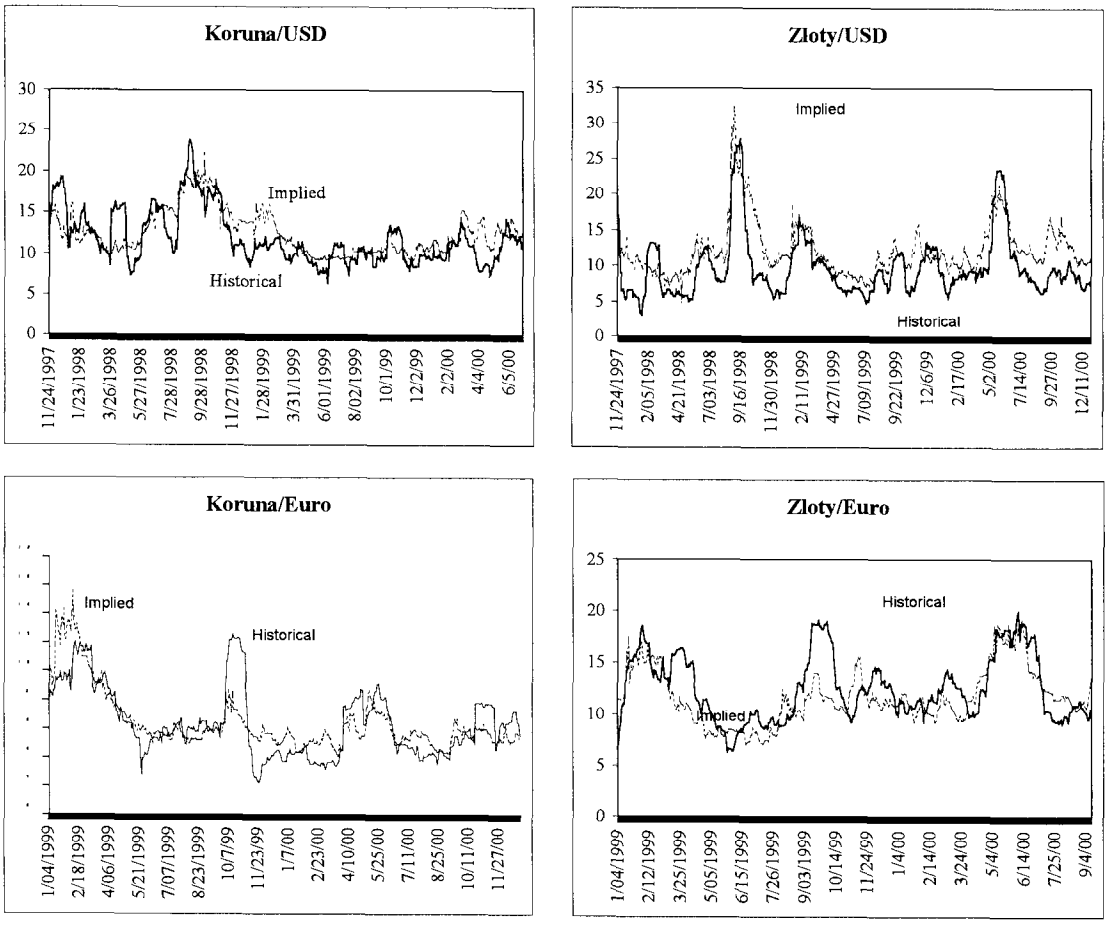
Chart 3 shows the evolution of one-month historical and implied exchange rate volatility. In general, both historical and implied volatility follow a similar pattern, as the spot market basically captures the same information available for agents in the currency option market. Granger causality tests (Table 7) show that generally exchange rate returns Granger-cause changes in implied volatility. However, some inconclusive evidence results especially for the koruna/euro exchange rate for two and three lags, and even for the koruna/U.S. dollar exchange rate for one lag. This would indicate some two-way information exchange between the spot and the currency option market for the koruna, making the identification of causality less conclusive.

