RISK MODELING OF EUR/HUF EXCHANGE RATE HEDGING STRATEGIES

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ABSTRACT[1]

Hedging is an important topic for both financial practice and theory. The rational of hedging and the optimal hedging ratio is examined by many papers, but the choice of hedging instrument is much less investigated, or restricted to options and futures. In this paper we analyze different hedging strategies from the aspect of Hungarian exporters with a long euro position. We evaluate each strategy by calculating expected values and risk measures, based on historical simulation and GARCH methods, in order to find the motives of financial innovation. We found that more complex exchange rate models, like GARCH, provide better framework for risk management, and only a limited financial structuring is to be accepted for hedging positions.

INTRODUCTION

The rational of hedging was justified by many authors (among others Smith and Stulz 1985), through the costs of financial distresses, asymmetric information (Tirole 2006) and other market imperfections. In reality one of the most important tasks of a financial manager is to set up the hedging policy. Parallel with the increased market volatility in the last decade, the financial institutions were very fruitful in developing more and more complex derivatives to meet the different needs of their client. As market turbulences are regularly causing huge financial losses on hedge positions, the usefulness of such financial innovation is questioned from time to time. As a consequence of the global financial crisis the derivatives got into the spotlight, and even hedging deals were regarded suspiciously. We evaluate several hedge strategies with different simulation methods and compare them.

The structure of the paper is as follows. First, we introduce the possible hedging strategies for a company with a long EUR/HUF position (a Hungarian exporter). In the next section we take an overview of some methods to model foreign exchange rate movements, in order to evaluate the riskiness of the strategies. Then, some risk measures are presented that can be used to describe the distribution of the stochastic future outcomes and quantify risk. The second part of the paper details our analysis, and the conclusion contains our findings.

The optimal hedging ratio is out of the scope of our analysis directly, but we compare the hedging strategies with the situation where all the open positions remain unhedged.

HEDGING STRATEGIES

A financial manager, facing open foreign exchange position, has to decide how to manage risk. The simplest way is to let all the position unhedged. This strategy is reasonable if managers' incentives are based on pure financial profit and loss, so they want to avoid any financial losses accounted on hedge position, or according to their expectation the future market movements are favourable from the aspect of their exposure.

A conservative way is to fully hedge risky positions through forward agreements. The risk can be eliminated, the variance of the position is set to zero. The other attractive feature of the forward sale of the future income is that the deal is free initially. The foreign exchange derivatives are typically over the counter contracts (not exchange traded like futures), and mark-to market profit or loss is not settled on a day by day basis, meaning that under normal circumstances the hedge requires no funding cash-flow. The relative high interest rate level of the Hungarian forint resulted in the last years – with the maturity – increasing EUR/HUF forward rates, which contributed to the popularity of forward hedge for exporters.

A forward agreement means an obligation, so if the market turns favourable from the aspect of the underlying position, the hedger is not able to make profit of this. Options are offering the right without any obligation to ensure a minimum or maximum price for a risky item. Hedging through options is rather costly, and the upfront option fee generally discourages managers from that kind of hedge, or in order to reduce upfront hedging costs only deep out-of-money options are bought.

The motivation of structuring financial derivatives was to combine the above advantages of forwards and

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options and to tailor hedging deals to the market expectations of the clients. New complex products were built from bought and sold options, but until the point, there was a worst-case rate granted, these structures can be considered as hedging deals.

The ensured exchange rate for a series of future income can be achieved through an average forward agreement, which is a kind of cross-currency swap in fact. The forward rate is the same for all the maturities, the whole construction has a zero value at contracting, but the single legs have out of market rates. In case of EUR/HUF the higher forward rates of the shorter maturities are financed from the lower than market rates of the longer ones, creating an implicit credit.

A forward can be divided to a bought and a sold option, where the strikes of the two options are the same, but their direction (put or call) is the opposite. By changing the strikes, a collar can be created. For our case it consists of a long euro put and a short euro call option. To any level of the protection (strike of the put) there exists a call strike that set the structure to zero-cost. As both options are out-of-money, the protection is lower than the forward rate, but the upside potential is ensured up to the level of the sold call option. The spread of the range can be adjusted: the lower the protection the higher the available profit.

Similarly to the average forward structure, a series of cash-flow can be hedged through collars having the same put and same call prices for all the maturities. Although the value of the complex structure is zero initially, the mark-to-market value of the single legs is differing.

