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Hungarian forint FX swap spreads during and beyond crisis times

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Abstract. Incentivised by a wide range of research discussing mispricing in USD related swap markets, the paper aims at discovering the factors contributing to the deviation of the 3-month FX swap points in the EURHUF and USDHUF market from their CIP based values primarily between the period January 2008 and December 2018 and with an extension to the end of 2021 using daily and monthly Bloomberg quotes. The period examined can be divided into three plus one subperiods as concerns FX swap spreads, largely determined by the effects of the global financial crisis and the volume of FX loans. Apart from the most important classes of variables explaining FX swap spreads, counterparty, funding and market liquidity risk indicators, the literature identifies, policy variables were also involved in the analysis. During and in the aftermath of the 2008 global financial crisis, the MNB applied various kinds of FX swap tenders to ease FX liquidity tensions in the Hungarian interbank market, and continued providing such operations even after the conversion of household FX loans to domestic currency. The results of VARX estimations suggest that indicators of market and liquidity tension, counterparty risk mostly positively contributed to the widening of FX swap spreads, in addition, policy intervention had a spread dampening impact throughout most of the period. The paper confirms that central bank FX swap market participation can mitigate mispricing especially in turbulent times.

Keywords: CIP condition, HUF FX swap spreads, central bank FX swap liquidity tenders, VARX

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1. INTRODUCTION

Our study aims to analyse and compare the main drivers of the FX swap market spreads, that is the deviation of the implied interest rate of EURHUF and USDHUF 3-month FX swap quotes from their estimated values based on CIP, first in the period between 2008 and 2018, with extension to the period between 2019 and 2021. Special emphasis is put on periods between the Lehman crisis and 2012 (the end of the most turbulent period of the sovereign debt crisis) and the separation of the data series before the forint conversion of foreign exchange loans and after the conversion had taken place in Hungary.

The demand and supply side of the swap market are primarily determined by hedgers and abritrageurs whose financial situation and risk characteristics largely confine the pricing of the market. The 2007-2008 global financial crisis revealed that covered interest parity, or as referred to in the literature as CIP, does not often prevail even in the case of the international financial markets' most important currency pairs, which is well underpinned by the example of foreign currency swap markets. The global financial crisis caused dollar liquidity shortage not only in the USA but also in the other continents where investors hold many dollar assets, which manifested itself above all in the forceful dollar demand in the EURUSD swap markets (and similarly in the case of JPYUSD, CHFUSD and AUDUSD contracts) and in market pricing contradicting the covered interest rate parity condition. (See among others Mancini-Griffoli and Ranaldo, 2012; Borio et al., 2016; Pinnington and Shamloo, 2016; Sushko et al., 2016; Kohler et al., 2018 and Tola et al., 2020). Disequilibria in swap market pricing gained a renewed impetus during the ensuing sovereign debt crisis, what is more, they further strengthened after the smoothing down of market turbulences in 2014.

The paper aims at revealing general tendencies in mispricing FX swaps in "peaceful" and "turbulent" times at the same time with the help of OLS and VAR(X) estimates using various indicators capturing market, liquidity, counterparty risk and the effect of policy intervention. The selected maturity segment, the three-month FX swap represents no more than 10% of the daily turnover in the HUF-related swap transactions, nevertheless, the MNB often applied FX swap tenders in this segment for euro liquidity provision between 2009 and 2016 and for forint liquidity provision from 2017 onwards. The paper therefore addresses how MNB swaps affected the market in different subperiods (2008-2012, 2013-2015, 2016-2018, 2019-2021) examined and how the effect of the other major drivers of FX swap spreads varied in the particular intervals and by currency pairs. For the Hungarian FX swap market, Csávás and Szabó (2010) provide an overall classification and a deep analysis on the major factors of swap spreads which our research greatly relied on. Based on their results we expect risk indicators to trigger and policy variables to mitigate mispricing.

The paper is stuctured as follows, first some important terms are clarified, then preceding research results on both global market processes and the Hungarian FX swap market are summarised on the basis of the related literature. Subsequently the characteristics of the Hungarian FX swap market and the role of the Hungarian monetary policy in this market is discussed. Materials and methods used for analysis and empirical findings are presented in separate chapters. Finally the paper concludes with reference to policy considerations.

2. LITERATURE REVIEW

2.1. Covered interest parity and foreign currency swap markets

Interest parity theory is often conceived of as a scientific relationship, a kind of economic law (Borio et al., 2016). Covered interest parity describes the difference between the forward and spot rate of a currency against another currency under arbitrage-free circumstances and at a given maturity, with the difference in the level of the interest rates of the two currencies. That is, the currency which yields exchange rate gain (forward premium) will pay the same discount in interest payment which means that the interest rate gain/loss and the exchange rate loss/gain counterbalance each other. The theory was confirmed by a series of empirical tests on the relationship between currencies of developed countries (Pasricha, 2006). Nevertheless, Keynes (1923), the founder of the preceding theory of covered interest parity himself, pointed to its limitations, among others, as regards credit risk and arbitrage (Coffey et al., 2009, Pasricha, 2006). However, numerous other costs (transaction, financing) and risks (e.g. counterparty, liquidity risk), as well as legal regulations (capital restrictions, differences in taxation) might encumber its fulfilment as well.

Foreign currency swaps can namely be corresponded to such a borrowing within which in the first phase the borrower is not indebted in the desired currency but in another one easier accessible, under more favourable circumstances, which is then exchanged for the currency originally planned to be purchased. The collateral of the currency obtained this way is the original currency offered for exchange, thus swap transactions can also be interpreted as covered loans. Two major types of swap transactions involving the exchange of different currencies are distinguished: FX-swaps of shorter, usually within a year maturity, and cross-currency interest rate swaps (CIRS) with longer, over a year maturity. In the case of the former, the exchange of the two currencies happens on the spot exchange rate in the first leg and on the forward exchange rate in the forward leg of the transaction, and between the two there is no interest payment. Traders quote the deviation between the forward (F) and the spot (S) exchange rate, the so-called swap (or forward) point (F-S), on the basis of which the implied interest rate of the deal can be calculated by applying the covered interest rate parity formula: $F/S \times (1+r^*) = 1+r$. Where r denotes the interest rate of the currency swapped, while r^* that of the currency obtained in the swap transaction. If we deduce the uncovered interbank interest rate (usually the interbank offer rate of corresponding maturity, but each financial institution uses the interest rate reflecting its own credit risk) from the implied rate, we receive the FX swap spread. This spread (whether positive or negative) indicates by how much the pricing of the transaction decouples from the value presumed under the covered interest rate theory.