Table 8 shows that Czech koruna/euro currency options show the smallest deviation of implied volatility relative to the corresponding historical volatility. The largest deviation is observed for Polish zloty/U.S. dollar currency options, which is supposed to be at least as liquid as Czech koruna/euro options. This may indicate the presence of a "volatility premium" charged for higher risk embedded in a more flexible exchange rate arrangement and reflecting the largest presence of cross-over investors. Deviations with respect to average volatilities are smaller for the less liquid Czech koruna/U.S. dollar and Polish zloty/euro options; however, this may reflect the larger average volatility for both

Table 7. Pairwise Granger-Causality Test

	One lag		Two lags		Three lags	
7a. Czech Republic						
A Koruna/USD						
Sample: 11/25/1997-6/30/2000						
Observations: 678						
Null Hypotheses:	F-Statistic	Probability	F-Statistic	Probability	F-Statistic	Probability
DLKRUUSD does not Granger cause DIVKRUS1M	18.2905	2.20E-05	9.51633	8.40E-05	6.16681	0.00039
DIVKRUS1M does not Granger cause DLKRUUSD	3.118	0.0778	1.00471	0.3667	1.25696	0.28821
B. Koruna/Euro						
Sample: 1/01/1999-12/29/2000						
Observations: 518						
DLKRUEUR does not Granger cause DIVKRUE1M	4.3686	0.0371	2.1841	0.11363	1.89348	0.18588
DIVKRUE1M does not Granger cause DLKRUEUR	0.18061	0.67103	2.61847	0.07389	1.61093	0.12968
7.b Poland						
A. Zloty/USD						
Sample: 11/25/1997-12/29/2000						
Observations: 808						
Null Hypotheses:						
DLZLOUSD does not Granger cause DIVZLOUS1M	19.8214	9.70E-06	14.7827	5.00E-07	10.7532	6.20E-07
DIVZLOUS1M does not Granger cause DLZLOUSD	2.43592	0.11898	1.45278	0.23453	1.00864	0.38823
B. Zloty/Euro						
Sample: 1/4/1999-12/29/2000						
Observations: 438						
DLZLOEUR does not Granger cause DIVZLOEU1M	8.27803	0.00421	5.57663	0.00406	3.61932	0.01325
DIVZLOEU1M does not Granger cause DLZLOEUR	0.00311	0.95556	0.74819	0.47383	0.67538	0.5675

Chart 3. Czech Republic and Poland: One-Month Historical and Implied Volatility



Sources: Bloomberg, Deutsche Bank; and staff calculations.

Table 8. Czech Republic and Poland: Implied Volatility Indicators

(In percent)

	1 month	2 month	3 month	6 month
Czech Koruna/USD				
Implied (IV) minus actual volatility 1/	2.429232	1.958569	2.109721	2.273488
IV deviation w/r to average volatility	20.39467	16.20347	17.40022	18.41838
IV deviation w/r to standard deviation	75.81407	73.13954	84.11008	102.512
Czech Koruna/Euro				
Implied (IV) minus actual volatility 1/	1.750716	1.862128	1.920281	1.926763
IV deviation w/r to average volatility	27.39136	28.70853	28.49366	24.87426
IV deviation w/r to standard deviation	72.32143	88.89087	101.7025	89.35784
Polish Zloty/USD				
Implied (IV) minus actual volatility 1/	4.202102	3.946465	3.835145	3.332458
IV deviation w/r to average volatility	43.01028	38.7614	36.57707	31.80347
IV deviation w/r to standard deviation	97.41509	108.961	125.1364	172.1178
Polish Zloty/Euro				
Implied (IV) minus actual volatility 1/	2.171059	2.318289	2.379874	2.129556
IV deviation w/r to average volatility	17.29299	17.25725	18.84959	16.70014
IV deviation w/r to standard deviation	68.50314	88.30775	120.8657	185.4091

1/ Average deviations in absolute value

Source: Bloomberg and staff calculations

IV. Exchange Rate Spot and Currency Option Volatility Patterns

This section assesses if deviations of implied volatility with respect to historical volatilities anticipate future changes in historical volatility for the maturity of the corresponding currency option (which would mean that they embed additional information content). A subordinated question is if the differential behavior of volatility against the U.S. dollar and the euro shown in the spot market also affects such information content in currency options.