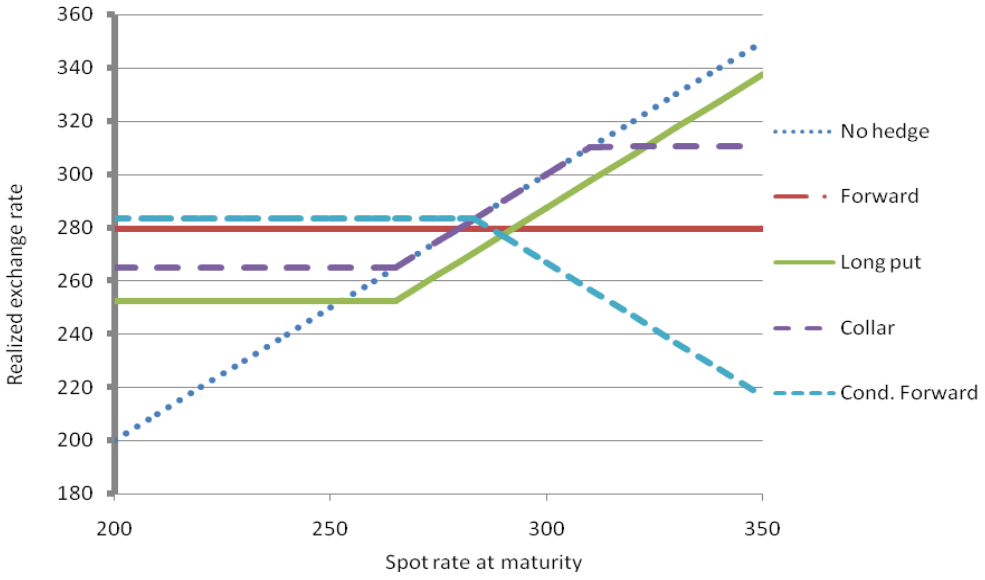
A wide range of hedging derivatives was structured beside the above ones. In order to improve the exchange rate of the future deal, further short options can be built in the structures, resulting a “hedging” deal without any worst-case rate. These kind of derivatives served as a hedge until a certain point, but hided sometimes the possibility of infinite loss. In our analysis we take a combination of a forward and a short call (we call it conditional forward). The fee of the written option improves the forward rate, but if exercised, it can cause unlimited loss.

Table 1 summarises the 7 strategies to hedge a series of long euro, short forint position and Figure 1 depicts the cash-flow position function of the strategies for one maturity.

Table 1: Hedging strategies

Strategy 1	No hedge
Strategy 2	Series of forwards: short EUR, long HUF at market rate
Strategy 3	Series of forwards: short EUR, long HUF at the same rate
Strategy 4	Series of bought options: EUR put, HUF call, strike equals to the forward rate
Strategy 5	Series of collars: long EUR put, HUF call at 265,00 and short EUR call, HUF put at changing strikes, which makes each leg to zero cost
Strategy 6	Series of collars: long EUR put, HUF call at 265,00 and short EUR call, HUF put at the same strike, making the whole structure to zero cost
Strategy 7	Series of forwards and short EUR call, HUF put options at "conditional” forward rate

Figure 1: Cash-flow position function of the strategies



EXCHANGE RATE MODELING

In order to analyse the different hedging strategies a priori, we have to model EUR/HUF exchange rate movements. We use Monte Carlo simulation, based on different assumptions about the exchange rate process.
We simulate logarithmic returns[2] of FX rates with Matlab and MS Excel, and generate exchange rates according to the following formula:

$$Y_t = Y_0 e^{\sum_{t=1}^{T} X_t} \quad (1)$$

Where Y_t denotes FX rates and X_t signs logarithmic return.

Historical simulation

The simplest way to model a variable with stochastic features is the historical simulation. The method requires no assumption about the distribution of the random variable, it just provides that the past is representative for the future. By random choice from the past movements (logarithm of the chain-index), a possible future trajectory can be created.
The past panel has to be long enough to be representative, but not too long to be relevant. We took the daily price changes of the previous 5 years (1st of January 2005 – 31st of December 2009). This timeframe is conveniently long, and contains the moderate price movements of the pre-crisis period, but the hectic of the crisis as well.