In both the opening and the closing leg of cross-currency basis swap transactions the currency is usually exchanged at the same exchange rate (hereafter denoted by S). In a generalised form, if the covered interest rate parity does not hold that is:

$$F-S < S\,[(1+r)/(1+r^*)-1]$$

then one of the currencies pays a premium compared to the other currency, which is expressed by the so-called basis (b). This is the spread earned by the more expensive currency over its market rate in a CIRS transaction:

$$F-S = S\,[(1+r)/(1+r^*+b)-1]$$

Earlier Taylor (1989) exhibited that despite the increasing efficiency of FX markets, the fulfilment of the CIP may fall flat in times of market turbulence and uncertainty until adequate arbitrage activity recovers market circumstances.

The mispricing of swap transactions is well observable in the "post-Lehman period". Though swap transactions were becoming more and more expensive, the demand for dollar-related contracts were just growing between 2008 and 2015. It can be first of all attributed to that financial (and through them non-financial) institutions applying for credit in dollar financing were still better off if they obtained dollars in synthetic transactions than if they had taken out directly dollar loans in the uncovered market. Thus, it was more favourable to become indebted in yen or euro in the uncovered market and subsequently exchange euros for dollars in the swap markets than directly resort to dollar credit as a consequence of the increased credit risk premia. During the global financial crisis, it first materialised in the culmination of dollar spreads in the FX swap markets then of the dollar basis spilling over to cross-currency basis markets.

Pricing discrepancies, and thus the violation of the covered interest parity (see Borio et al., 2016; Fumihiko et al., 2016), is explained further by the intensifying demand pressure from the hedgers while arbitrage activity is impeded by a series of regulatory restrictions. The uneven but increasingly expanding demand of hedgers for particular currencies can tumble down market principles even in crisis-free periods.

Outstanding net foreign currency demand for hedging purposes is chiefly fed by three actors relatively neutral towards the costs (and thus in long-term swap agreements the basis) of the hedge:

1, *banks* which get involved in swap contracts in order to manage foreign currency mismatches of assets and liabilities in their balance sheets: banks generally need to cope with funding shortages in one of the foreign currencies due to the dominant denomination of their deposit stock, this is above all true for the dollar based on global market transactions. (This dollar shortage is quantified and referred to as „funding gap" by the BIS.) This shortage is usually recouped with off-balance sheet items and foreign currency swaps.

2, *institutional investors* as a consequence of their strategic hedge decisions: institutional investors hedge a part of their foreign currency investments (hedge ratio). Characteristically this hedge ratio has a low sensitivity to the costs of hedge.

3, *non-financial corporations* through the issuance of debt securities: non-financial firms seek for the cheapest borrowing facilities in international markets, the decrease in credit spreads in a given currency significantly influences their demand.

The costs of arbitrage activity have increased thanks to the more stringent risk management provisions and the related balance sheet restrictions (e.g. the priority treatment of counterparty risk due to regulatory changes) which is then incorporated in higher swap market spreads. Sovereign arbitrage activity can notably cut down on the basis as sovereign debtors can apply for dollar credit at low costs and swap it for the desired foreign currency arbitrarily (first of all Eurozone sovereigns endeavour to reduce the costs of financing this way) but the profitability of this investment strategy can significantly reduce when the rate of dollar interest rate swaps decreases, like in the third quarter of 2015 when they dropped below US treasury yields.

Csávás and Szabó (2010) identify the most important categories of variables which are used to explain FX swap spreads in the literature. Increased counterparty risks in the swap differential can be captured among others by the CDS spreads of the riskier economy – generally non-US market actors – involved in the FX market transaction. Funding liquidity risk can be approximated with Libor-OIS spreads, which can also be applied in a double form, e.g. [Libor (euro) – OIS (euro)]-Libor (USD)-OIS (USD)], characterising the difference between market actors' willingness to provide interbank loan in the two different currencies. A similar indicator is the TED spread which might also indicate the flight to safe government investment in turbulent times. Market liquidity risk, in contrast, may well be represented by bid-ask spreads in spot, forward FX and OIS pricing. Spot rate movements of the riskier currency and volatility measures help describe the risk aversion of market actors. Furthermore, policy variables are also included among independent variables to explain the influence of economic policy measures – with special regard to monetary policy – in market processes. These include liquidity enhancing, quantitative easing measures in the domestic currency, as well as foreign currency liquidity providing instruments. Some of these need not to be effectively implemented but simply announced, signalling the shift of monetary policy to a new direction. On the whole, the variables selected for FX swap spread estimations should be evaluated with caution as simultaneity problems might occur and some variables might reflect multiple risks which can even offset each other.

Among the factors moving hedge demand and thus swap pricing differentials Borio et al. (2016) emphasise first and foremost the globally differing monetary policies, for instance the easing measures of the ECB and the Japanese central bank (BoJ) which were then launched when the Fed had started its tapering programme and interest rate increases. The opposite monetary policy measures mean a further stimulus for euro and yen borrowing from the part of those market actors who want to become indebted primarily in dollar and finally remedy it with the help of the swap market. Fumihiko et al. (2016) identify further factors explaining the increasing dollar basis with respect to the yen-dollar swap market beyond the divergent monetary policies. They point out that on account of more rigorous regulations, the price taker and arbitrage activity of banks had become more subdued and that the dollar supply of organisations managing international reserves, as well as that of sovereign trust funds declined as a consequence of moderating raw material prices and the depreciation of emerging foreign currencies, which might also boost pricing imbalances. Borio et al. (2016) empirically investigate whether the above factors indeed explain the magnitude of the swap market basis in the yen-dollar context in the three- and twelve-month maturities. Following on Mancini-Griffoli and Ranaldo (2012), as well as Pinnington and Shamloo (2016) they explain the basis prevailing between 2007 and 2015 in the JPY/USD currency pair with the following variables: (1) counterparty risk (Libor-OIS spread), (2) financing risk (repo spread), (3) market liquidity (foreign currency market bid-ask spread). In addition, based on Sushko et al. (2016) net hedge demand was involved in the set of explanatory variables, by itself and by its cross product with the Libor-OIS spread, both having significant explanatory power especially in the case of the long-term cross currency basis swap, which confirms the effect of hedge demand on the basis.

The Swiss franc is often used as a "shelter" currency, although its rift from USD has been observed several times over the past decade. Several empirical studies have examined the cause of the increased FX swap base and the circumstances of non-fulfillment of CIP in the Swiss franc market. Among others, Kohler et al. (2018) thoroughly analyse the CIP deviations between the US dollar and the Swiss franc with special attention to the time factor and the different interest rates. Their analysis shows that the spread between US dollar CCY repo and US dollar OIS interest rates is an excellent proxy for the cross-currency basis. Kohler et al. point out that the basis widening from 2014 is still a great puzzle. They also analyse the EURUSD CIP deviations relying on CCY GCP Repo rates as a benchmark to their findings. (Kohler et al., 2018) Tola et al. (2020) explore the relationship between the USD/CHF basis and portfolio investment (PI) debt outflows denominated in USD. Their primary explanatory variable is the 3-month, 1-year, and 2-year USD/CHF cross-currency basis in three separate specifications. As a control variable, they include the change in the USD effective exchange rate, the lagged PI debt stock in USD, the VIX index, the GDP growth differential between the US and Switzerland, the yield differential between US and Swiss 10-year government bonds, and the term-spread differential between the US and Switzerland (10-year over 2-year). They found that with increasing CIP deviations, Swiss portfolio investment debt outflows decrease significantly. (Tola et al., 2020)

In emerging markets as financial actors use other currencies than US dollar in their daily transactions the increase in FX swap spreads and swap market bases often appears against other globally important currencies as well. This is the case with the Hungarian forint whose FX market transactions are very susceptible to global, regional and domestic risk factors which are reflected in the widening of FX swap spreads and CIRS bases against the US dollar but also the euro, Swiss franc and other market leading currencies (Csávás & Szabó, 2010; Banai et al., 2014).