A. Predictability of the Direction of Exchange Rate Volatility

Following Levich, [17] this section distinguishes between "accurate forecasts" and "useful forecasts," i.e., useful forecasts would be those that lead to correct hedging decisions although the forecasted magnitudes were not accurate in terms of statistical significance. In that regard, if implied volatilities anticipate the direction of volatility correctly, it would be sufficient to use currency options to hedge that risk. Table 9 shows a summary of the results of comparing the implicit predictions of the direction of exchange rate volatility for four different option maturities. The main conclusions are the following:

- Except for the zloty/euro exchange rate volatility, implied volatility appears more "accurate" in predicting volatility increases relative to decreases. This may reflect a more intensive use of derivatives at times of volatility increases, which makes the market more liquid in such events, or an overall tendency to implied-volatility overshooting in times of volatility increases.

- Koruna/euro currency option volatilities show the most balanced performance, with 97.7 percent significance of predictions for both volatility increases and decreases for two- and three-month currency options, and a good performance predicting increases for other maturities. The zloty/U.S. dollar currency option volatility shows an overwhelming good performance predicting volatility increases (practically 100 percent accuracy for all maturities), but only for the two- and three-month volatility show, this contributes to an overall good performance (i.e., including both volatility increases and decreases). In other cases, the good performance predicting volatility increases apparently reflects the tendency to overpredict volatility increases (in line with reported volatility overshooting at times of volatility increases).

- Even the less liquid zloty/euro and koruna/U.S. dollar currency option volatilities show an overall good performance for one-, two- and three-month currency options, although biased to overpredict decreases in the case of the zloty/euro and increases in the case of the koruna/U.S. dollar currency options.

In general, there appears to be information content in currency options with the koruna/euro currency option market showing better performance than the zloty/U.S. dollar in producing efficient "useful forecasts." This may be an indication that the introduction of the euro allows for a better incorporation of expectations in the currency option market than currency options quoted in U.S. dollars for both Eastern European currencies, in spite of the earlier development of U.S. dollar denominated currency options.

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[17] Levich, Richard (1998). Chapter 8 on Exchange Rate Forecasting.

Table 9. Czech Koruna and Polish Zloty: Success Rate of Implied Volatility to Forecast Volatility Changes

	One-month volatility			Two-month volatility			Three-month volatility			Six-month volatility		
	Volatility increases	Volatility decreases	Total	Volatility increases	Volatility decreases	Total	Volatility increases	Volatility decreases	Total	Volatility increases	Volatility decreases	Total
KORUNA/EURO												
Episodes	51	49	100	55	41	96	45	46	91	11	67	78
Succesful Predictions	70.6	57.1	64.0	87.3	73.2	81.3	100.0	71.7	86.7	81.8	40.3	46.2
Wrong Predictions	29.4	42.9	36.0	12.7	26.8	18.7	0.0	28.3	14.3	18.2	59.7	53.8
ZLOTY/EURO												
Episodes	46	42	88	45	43	88	37	51	88	50	28	78
Succesful Predictions	60.9	92.9	76.1	46.7	86.0	65.9	40.5	80.4	63.6	32.0	60.7	42.3
Wrong Predictions	39.1	7.1	23.9	53.3	14.0	34.1	59.5	19.6	36.4	68.0	39.3	57.7
KORUNA/USD												
Episodes	63	73	136	65	71	136	68	68	136	74	62	136
Succesful Predictions	88.9	49.3	69.1	80.0	39.4	58.8	85.3	32.4	58.8	79.7	29.0	56.6
Wrong Predictions	11.1	50.7	30.9	20.0	60.6	41.2	14.7	67.6	41.2	20.3	71.0	43.4
ZLOTY/USD												
Episodes	66	92	158	81	73	154	68	81	149	70	66	136
Succesful Predictions	100.0	20.7	53.8	100.0	35.6	69.5	100.0	23.5	54.4	91.1	7.6	53.7
Wrong Predictions	0.0	79.3	46.2	0.0	64.4	30.5	0.0	76.5	41.6	2.9	92.4	46.3

Shadow areas indicate significance beyond 2 standard deviations (97.7 percent confidence).