GARCH(1,1) model

The class of Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models is commonly used for FX rates volatility prediction. GARCH modeling provides the stylized facts of daily return series: the returns of FX rates are leptokurtic, the series of squared returns show serial correlation, and the extreme returns appear in clusters (volatility clustering). We fit GARH(1,1) to the above 5-year panel of the logarithmic returns, the parameters are estimated by maximum likelihood method. The estimated expected value (2) and variance equations (3) of the GARCH(1,1) are:

$$X_t = -1.31\times10^{-5} + \sigma_t Z_t \quad (2)$$

$$\sigma_t^2 = 5.52\times10^{-7} + 0.1203 X_{t-1}^2 + 0.8719\sigma_{t-1}^2 \quad (3)$$

Where X_t denotes the logarithmic returns, σ_t stands for the standard deviation and Z_t is an independent standard normal distributed random variable.

[2] We use logarithmic return and logreturn as synonyms and we understand the logarithm of the chain-index of the exchange rate and disregard the yield curve of the currencies.

EVALUATION MEASURES

The hedging strategies can be evaluated according to different aspects. Although the traditional aim of hedging is to minimize the variance, the practice shows, that hedging, similar to any investment decision, is optimized on a mean-variance basis.
In order to describe the whole distribution, we calculated beside the expected value ($E(X)$) and the standard deviation, (also called volatility $\sigma(X)$) the skewness ($\gamma(X)$) (4) and some other risk measures, which are characteristic for the tails of the distribution.

$$\gamma(X) = \frac{E\left[(X-E(X))^3\right]}{E\left[(X-E(X))^2\right]^{3/2}} \quad (4)$$

Cash-flow-at-risk (CFaR, a Value at Risk measure applied for cash-flows) represents the minimum cash value for a given period with certain probability. Applying simulation methods, CFaR is the appropriate quantile of the cash-flow distribution:

$$CFaR_x(\alpha) = \inf\{x \in R : F(x) \geq \alpha\} \quad (5)$$

where $F(x)$ is the distribution of cash-flows, and α is the confidence level. CFaR is easy to interpret, but it provides no information about the worst outcomes.
Expected shortfall (ES) is the expected value of the below-threshold realizations. For a cash-flow x, expected shortfall at α confidence level is defined as

$$ES(\alpha) = \frac{1}{1-\alpha}\int_{\alpha}^{1} CFaR_x(u)du \quad (6)$$

This measure facilitates to judge the severity of the potential differences from the expected value of future cash. ES (unlike CFaR) is a coherent risk measure and provides better information about the risk (Acerbi and Tasche 2002), but the usage of CF-at-Risk is more widespread in risk management.
In our analysis both CFaR and ES are calculated with a significance level of 95% and 99%.
We measure not only the downside, but the upside too, by creating a new measure – expected gain, - which shows the expected value of the outcomes above a certain level. We study the mean of the above average outcomes, and that of the best 5%.

RESULTS OF OUR ANALYSIS

In our simulation we model the position of a Hungarian euro exporter, having (the same) euro income at the end of each month in 2010. We simulate a static hedging strategy, which has to be decided at the beginning of 2010 and determines the position of the firm for the whole year.

Data

Table 2 contains the prices of each strategies, calculation was based on market data as of the 4th of January 2010. The EUR/HUF daily ECB fixing rates were used, the source of the EUR/HUF swap-rates, Budapest Interbank Offered Rates (BUBOR) and volatilities was Reuters. As data were available only for some reference maturities (1, 3, 6, 9 and 12 month) we applied linear interpolation to gain rates for the broken periods. As we had access only to at-the-money EUR/HUF volatilities, we were not able to consider the whole volatility surface when calculating the prices of the derivatives.

Table 2: Prices of the hedging strategies at the beginning of 2010.

	Strat1	***Strat2***	***Strat3***	***Strat4***	***Strat5***		***Strat6***		***Strat7***
EUR/HUF		Forward rates	Forward rates	Fee of a forward at the money LP	Strike of LP	Strike of SC	Strike of LP	Strike of SC	Conditional Forward rates
1 month		270,94	275,48	3,78	265,00	277,72	265,00	296,24	283,38
2 month		271,85	275,48	7,56	265,00	280,63	265,00	296,24	283,38
3 month		272,97	275,48	8,70	265,00	283,54	265,00	296,24	283,38
4 month		273,73	275,48	9,41	265,00	286,49	265,00	296,24	283,38
5 month		274,49	275,48	10,01	265,00	289,45	265,00	296,24	283,38
6 month		275,25	275,48	10,55	265,00	292,43	265,00	296,24	283,38
7 month		276,00	275,48	10,77	265,00	295,44	265,00	296,24	283,38
8 month		276,76	275,48	10,93	265,00	298,42	265,00	296,24	283,38
9 month		277,52	275,48	11,02	265,00	301,41	265,00	296,24	283,38
10 month		278,22	275,48	11,31	265,00	304,45	265,00	296,24	283,38
11 month		278,91	275,48	11,55	265,00	307,62	265,00	296,24	283,38
12 month		279,61	275,48	11,79	265,00	310,70	265,00	296,24	283,38