2.2. The Hungarian FX swap market and the role of the MNB

The most important financial markets for the Hungarian banking sector are the EUR/HUF spot FX market, the HUF FX swap market, the government bonds market, and the interbank unsecured money market. (MNB, 2008) The FX swap market is also popular thanks to banks' legal obligation to provide additional capital on open foreign exchange positions, thus banks are pushed to close on balance sheet open FX positions, where they typically resort to FX swaps. (Banai et al., 2014) The swap market also provides liquid and synthetic FX funds and a wide range of hedging opportunities for the resident and non-resident participants of the economy. (Mák & Páles, 2009) In an international context, HUF related FX swap transactions are dwarfed by the major currencies, they accounted for 0.3-0.5% of the total daily turnover on

OTC markets between 2013 and 2019. Furthermore, some 90% of them were of a maturity of not more than three months. (BIS, 2019) The daily average turnover has undergone significant fluctuation in the last ten years, reaching a trough in 2016, due presumably to a significant decrease in FX lending which has largely determined banks' FX positions since the beginning of the 2000's with a strong FX loan expansion from 2004. Concurrently foreigners' FX positions against the forint are often related to HUF denominated government bond purchases.

At the onset of the 2007-2008 global financial crisis the economy was exposed to huge foreign currency risk due partly to a high ratio of FX (mostly CHF) to total loans expanded to households – reaching its 70% peak in autumn 2008 – and public debt over the Maastricht level a close to 50% of which was also denominated in foreign currency. These inherent risks coupled with interest rate risk, credit risk and systemic risk became apparent after the collapse of the Lehman Brothers.

The banking system facing an ever so great FX exposure was hedging its on-balance sheet foreign exchange exposure partly by applying forint/foreign exchange swaps and therewith kept the overall open position low. Hedging exchange rate risk, however, became more cumbersome due to limitations in access to longer-term foreign currency funds, liquidity tensions in the FX swap market, and reduced counterparty limits which the MNB was trying to counterbalance by the announcement of currency swap tenders. (MNB, 2009). By mid-2009 in the FX swap market, the Swiss franc and euro occupied the leading role with equal shares, by crowding out the dollar segment temporarily. (Páles et al. 2010) From 2010 onwards the intensification of the sovereign debt crisis increased financial risks again and the market answered with widening FX swap spreads anew. Banai et al. (2014) found that swap spreads also stem from the dominance of large players of the Hungarian interbank market by investigating its network structure besides the changing market characteristics indicated by implied yield, spread and turnover and other liquidity measures.

The high level of foreign currency exposure and even the great volume of foreign exchange swaps involves substantial financial stability risk, which made the MNB take actions. Similarly to the ECB and the NBP between 2008 and 2009, the MNB announced FX swap tenders – first in the O/N EURHUF segment and later at longer maturities and also in the form of CHF liquidity providing instruments – to restore stability and stimulate the lending activity of banks (Krekó et al., 2013). Furthermore, after a series of measures aimed to rescue indebted households, the Parliament decided to oblige banks to convert foreign currency loans into forints. The MNB provided the foreign currency necessary for the conversion at the end of 2014 in the form of EUR CIRS and FX swap tenders (minor tenders also took place in 2015). It happened in the last minute, as the Swiss central bank decided in January 2015 to abolish the exchange rate threshold of the franc against the euro which caused an extreme devaluation of the forint against the Swiss franc and in a period where MNB's reserve adequacy allowed it. The open position of the banking system within the balance sheet narrowed and FX swap demand started declining (MNB, 2016).

The central bank was not simply supporting the government in the different periods of phasing out FX loans but through its central bank toolkit it also mitigated external vulnerability. The MNB introduced various instruments bound to the condition of the reduction of external debt, among others a part of currency swap facilities required a commitment from banks to reduce short-term liabilities (Novák-Vámos, 2017). The forint conversion of FX loans was precedented by the self-financing programme launched in June 2014 by the MNB which encouraged banks' purchases of domestic securities, above all HUF denominated government securities mostly supported by the MNB's IRS tenders and other forint liquidity providing operations which also contributed to the decrease in the foreign financing of the economy. The results of the forint conversion and the self-financing programme was also acknowledged by international organisations and credit rating agencies (IMF, 2016). The MNB has been continuing to provide foreign exchange swap instruments. Since 2016, the MNB has launched forint liquidity providing fine-tuning FX swap instruments. Due to the foreign exchange swap tenders, forint liquidity is regularly flowing into the banking system and has lately been much more frequently taken by banks than the still existing euro liquidity providing FX swap instruments. Thus, the foreign exchange funding of the banking system has become stable. Meanwhile, the net swap position against the forint has shown a declining trend. FX swaps, as unconventional monetary policy instruments are becoming conventional elements of the MNB's monetary policy operational framework as they are among the MNB's regularly announced assets. (Novák, 2019)

As concerns the preceding empirical analyses of Hungarian swap markets, Csávás et al. (2008) examine the main drivers of the forint interest rate swap spread before the Lehman crisis. They put several factors in their regression model, namely, BUBOR spread, Maggie A spread, demand for government bonds by residents, auction days and overbidding, government bond turnover, the slope of the yield curve, and the forward yield spread. Csávás and Szabó (2010) analyse the factors affecting the short, and long-term FX swap spreads in EURHUF transactions for the period between October 2008 and June 2010. They revealed that besides the most important explanatory variables like the TED spread, change in foreigners' HUF government bond holding, the daily change in the EURHUF exchange rate, the net amount of FX swap redemptions, the volume of the ECB deposit facility and Hungary's CDS spread, policy variables, more specifically the swap spread of the central bank's (MNB) FX swap tenders in the case of short-term and tender day dummies in the case of long-term swap transactions were proved to be significant in FX swap spread regression estimates. Csávás and Szabó (2010) thus point out that monetary policy instruments can have a material bearing on the pricing characteristics of the FX market. Our paper has much drawn on these results.

3. METHODOLOGY

EURHUF and USDHUF FX swap spreads were explained by econometric methods for the period between January 2008 and December 2021. For the calculation of FX swap spreads, data were obtained from Bloomberg and Reuters daily exchange rate and forward point quotes, supplemented with daily 3-month BUBOR, EURIBOR and USD LIBOR rates.