B. Information Content of Changes in Implied Volatility

Implied volatility responds in general to the behavior of historical volatility. However, there appears to provide additional information content about the direction of future volatility. If the options market is better informed than the spot market, changes in implied volatility should help predict changes in spot volatility. More specifically, it could be tested if lagged changes in implied volatility contain information additional to that provided by historical data, more efficiently than other high-frequency economic variable.

A GARCH model allows for the evaluation of whether changes in implied volatility have information different from that provided from historical data (and its impact on expectations within a particular expectations formation framework) that affects the determination of spot volatility patterns.[18] As a reference to assess its performance, the results using changes in

[18] GARCH models help to analyze high-frequency information under the hypothesis that the variance of a given variable is an average of an (unconditional) long-term average, the forecasted variance from the previous period (the GARCH term) and the error from volatility observed in the previous period (the ARCH term). This modeling is consistent with volatility clustering. The more persistent the changes in conditional volatility, the closer to one the sum of the coefficients for the ARCH and GARCH terms would be.

implied volatility are compared with the performance of changes in the domestic foreign short-term interest rate differential within the same models.

A GARCH model is appropriate in cases of volatility clustering (that reflect volatility persistence), and should be applied for variables following a stationary process. Chart 4 shows clustering in both exchange rate returns and changes in one-month implied volatility. Table 10 shows a summary of Augmented Dickey-Fuller Unit Root Tests, for selected variables including exchange rate returns and changes in one-month implied volatility. All variables are clearly stationary.

To allow for different specifications, a GARCH and a TARCH model are used. [19] A dummy variable for Monday is introduced to account for weekend distortions. [20] For all the equations, it could not be rejected that mean exchange rate returns were equal to zero, thus that condition was imposed to analyze only volatility patterns. The interest rates that were used for the alternative formulation were 3-month interbank interest rates in the Czech Republic (PRIBOR), Poland (WIBOR), USA and Europe (Euribor). Significant coefficient of ARCH and GARCH terms would reflect the presence of volatility persistence in the GARCH formulation and significant coefficient of the TARCH term would reflect the presence of assymetric volatility responses.

The main results are the following (Table 11):

- For the koruna/U.S. dollar equations, volatility persistence is confirmed, but asymmetry is not significant at 95 percent confidence. For the symmetric GARCH process neither the daily change in implied volatility nor the daily change in the interest rate differentials appear significant to explain volatility patterns.

- For the koruna/euro equations, there is evidence of volatility persistence and assymetry when changes in daily implied volatility are used rather than changes in the interest rate differential. Both variables are significant, with the expected sign (lagged increases in interest rates associated with lower exchange rate volatility and lagged positive changes in implied volatility associated with increasing spot exchange rate volatility).

- For the zloty/U.S. dollar, there is evidence of volatility persistence, except for the model without asymmetry when using implied volatility (the model does not converge). Evidence of asymmetry is weak. Although changes in the interest rate differential are highly significant, their impact shows a surprising positive sign.