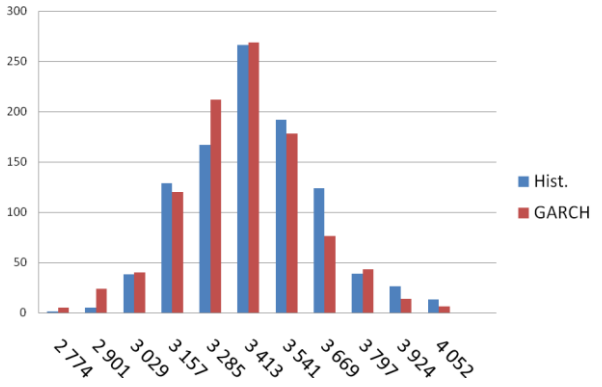
Source: Reuters, ECB statistics

Performance evaluation of the strategies

We measure the performance of the strategies with the cumulated cash-flow generated by the conversion of 1 unit of euro at each maturity dates (at the end of every month of 2010). We used the actual forint interbank rates (BUBOR), to convert all the cash-flows to the end of the year 2010. As a result the generated random variable is the future value of the annual cash inflow in Hungarian forint, expressed in the unit of the monthly euro income.

The historical simulation overestimates the expected value of all strategies compared to the GARCH model, except for the speculative strategy, where the mean of the cases is almost the same. The risk measures however tend to be underestimated by the historical model, showing the limits of that kind of simulation. The GARCH model predicts on a more conservative way the possible extreme outcomes, as it considers the autocorrelation in the volatility and proves to be a more prudent tool for risk management purposes. Figure 2 presents the histogram of the distribution of the unhedged cumulated cash-flow according to both simulation methods.

Figure 2: Distribution of the Cumulated unhedged CF



The values of the different evaluation measures are shown in table 3 – based on historical simulation - and table 4 – according to the GARCH(1,1) model. The best performance is marked with bold, and the poorest with italics.

Table 3: Performance of the strategies, valuation based on historical simulation

HUF	***Strat1***	***Strat2***	***Strat3***	***Strat4***	***Strat5***	***Strat6***	***Strat7***
	No hedge	**SF**	**Average fwd**	**Series of forward ATM LP**	**Series of zero cost collars LP at 265**	**Series of collars with same strikes**	**SF + SC**
Expected value	3 369	3 388	3 388	*3 355*	3 396	3 396	**3 428**
St. Deviation	*214,09*	**0,00**	**0,00**	123,17	114,44	112,59	98,19
Skewness	0,31	0,00	0,00	**1,92**	0,47	0,47	*-2,44*
CF-at-Risk 95%	*3 044*	**3 388**	**3 388**	3 264	3 260	3 260	3 218
CF-at-Risk 99%	*2 911*	**3 388**	**3 388**	3 264	3 260	3 260	3 022
Expected Shortfall 95%	*2 911*	**3 388**	**3 388**	3 264	3 260	3 260	3 096
Expected Shortfall 99%	*2 608*	**3 388**	**3 388**	3 264	3 260	3 260	2 991
Expected Gain 50%	**3 539**	*3 388*	*3 388*	3 437	3 495	3 492	3 485
Expected Gain 5%	**3 864**	*3 388*	*3 388*	3 742	3 611	3 618	3 486
Realized	3 401	3 388	3 388	*3 303*	3 401	3 401	**3 476**