The following, generally applied formula (see Csávás & Szabó, 2010) was used to calculate FX swap spreads:

$$FX\ swap\ spread = r_{HUF\ interbank\ (BUBOR)} - \frac{Spot\ \left(\frac{Foreign}{HUF}\right) + forward\ points}{Spot\ \left(\frac{Foreign}{HUF}\right)}\left(1 + r_{interbank\ (foreign)}\right) + 1$$

where Foreign/HUF stands for the HUF price of the foreign currency (EUR or USD).

The source of most of the explanatory variables involved in the estimation of FX swap spreads, such as 5-year Hungarian CDS spread, JP Morgan EMBI Global Diversified Index spread, the 3- and 5-year Hungarian government bond tender data (quotes and accepted amounts), the USD Ted spread and other interest rate spreads was also Bloomberg and Reuters market data. The MNB FX swap tender dates (used as dummy variables) and 3-month FX swap points (maximum in the case of foreign currency liquidity and minimum in the case of forint liquidity providing operations) announced were downloaded from the central bank's (MNB) website. Data were tested in the open source statistical software Gretl 2020e.

In contrast to Csávás and Szabó (2010) swap spread data were not logarithmised as it would have entailed the loss of negative values. This way data of 3556 and 3575 trading days were involved in the analysis among EURHUF and USDHUF quotes respectively. First the level of the above data were tested for unit root using Augmented Dickey Fuller (ADF) tests (see Appendix I.). Apart from the swap spread time series some of the explanatory data were found to be stationary as well, like the log change in forint exchange rates, the tender results for government bonds and MNB foreign currency transactions involved in the estimates. Other regressors were first-order serially correlated, and therefore their first difference was used as input for OLS regressions and finally tested in a VAR framework. When an extended timeframe was investigated TED spread could also be regarded as stationary. Month-end data were also tested for unit root and similar results could be detected. In this latter case MNB tender days and government bond overbidding were cumulated monthly.

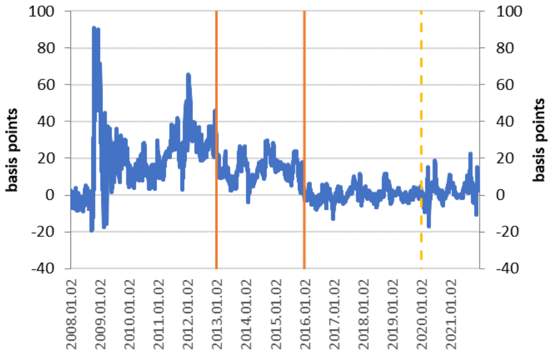

Figure 1a: EURHUF FX swap spreads, 2008-2021

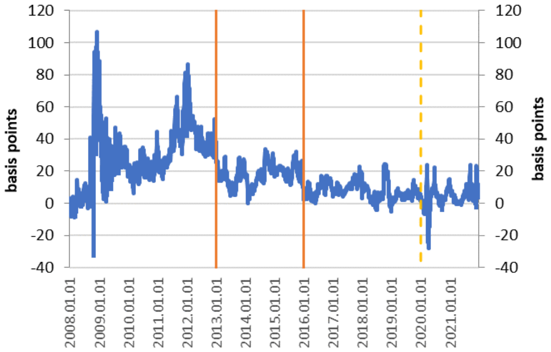

Figure 1b: USDHUF FX swap spreads, 2008-2021

Source: Bloomberg, own figure

First swap spreads were examined for the period 2008 and 2018 then extended to 2021 to also discover FX market processes during the pandemic crisis. The reason for the first limitation till 2018 was that the entire time series showed a rather variable picture (Figure 1a and 1b) which made it reasonable to divide the whole period into three subperiods for sensitivity analysis, the first subperiod covered the crisis years between 2008 and 2012 (average swap spreads were 20 and 30 basis points for EURHUF and for USDHUF), the second those between 2013 and 2015 (swap spread moved around 14- and 18-basis point means respectively) and the third those between 2016 and 2018 (with a close to zero average for EURHUF and below 10-basis point average values for USDHUF) (see Figure 1a and b). The two latter "calming down" and "tranquile" periods were of equal length this way. With the extended timeframe we can observe that spreads continued to move between zero and ten basis points even after 2020 but with somewhat larger volatility then in the pre-COVID-19 period of 2016-2019. While the average swap spread for the entire interval of 2016-2021 had a moderate level of 0.94 bps for the euro and 6.70 bps for the USD (with standard deviations of 3.9 and 5.7 respectively), it fluctuated around 2.22 bps for the euro and 4.32 bps for the USD (with standard deviations of 4.7 and 6.1 respectively) between 2020 and 2021.

Both EURHUF and USDHUF swap spread series reached their peak in the months after Lehman Brothers' bankruptcy filing, however, the absolute maximum of 91 basis points occurred on 27 October 2008 in the case of EURHUF (three weeks after the so called "black Thursday" on 9th October 2008 when a severe shock hit Hungarian financial markets) and an above 100 basis points (107) record high could be established on the 3rd December in the case of USDHUF forward point quotes. We can record below zero data in the pre-Lehman period and mostly after December 2015 in the case of both currency pairs but in the USDHUF currency quotes it rarely happened before 2020 (apart from the great crash to minus 30 basis points on 22 October 2008, on the day of the increase of the MNB base rate to 11.5% after both the Fed and the ECB announced rate cuts). Furthermore, the period after 2012 also indicates an epoch in which monetary policies started strongly deviating, whereas the Fed started tapering in December 2013 (having announced it as early as May), the ECB moved to a stronger easing in January 2015 by expanding its asset purchases. At the same time, the MNB in addition to continuously decreasing its policy rate, launched its self-financing programme in mid-2014 contracting the HUF liquidity of banks and – partly through its IRS instrument – channelling it towards domestic securities and later by further IRS programmes aimed to promote lending. The Fed gradually cut its base rate to zero between August 2019 and mid-March 2020 and has maintained it around zero, like the ECB until today. The MNB started its shift towards restriction in June 2021, raising the base rate from 0.9% to 2.4% by mid-December 2021. These dissimilar monetary policies might account for a great part of pricing fluctuations in the FX markets.