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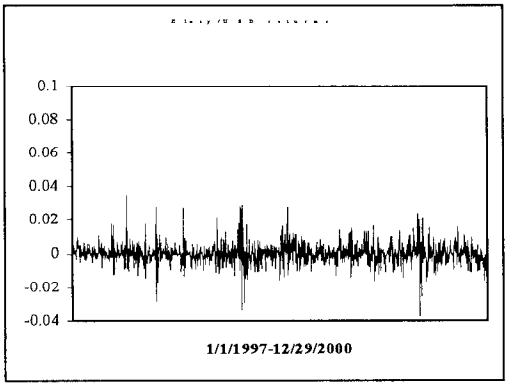
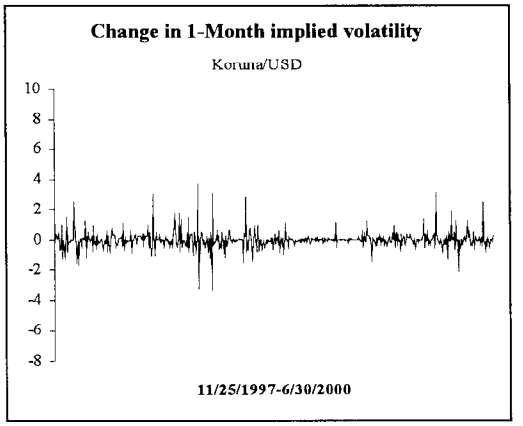
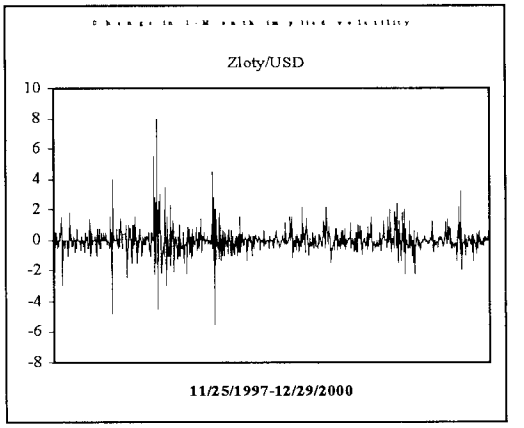
[19] TARCH models allow for the inclusion of assymetric responses in case of exchange rate depreciation relative to appreciation.

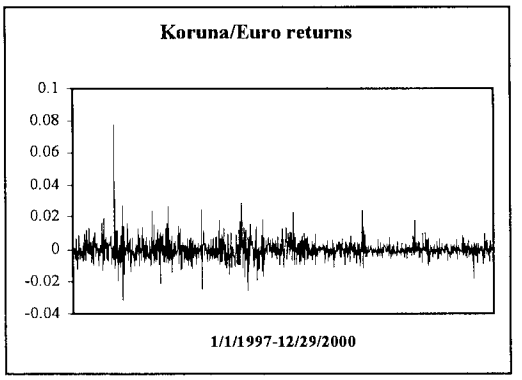
[20] However, MONDAY did not appear to be significant for exchange rates against the Euro.

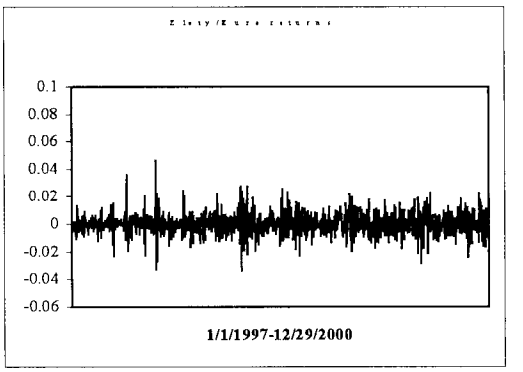
Chart 4. Exchange Rate Returns and Changes in One-Month Implied Volatilities

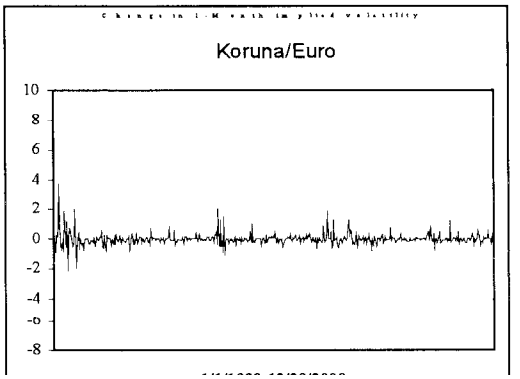












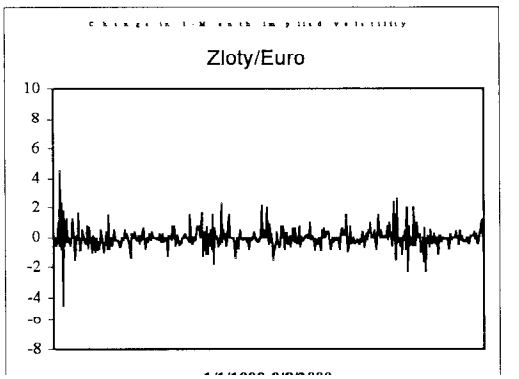


Table 10. Czech Republic and Poland: Augmented Dickey-Fuller Unit Root Test for Selected Variables