Table 4: Performance of the strategies, valuation based on GARCH(1,1) simulation

HUF	***Strat1***	***Strat2***	***Strat3***	***Strat4***	***Strat5***	***Strat6***	***Strat7***
	No hedge	**SF**	**Average fwd**	**Series of forward ATM LP**	**Series of zero cost collars LP at 265**	**Series of collars with same strikes**	**SF + SC**
Expected value	*3 347*	3 388	3 388	3 349	3 379	3 380	**3 429**
St. Deviation	*269,053*	**0,000**	**0,000**	187,462	108,368	108,240	170,484
Skewness	2,628	0,000	0,000	**7,220**	0,678	0,693	*-8,589*
CF-at-Risk 95%	*2 979*	**3 388**	**3 388**	3 264	3 260	3 260	3 225
CF-at-Risk 99%	2 808	**3 388**	**3 388**	3 264	3 260	3 260	*2 799*
Expected Shortfall 95%	*2 806*	**3 388**	**3 388**	3 264	3 260	3 260	2 905
Expected Shortfall 99%	2 457	**3 388**	**3 388**	3 264	3 260	3 260	*2 129*
Expected Gain 50%	**3 526**	*3 388*	*3 388*	3 430	3 469	3 469	3 486
Expected Gain 5%	**4 039**	*3 388*	*3 388*	3 926	3 608	3 616	3 486
Realized	3 401	3 388	3 388	*3 303*	3 401	3 401	**3 476**

All the hedging strategies generate not only lower volatility (measured by the standard deviation) than the unhedged situation, but higher expected value as well, the only exception is the option hedge (strategy 4) based on the historical simulation. This fact is caused by the huge swap-differential of Hungarian Forint compared to the euro, which makes the euro short position attractive. Generally the lower volatility is more advantageous for an investor, but if the distribution is asymmetric, - for example there exists a fixed worst outcome - the volatility helps in reaching better performance. The series of long euro put options guarantees lower worst case rate than the series of forwards, as the strike price of each options equals to the actual forward rate, but this strategy has some initial costs. Any change however can happen only in the advantageous direction. On the other hand, the volatility of strategy 7 – containing speculative position – is although lower than that of the "no-hedge" strategy, but this is a "bad"-volatility, being here the upside is limited. The skewness calls the attention to the asymmetry of the distribution, the sign indicates the direction (positive or negative) of the deviation from the mean. The massive positive skewness of strategy 4 shows the high upside potential of long options. Hedging by long options presumes positive market expectations, in case of EUR/HUF this strategy is the rational choice for an exporter, if higher than forward rates are predicted for the future (which was not typical in the last years).

Value-at-Risk type risk measures are defined to show the maximum loss (at a predetermined significance level), in corporate risk management the usage of cash-flow at risk is more common, being the volatility of the cash-flow is critical. Here we identify CFaR with the minimum cumulated cash-flow amount on a certain significance level. The risk is reduced, if the CFaR value is high. Similarly ES is the average annual cash-flow in the worst α percent of the cases.

The highest CFaR and ES figures of the forward hedge illustrate the advantage of the strategy: the available best worst case income is granted. The upside potential however is the lowest of this strategy (zero). The only difference of the two forward hedges is the sharing of the swap-difference among the maturities, but both strategies result the same cumulated amount.

Collars were used frequently for hedge in term of EUR/HUF, because the strategy provides almost the same downside- and until a certain level the same upside potential than an at-the-money long option, but a collar strategy requires no initial cost.

The highest cash-flow is provided by the conditional forward deal (strategy 7), and this strategy proved to be the most profitable ex-post in 2010. However the risk of this speculative hedge is presented by the lowest ES figures in case of extreme price changes. This feature of short derivatives was highlighted during the financial crisis, causing enormous financial losses on "hedge position".

CONCLUSION

We found that the simple historical simulation to model foreign exchange rate movements systematically underestimates the risk of the hedging strategies. Improving the forecast by more complex models, like GARCH, contributes to more prudent analysis of potential risk of financial derivatives.

The forward strategy proved to be the best hedging solution, if the company is more sensible to the downside risk. On the other hand other strategies, preserving the upside potential, can be more adequate for hedging for whom deciding on risk taking by mean-variance analysis.

In this sense financial innovation is useful, as widening the variety of hedging instruments contributes to fit the risk-return features of hedging to the firm's position and expectations. Nevertheless a structure without a guaranteed lowest outcome is not supported for hedging purposes.

The research is to be expanded further to a dynamic framework, which allows the adjustment of the strategy on certain points. However allowing the modification of the strategy can lead to speculation and increasing agent costs. Another direction of further researches is to model the corporate utility function, based on which the hedging decision is to be determined.

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