Swap spread data were found to have a strong autoregressive nature based on ACF and PACF functions. Moreover, based on the results of the unit root tests on explanatory variables it proved to be reasonable to choose a VAR framework for analysing the relationship between swap spreads and other financial variables. VAR is an adequate econometric method to analyse multivariate time series, due to its flexibility and ability to capture dynamic economic and financial processes (Zivot & Wang, 2006). VAR models were developed to provide an alternative to the application of several equations for multidimensional problems by behaving like a mulivariate multiple regression. VAR models have extensively discussed, good statistical properties, their estimation with various approaches, e.g. MLE and OLS, produce asymptotically equivalent results (Warsono et al., 2019). In the general form of p-lag VAR the dependent variables can be expressed by their own lagged values and those of other regressors:

$$Y_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \cdots + \Pi_p Y_{t-p} + \varepsilon_t \quad t = 1, 2, \ldots T$$

where c is an (nx1) constant vector, Y_t is an (nx1) vector of time series variables, Π_i are (nxn) coefficient matrices and ε_t is an (nx1) unobservable error vector, a zero mean white noise process with time invariant covariance matrix. The above equation can be supplemented with exogenous variables, which can capture, among others, policy effects.

$$Y_t = c + \Pi_1 Y_{t-1} + \Pi_2 Y_{t-2} + \cdots + \Pi_p Y_{t-p} + G\mathrm{X}_t + \varepsilon_t \quad t = 1, 2, \ldots T$$

where G is an (nxm) coefficient matrix and X_t is an (mx1) vector of exogenous variables. Even exogenous variables can be involved in the equation with lagged variables. These types of vector autoregressions are the so called VARX(p,q) (Vector Autoregressive with Exogenous Variables) models, in which p and q denote the number of lags in the endogenous and exogenous variables respectively.

The construction of VAR models often serves forecasting purposes and structural analysis in which the causal impacts of unexpected shocks and innovations to given variables is observed (Warsono et al., 2019). In this paper, however, our aim is simply to provide an adequate framework for analysing policy effects in different (crisis and post-crisis) time periods. Data were subjected to Granger causality test automatically offered by the statistical software used in a multivariate interpretation and also pairwise with the help of F-statistics. (In the majority of cases coefficients of swapspread variables explaining the dependent variabes were either zero or if not – like for TED spread and overbidding in givernment bonds – the F-statistics were much lower than in the opposite direction.) Time series were also tested with VECM, Engel-Granger and Johansen cointegration models. Unit-root and trace statistics revealed some cointergating relationship among the variables but as asome of the inputs themeselves were stationary, R^2 statistics wer hardly above 50% and the last eigenvalue of the Johansen test was zero, these tests brought biased results. While VECM and cointegration models failed to explain the relationship among the data used for swap spread analysis reliably, which in contrast can be well fitted with VARX models in which exogenous variables capture policy implications.

4. EMPIRICAL RESULTS

For starters, the first differences of FX swap spreads were tested in an OLS linear regression framework. The results were mostly confirming the supposed relationship between explanatory variables and the dependent variable, market liquidity and counterparty risk indicators positively contributed to swap spreads (EMBI index, CDS spread, change in the forint price of the two currencies, TED spread, 3-month IRS-OIS spreads, overbidding in HUF government bond tenders), while MNB FX tenders (measured as dummy) negatively. The only exception was the announced 3-month MNB swap spread which further increased market FX swap mispricing. OLS estimates, however, had very low explanatory power, they could only explain less than 5% of the daily change in FX swap spreads for the whole period examined, therefore VAR models seemed to be a better choice having observed the strong autoregressive process in swap spread data series.

The VAR models provided much better estimates for the deviation from the CIP condition. The involvement of the log change in the HUF exchange rate of the foreign currency (dlnEURHUF and dlnUSDHUF), the TED spread, the EMBI spread and the 5-year Hungarian government bond CDS (HUN5YUSDCDS) as endogenous variables resulted in the best estimate for the swap spread variable. (CDS spreads were involved both on a daily basis and as monthly averages, finally monthly averages were selected for their better explanatory power.) Alternative interest rate variables such as three-month IRS-OIS spreads, ON deposit rates, effective Fed funds rate, three-month repo rate, however, only became significant with a great number of lags or contributed to swap spreads with negative coefficients in the majority of cases. The only exception was the effective Fed funds rate for the USD swap spread which had a positive coefficient. For lag selection all the three IC criteria (Akaike (AIC), Schwarz-Bayesian (BIC) and Hannan-Quinn (HQC)) were considered. The AIC criterion asymptotically overestimates the number of lags, while the BIC and HQ offer consistent order estimates (Wang & Zivot, 2006). In the AIC case the maximum lag was always the right choice, while the BIC recommended the lowest values, generally 2 lags were indicated as sufficient. The results of the two-lag VAR estimations for the entire 2008-2018 period are detailed in Table 1.

For this period the lagged change in the foreign currency exchange rates negatively contributed to FX swap spreads in both the EURHUF and USDHUF cases for which a possible interpretation is that increases (decreases) in the spot rates of the HUF price of foreign currency exchanges were overcompensated by an even greater increase (decrease) in forward points in the period examined which then mitigated the difference between interbank market rates and implied interest rates. In addition, it is interesting to observe that the USD TED spread was more significant for EURHUF quotes than for USDHUF quotes, though in the first case the second lag took a larger negative coefficient than the positive coefficient of the first lag, which makes the effect of the funding liquidity risk indicator rather questionable in the case of EURHUF swap pricing. EMBI and CDS spreads consequently appeared with positive signs when they took significant values. For the USDHUF swap spreads Hungarian CDS appeared to be a more persistent counterparty risk indicator than for EURHUF swap spreads.

This can be interpreted partly by the Hungarian counterparty's risk being a more important barrier for USDHUF swap transactions than general liquidity tensions in the USD interbank market captured by the TED spread. Another explanation might be that in the most turbulent periods turnover in the HUF FX swap market concentrated on EUR and CHF, while USD transactions were pushed into the background. At the same time, compared to country-specific risk indicators, the change in the general risk level in emerging markets (as reflected by the EMBI values) exercised a relatively larger spread widening impact on the EURHUF product than the USDHUF transactions.

Table 1
VAR estimation results for EURHUF and USDHUF FX swap spread covering the whole period between 2008-2018
Dependent variable: swapspread

	EURHUF	***USDHUF***
const	**0.00287***** (0.00086)	**0.00707***** (0.00148)
swapspread_1	**0.87830***** (0.01865)	**0.67234***** (0.01814)
swapspread_2	**0.10079***** (0.01872)	**0.29589***** (0.01816)
dlnEURHUF_1	**−0.99230***** (0.10504)	
dlnEURHUF_2	**−0.61636***** (0.10706)	
dlnUSDHUF_1		**−0.20924**** (0.09449)
dlnUSDHUF_2		**−0.23451**** (0.09490)
d_TED_spread_1	**0.00058***** (0.00013)	**0.00047**** (0.00019)
d_TED_spread_2	**−0.00073***** (0.000134)	−0.00021 (0.00019)
d_EMBI_1	**0.00066***** (8.1832e-05)	**0.00052***** (0.00012)
d_EMBI_2	**0.00036***** (8.0427e-05)	**0.00027**** (0.00012)
d_HUN5YUSDCDS_1	**0.00022***** (6.5214e-05)	**0.00023**** (9.5304e-05)
d_HUN5YUSDCDS_2	−7.2892e-05 (6.5477e-05)	**0.00028***** (9.5110e-05)
FX_MNB_tender (dummy)	**−0,00753***** (0.00239)	**−0.00729**** (0.00347)
MNB swap spreads	**0.03497**** (0.01608)	0.03218 (0.02352)
HUF3y_5y_overbid	**0.00307**** (0.00128)	0.00053 (0.00186)
adjusted R^2	0.95024	0.91986
Durbin-Watson	2.01945	2.10502