	Variable	No trend No intercept	No trend with intercept	With trend and intercept
Czech Republic				
d LN(Koruna/USD)	DLKRUUSD	-13.999	-14.052	-14.075
d LN(Koruna/Euro)	DLKRUEUR	-14.771	-14.764	-14.791
d (PRIBOR-US 3M INTERBANK RATE)	DKRISDIF	-17.829	-17.84	-17.839
d (PRIBOR-3M EURIBOR)	DKRIEDIF	-6.465	-7.234	-7.859
d (One-month implied volatility Koruna/USD)	DIVZLOS1M	-12.998	-12.989	-12.985
d (One-month implied volatility Koruna/Euro)	DIVZLOE1M	-11.686	-11.689	-11.693
Poland				
d LN(Zloty/USD)	DLZLOUSD	-13.308	-13.416	-13.483
d LN(Zloty/Euro)	DLZLOEUR	-16.771	-16.768	-16.816
d (WIBOR-US 3M INTERBANK RATE)	DZLISDIF	-14.516	-14.532	-14.552
d (WIBOR-3M EURIBOR)	DZLIEDIF	-11.598	-11.623	-11.619
d (One-month implied volatility Zloty/USD)	DIVKRUS1M	-11.921	-11.914	-11.907
d (One-month implied volatility Zloty/Euro)	DIVKRUE1M	-9.358	-9.347	-9.335

Source: Staff calculations.

- For the zloty/euro equation, again evidence of volatility persistence is more clear when changes in implied volatility are used. Asymmetry does not appear significant. Information from changes in daily implied volatility are clearly more significant than interest rate differentials to explain changes in spot exchange rate volatility.

Changes in implied volatility appear to contain information that translate into volatility changes of the same sign in the spot market, clearly in the case of the exchange rate of zloty against the euro, and conditional on the validity of the GARCH framework for the Czech koruna against the euro. This is not true for the corresponding exchange rates against the U.S. dollar. This may reflect a better flow of information between the spot and option markets of Eastern European currencies against the euro, relative to against the U.S. dollar.

V. Conclusions

A relatively flexible exchange rate has increasingly facilitated the incorporation of expectations in interest rate and exchange rate changes in the Czech Republic and Poland. However, important differences resulted from initial differences in inflation, shares of foreign currency deposits, size of external debt and openness of the economy. A peg to the U.S. dollar in the context of sizable dollarized deposits strengthens the link of the Polish zloty with that currency. Faster development of financial markets in the Czech Republic led to stronger financial links with other European economies.

Partly as a result of this, lower exchange rate volatility can be observed for the Czech koruna against the euro and the Polish zloty against the U.S. dollar. In the currency option market, benchmark quotes for the Czech koruna in the currency option market are against the euro, while for the Polish zloty are against the U.S. dollar.

Although currency options are traded basically at the money, as liquidity in both currencies for trading options at strike prices other than at the money is low, daily quotes allow for the identification of implied volatility patterns. The Polish zloty/U.S. dollar exchange rate seems to show the presence of a "volatility premium" that may be related to a relatively more flexible exchange rate arrangement and probably reflecting a large presence of cross-over investors. There appears to be information content in currency options, especially the koruna/euro currency option market, as it shows better performance than the zloty/U.S. dollar in producing "useful forecasts" of the direction of change in volatility. This may be an indication that the introduction of the euro allows for a better incorporation of expectations in the currency option market than currency options quoted in U.S. dollars for both Eastern European currencies, in spite of the earlier development of U.S. dollar denominated currency options.