Notes: coefficients are sigificant at *10, **5 and ***1 per cent.
Data should be interpreted as change in the given variables cause a given percentage point change in swap spreads. "_1" and "_2" stand for one- and two-period lag. "d" stands for the first difference of the data.
Source: Authors' results

The VARX model used to fit the swap spread data series also involved exogenous variables. The three selected exogenous variables were partly representing policy intervention (the "FX_MNB_tender" dummy capturing all MNB tender days on which any kind of currency swap was offered to credit institutions by the MNB, the "MNB swap spreads" indicator was calculated from MNB swap points and measures its influence on pricing in the market), and partly extra demand for HUF denominated government bonds ("HUF3y_5y_overbid") in the most popular 3- and 5-year segment. MNB tenders proved to be adequate policy tools to counteract market mispricing whereas 3-month MNB swap prices further increased the deviation of forward point quotes from their theoretically reasonable values in the EURHUF market. Excessive demand for HUF government bonds also contributed to the widening of EURHUF swap spreads. These exogenous variables, apart from FX swap tender dummies, however, exerted no effect on the USDHUF market which is understandable as MNB swap tenders were mostly EUR related (apart from some CHF tenders closely after the Lehman collapse) and those investors interested in hedging against HUF currency exposure when entering the HUF securities markets tend to be rather euro than dollar income holders. Taking the first lagged values of exogenous variables exerted the same effect on spreads as the contemporaneous equivalents, apart from the tender dummy in the case of which no lag seemed to be of any influence on pricing deviations.

Table 2

VAR estimation results for EURHUF and USDHUF FX swap spread covering the whole period between 2008-2020

Dependent variable: swapspread

	EURHUF	***USDHUF***
const	**0.00245***** (0.00068)	**0.00540***** (0.00112)
swapspread_1	**0.88761***** (0.01661)	**0.68536***** (0.01610)
swapspread_2	**0.09063***** (0.01664)	**0.28617***** (0.01610)
dlnEURHUF_1	**−0.81325***** (0.08973)	
dlnEURHUF_2	**−0.47649***** (0.09194)	
dlnUSDHUF_1		**−0.17877**** (0.07889)
dlnUSDHUF_2		**−0.18673**** (0.08015)
d_TED_spread_1	**0.00064***** (0.00012)	**0.00053***** (0.00017)
d_TED_spread_2	**−0.00066***** (0.00012)	−0.00025 (0.00017)
d_EMBI_1	**0.00030***** (4.5998e-05)	**0.00028***** (6.4302e-05)
d_EMBI_2	**0.00026***** (4.5759e-05)	**0.00015**** (6.3852e-05)
d_HUN5YUSDCDS_1	**0.00020***** (6.0778e-05)	**0.00020**** (8.6910e-05)
d_HUN5YUSDCDS_2	−7.5563e-05 (6.0980e-05)	**0.00027***** (8.6778e-05)
FX_MNB_tender (dummy)	**−0.00524***** (0.00185)	**−0.00500*** (0.00265)
MNB swap spreads	**0.03100**** (0.01427)	0.02436 (0.02046)
HUF3y_5y_overbid	**0.00284***** (0.00107)	0.00043 (0.00154)
adjusted R^2	0.95223	0.93097
Durbin-Watson	2.02280	2.10118

Notes: coefficients are sigificant at *10, **5 and ***1 per cent.

Data should be interpreted as change in the given variables cause a given percentage point change in swap spreads. "_1" and "_2" stand for one- and two-period lag. "d" stands for the first difference of the data.

Source: Authors' results

The examination was extended to the end of 2021 (Table 2) to see whether the model remains well-fitting when adding the pandemic years 2020-2021. The coefficients generally took somewhat lower values but remained robust. The explanatory power of government bond overbidding for the EURHUF and that of the TED spread for the USDHUF model became greater while the MNB tender dummy less significant for the USDHUF case in the longer time series.

The models on daily data series were subjected to a series of sensitivity and robustness checks. Because of the improved statistical properties of the variable, the level of TED spreads was involved for the period 2008-2021 which resulted in a less significant outcome than their first difference. Two dummies were also added to the model, dummy1 put larger weight on crisis periods and took a value of zero after the end of 2015. Dummy2 only differed from 0 between 2020 and 2021. Dummy1 proved to be significant in all regression estimates without materially changing the test statistics of other variables (apart from the MNB tenders which lost their significance for USDHUF estimates entirely), while dummy2 had no explanatory power. Adopting HC1 and HAC heteroskedasticity- (and autocorrelation-) robust standard error checks, however, limited the validity of the model. In the EURHUF case HC1 dropped MNB swap spreads while HAC EMBI among the regressors, in the USDHUF case both TED spread and EMBI had to be cast off based on their p value in both robust error checks. (Coefficient signs remained robust). F-statistics of causality tests reveal that swap spread estimates Granger-cause all other regressions.

Taking month-end data for analysis the (monthly) change in the exchange rate either turned its sign to positive or became insignificant. As a general observation one could conclude from the positive coefficients of both the MNB tender dummy (significant only if dummy1 was involved) and 3-month MNB swap spreads (significant only for USDHUF) in these monthly estimations, that the Central Bank of Hungary intervened in those months more forcefully when swap spreads were relatively higher than in other months. Although we used month-end data also for the O/N deposit facility of the ECB capturing potential liquidity problems in the eurozone interbank market, it did not improve the regression results. Among counterparty risk and funding liquidity risk indicators EMBI spreads and TED spreads contributed still positively to swap spreads, whereas CDS spreads operated in the opposite direction. It means that a monthly increase in country risk in the previous month mitigated swap spreads in the given month. Government bond overquotes' coefficients were only significantly positive for the USDHUF data. In general, other variables than lagged swap spreads had a varying degree of explanatory power based on the currency pairs and lag selection applied (for monthly data one lag was recommended by both BIC and HQC).

When dividing the whole period examined into subperiods, daily data estimates result in very similar relationships among the dependent and explanatory variables for the 2008-2012 period of the two subsequent crises. (Appendix II.) MNB tender variables also take the same signs, however, lose much of their significance for EURHUF swaps, in contrast their explanatory power increases for USDHUF data. It is thus worth mentioning that in the first subperiod examined representing the global financial and European sovereign crisis, the announcement of MNB FX swap tenders mitigated swap pricing anomalies also in the USDHUF market whereas MNB swap points distorted both markets' valuation. Most of the endogenous variables lost their explanatory power for the last three subperiods which is partly owing to the easing of market tensions and the dissimilar monetary policies and partly to the shorter time series. In addition, bond overbidding became the only significant exogenous variable in the period 2013-2015 where the self-financing programme and the forint conversion of FX consumer loans took place. These policy interventions caused an increased demand for HUF government securities by domestic banks which partly crowded out foreign investors. In the 2016-2018 period after the conversion of foreign currency loans and the active use of the forint liquidity providing MNB FX swap tenders captured by the MNB tender dummy became again significant. Its effect varies, however, in this period considered, MNB EURHUF FX swap tenders contribute to the widening of FX swap spreads in the USDHUF market. In the years 2020-2021, representing the COVID-19 crisis, USD market risk (TED spread) and exchange rate volatility seem to dominate the evolution of swap spreads. Interestingly, Hungarian CDS spreads mitigated swap differentials due probably to the downside volatility of the latter being stronger connected to country risk, as in this period not the level but the variability of swap spreads was the major sign of market tensions.

5. DISCUSSION

The empirical results confirm those of most of the literature and thus reflect our expectations. There are two major differences to what Csávás and Szabó (2010) substantiated: the variability of daily exchange rates did not prove to be positively influencing FX swap spreads, in contrast MNB pricing of swap products, if it had any effect, further increased pricing tensions in our estimations. The smoothing effect of MNB swap tenders cannot be questioned, at least in the periods where foreign currency providing FX tenders made up the majority of central bank FX instruments. At the same time, applying monthly data, higher exchange rate movements even underpin the spread enlarging effect of exchange rate volatility and some endogeneity between policy instruments and market processes can be observed. Though Granger causality does not confirm this assumption, the Central Bank of Hungary (MNB) seems to have reacted to higher-than-average swap spreads with a more frequent announcement of swap tenders based on monthly VARX regressions. As for the difference between the two currency pairs examined, one can conclude that USD related swap transactions were more affected by the country-specific risk indicators and demand for domestic assets than the EUR related ones.

On the whole, the variables selected help obtain an overall picture on what have moved deviations from CIP in the Hungarian forint context since the global financial crisis of 2007-2008. In certain periods the role of both endogenous and exogenous variables changed: under strong market turmoil the USD TED spread and MNB swap tenders became more important, while other policy interventions (like the self-financing programme) and hedge demand in general were more dominant in FX pricing in more tranquil periods. The declining effectiveness of FX swap tenders on swap spreads can stem from the gradual shift of monetary policy to forint liquidity providing instruments and probably due to market actors' already smoothed expectations having built in the weekly tender facility in their own pricing behaviour. This assumption seems to be underpinned by the moderate swap spreads in the last two years. The volatility in swap differentials on the other hand can also be attributed to strongly differing monetary policies as suggested by the literature (see Borio et al., 2016).

Nevertheless, the methodology adopted in the paper has many limitations. First of all, VARX are often used for forecasting autoregressive processes, instead of simply explaining policy effects. The model was applied as a best fit compared to less well performing cointegrating relationships. The models used for various time periods and currency pairs is thus very sensitive to lag (for shorter time series and monthly data lower number of lags seem to be more adequate) and also variable selection and the granularity of data. For the latter reason important factors such as foreigners' net HUF position or the share of FX dominated loans in the total loan portfolio were not involved in the estimates, though they might have significantly contributed to our understanding of FX market processes. Moreover, we did not differentiate between foreign currency and forint liquidity providing MNB facilities, though this might also help refine our results.

6. CONCLUSION

Since 2008, the beginning of a period marked by a series of financial market turbulences, the Hungarian FX swap market has experienced significant pricing anomalies. As interbank liquidity tensions eased, exposure due to the funding need of household FX loans declined and the country's credit rating improved FX swap spreads were tapering off until they eventually disappeared in the EURHUF market, while the global dollar shortage kept USD FX swap spreads on average significantly over zero for the whole 2008-2021 period. The VARX framework adopted in the paper proved to be an adequate tool to account for both the impact of funding and market liquidity, as well as counterparty risk in the HUF related FX swap markets and through exogeneous policy and market demand variables, it could also explain policy effects on pricing. The Hungarian monetary policy, by making a strong commitment to alleviate the external vulnerability of the country, contributed to the tempering of pricing anomalies through the signalling effect of its own FX swap tenders in general and due to its provision of the foreign currency necessary to the phasing out of household FX loans in particular. The tender announcements unquestionably helped regain confidence in market actors in HUF related products, but with varying effect both in terms of currency and economic policy period. Notwithstanding, the examination also reveals that the central bank might also further strengthen spreads in the market by its more favourable pricing applied toward counterparty credit institutions. Other monetary policy tools, such as those applied within the frames of the MNB's self-financing programme and on the whole, differing monetary policy stances might also distort the pricing conduct of market actors which makes the judgement about the benefits of central bank intervention more nuanced. The example of the MNB justifies that central banks' liquidity provision in the form of FX swaps has its rationale not only in a global or regional perspective, the way the Fed and the ECB supply their counterparties with USD and EUR, but also in the domestic market of a small, open economy.

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APPENDIX I

ADF tests of regression variables (28 lags based on the Schwert (1989) rule) for 2008-2018

Variable		t-statistic	p-value
EURHUFswapspread	without constant	-2.6075	0.0088
	with constant	-3.8133	0.0028
	with constant and trend	-4.5045	0.0014
dln(EURHUF)	without constant	-17.5075	4.969e-037
	with constant	-17.5294	4.254e-042
	with constant and trend	-17.5291	3.144e-056
USDHUFswapspread	without constant	-1.9544	0.0485
	with constant	-3.3689	0.0121
	with constant and trend	-4.0816	0.0066
dln(USDHUF)	without constant	-52.5331	0.0001
	with constant	-52.5389	0.0001
	with constant and trend	-52.5311	4.09e-070
TED spread	without constant	-2.1797	0.0282
	with constant	-2.8263	0.0546
	with constant and trend	-2.9226	0.1552
EMBI	without constant	-0.3390	0.5634
	with constant	-3.0835	0.0278
	with constant and trend	-3.1013	0.1059
5-year CDS spread	without constant	-0.8788	0.3355
	with constant	-1.7875	0.3871
	with constant and trend	-2.7074	0.2336
HUF bond overquote	without constant	-3.9729	7,234e-005
	with constant	-7.0920	1,863e-010
	with constant and trend	-7.0898	1.362e-009
MNB swapspread	without constant	-3.8818	0.0001
	with constant	-4.4560	0.0002
	with constant and trend	-4.5790	0.0011

ADF tests of regression variables (28 lags based on the Schwert (1989) rule) for 2008-2021