Table 11. Czech Republic and Poland: GARCH and TARCH Models of Exchange Rate Returns 1/

9.a Czech Republic	Koruna/USD		Koruna/Euro	
	With Implied volatility	With interest rate differential	With Implied volatility	With interest rate differential
A. With assymetry				
Constant	3.12E-06	3.66E-05	1.13E-06	4.56E-06
	(0.968541)	(5.225309)*	(4.572405)*	(3.217378)*
ARCH(1)	0.0088893	0.145266	0.092589	-0.019786
	(3.526076)*	(2.34365)*	(3.487152)*	(-.520285)
ARCH(1) (RESID<0)	-0.038027	0.047529	-0.026641	0.105467
	(-1.144163)	(.605054)	(-1.151405)*	(1.11999)
GARCH(1)	0.808993	0.587239	0.860086	0.588461
	(12.95347)*	(6.331379)*	(29.58055)*	(5.541017)*
MONDAY	1.81E-05	-5.09E-05		
	(2.186157)*	(-2.15E+99)*		
Change in daily implied volatility	-4.52E-06		5.27E-06	
	(-1.302644)		(4.705654)*	
Change in daily interest rate differential		6.03E-05		-0.000104
		(7.554767)		(-4.247847)*
B. Without assymetry				
Constant	3.27E-06	1.88E-06	1.07E-06	4.43E-06
	(1.034686)	(.84283)	(4.624944)*	(3.099219)*
ARCH(1)	0.0717	0.050866	0.082532	0.020031
	(3.626453)*	(3.474972)*	(3.571157)*	(.571209)
GARCH(1)	0.807723	0.87082	0.861109	0.607485
	(13.13309)*	(21.27291)*	(31.29453)*	(5.367897)
MONDAY	1.74E-05	1.32E-05		
	(2.097875)*	(1.648967)		
Change in daily implied volatility	-3.89E-06		5.29E-06	
	(-1.133643)		(4.813203)*	
Change in daily interest rate differential		9.52E-06		-0.000103
		(0.840978)		(4.487901)*

1/ It cannot be rejected that mean exchange rate returns are equal to zero.

9.b Poland	Zloty/USD		Zloty/Euro	
	With Implied volatility	With interest rate differential	With Implied volatility	With interest rate differential
A. With assymetry				
Constant	2.99E-05	2.12E-05	1.10E-06	1.98E-05
	(4.708987)*	(18.24769)*	(2.256578)*	(1.913729)
ARCH(1)	0.148384	0.149088	0.007143	0.144915
	(2.620831)*	(14.75099)*	(1.49E+99)*	(1.7111941)
ARCH(1) (RESID<0)	0.048925	0.049076	-0.011988	0.047253
	(0.452581)	(2.383009)*	(-.979991)	(.375022)
GARCH(1)	0.593923	0.593835	0.978368	0.584956
	(6.493471)*	(20.85831)*	(157.7839)*	(3.581449)*
MONDAY	-2.83E-05	-4.45E-05		
	(-2.671914)*	(-1.2E101)*		
Change in daily implied volatility	1.04E-05		1.15E-05	
	(3.29E99)*		(5.427858)*	
Change in daily interest rate differential		6.10E-06		-7.97E-06
		(9.26E+98)*		(-8.66E+99)*
B. Without assymetry				
Constant		2.17E-05	5.67E-07	2.70E-06
		(16.80117)*	(1.882833)	(1.316934)
ARCH(1)		0.149365	0.003255	0.061106
		(10.52484)*	(7.53E+98)*	(2.104557)*
GARCH(1)		0.595602	0.9837771	0.893474
		(20.13567)*	(189.995)*	(17.43156)*
MONDAY		-4.33E-05		
		(-5.3E+100)*		
Change in daily implied volatility			1.02E-05	
			(5.436508)*	
Change in daily interest rate differential		4.62E-06		6.82E-07
		(4.37485)*		(.112351)

1/ It cannot be rejected that mean exchange rate returns are equal to zero.

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