Variable		t-statistic	p-value
EURHUFswapspread	without constant	-2.9715	0.0029
	with constant	-4.0587	0.0011
	with constant and trend	-5.0445	0.0001
dln(EURHUF)	without constant	-19.5269	8.429e-040
	with constant	-19.5723	1.346e-046
	with constant and trend	-19.5703	4.149e-067
USDHUFswapspread	without constant	-2.2132	0.0259
	with constant	-3.5001	0.0080
	with constant and trend	-4.6539	0.0008
dln(USDHUF)	without constant	-16.1598	1.352e-034
	with constant	-16.1991	1.304e-038
	with constant and trend	-16.1972	3.344e-049
TED spread	without constant	-2.5829	0.0095
	with constant	-3.2825	0.0157
	with constant and trend	-3.5246	0.0367
EMBI	without constant	-0.6596	0.4317
	with constant	-3.4476	0.0095
	with constant and trend	-3.4956	0.0398
5-year CDS spread	without constant	-1.1617	0.2244
	with constant	-1.9619	0.3041
	with constant and trend	-3.4369	0.0466
HUF bond overquote	without constant	-4.0852	4.552e-005
	with constant	-7.9224	8.428e-013
	with constant and trend	-7.9454	2.951e-012
MNB swapspread	without constant	-4.2624	2.149e-005
	with constant	-4.9342	2.778e-005
	with constant and trend	-5.0204	0.0002

APPENDIX II

VAR estimates for the various subperiods 2008-2012

	EURHUF	***USDHUF***
const	0.00602*** (0.00201)	0.01568*** (0.00354)
swapspread_1	0.85082*** (0.02768)	0.64266*** (0.02692)
swapspread_2	0.12195*** (0.02791)	0.31069*** (0.02693)
dlnEURHUF_1	−1.17105*** (0.16558)	
dlnEURHUF_2	−0.75021*** (0.16941)	
dlnUSDHUF_1		−0.27570* (0.16112)
dlnUSDHUF_2		−0.33015** (0.16059)
d_TED_spread_1	0,00056*** (0.00019)	0.00041 (0,00030)
d_TED_spread_2	−0.00082*** (0.00019)	−0.00026 (0.00029)
d_EMBI_1	0.00084*** (0.00013)	0.00069*** (0.00021)
d_EMBI_2	0.00050*** (0.00013)	0.00043** (0.00020)
d_HUN5YUSDCDS_1	0.00026*** (9.6614e-05)	0.00029** (0.00015)
d_HUN5YUSDCDS_2	−7.3095e-05 (9.7166e-05)	0.00035** (0.00015)
FX_MNB_tender (dummy)	-0.01123** (0,00539)	−0.02053** (0.00798)
MNB swap spreads	0.04304* (0.02606)	0.06667* (0.03912)
HUF3y_5y_overbid	0.00365 (0.00254)	−0.00024 (0.00381)
adjusted R^2	0.92789	0.88209
Durbin-Watson	2.02316	2.11841

2013-2015

	EURHUF	***USDHUF***
const	0.00329** (0.00143)	0.00482*** (0.00176)
swapspread_1	1.01629*** (0.03695)	0.99837*** (0.03704)
swapspread_2	−0.04456 (0.03691)	−0.02856 (0.03699)
dlnEURHUF_1	−0.42001*** (0.12645)	
dlnEURHUF_2	−0.23394* (0.12895)	
dlnUSDHUF_1		−0.26430*** (0.08116)
dlnUSDHUF_2		−0.02841 (0.08297)
d_TED_spread_1	2,4287e-05 (0.00052)	−0.00010 (0.00052)
d_TED_spread_2	−0.00101* (0,00054)	−0.00074 (0.00054)
d_EMBI_1	0.00012 (9.7369e-05)	9.5997e-05 (9.6585e-05)
d_EMBI_2	4.1339e-05 (9.5310e-05)	−1.1680e-05 (9.5122e-05)
d_HUN5YUSDCDS_1	6.4506e-05 (9.5616e-05)	0.00013 (9,6308e-05)
d_HUN5YUSDCDS_2	−1.4780e-05 (9.,4851e-05)	−1.3266e-05 (9.6345e-05)
FX_MNB_tender (dummy)	−0.00370 (0.00270)	−0.00242 (0.00273)
MNB swap spreads	0.01954 (0.03461)	0.02316 (0.03487)
HUF3y_5y_overbid	0,00529*** (0.00135)	0.00405*** (0.00135)
adjusted R^2	0.93777	0.93628
Durbin-Watson	2.00411	1.99543

2016-2018

	EURHUF	***USDHUF***
const	0.00042 (0.00054)	0.00244** (0.00107)
swapspread_1	0.95297*** (0.03633)	0.96340*** (0.03647)
swapspread_2	0.02042 (0.03656)	−0.00015 (0.03668)
dlnEURHUF_1	−0.11810 (0.19856)	
dlnEURHUF_2	−0.46132** (0.19710)	
dlnUSDHUF_1		0.11303 (0.09475)
dlnUSDHUF_2		−0.08359 (0.09583)
d_TED_spread_1	4.1176e-05 (0.00026)	0.00050* (0.00029)
d_TED_spread_2	0.00031 (0.00026)	0.00024 (0.00028)
d_EMBI_1	0.00019* (0.00011)	−3.4437e-05 (0,00011)
d_EMBI_2	−0.00015 (0.00011)	−0.00023** (0.00012)
d_HUN5YUSDCDS_1	−6.5849e-05 (0.00027)	−0.00012 (0.00030)
d_HUN5YUSDCDS_2	−0.00015 (0.00027)	−4.7268e-05 (0.00030)
FX_MNB_tender (dummy)	−0.00411** (0.00178)	0.00480** (0.00197)
MNB swap spreads	0.04128 (0.04082)	0.00826 (0.04572)
HUF3y_5y_overbid	0.00116 (0.00103)	4.6722e-05 (0.00114)
adjusted R^2	0.86105	0.92484
Durbin-Watson	2.00040	1.98060

2020-2021

	EURHUF	*USDHUF*
const	0.00184 (0.00120)	0.00395*** (0.00150)
swapspread_1	0.91620*** (0.04538)	0.92154*** (0.04616)
swapspread_2	−0.02434 (0.04514)	−0.01064 (0.04603)
dlnEURHUF_1	−0.62168*** (0.21756)	
dlnEURHUF_2	−0.50022** (0.21817)	
dlnUSDHUF_1		−0.58658*** (0.15616)
dlnUSDHUF_2		−0.24581 (0.15774)
d_TED_spread_1	0.00063* (0.00034)	0.00115*** (0.00040)
d_TED_spread_2	0.00055 (0.00035)	−0.00047 (0.00028)
d_EMBI_1	−9.1872e-06 (4.4186e-05)	5.6854e-05 (4.9036e-05)
d_EMBI_2	4.4481e-05 (4.4315e-05)	1.0802e-05 (4.9019e-05)
d_HUN5YUSDCDS_1	−0.00076* (0.00047)	−0.00206*** (0.00052)
d_HUN5YUSDCDS_2	−0.00120 (0.00048)	0.00030 (0.00054)
FX_MNB_tender (dummy)	0.00018 (0.00287)	0.00118 (0.00316)
MNB swap spreads	0.06460(*) (0.03954)	−0.06698 (0.04388)
HUF3y_5y_overbid	0.00295 (0.00216)	0.00170 (0.00239)
adjusted R^2	0.80669	0.85921
Durbin-Watson	1.99865	2.00961