Determinants of Hungarian forint FX swap spreads after the Lehman crisis

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Abstract

In this paper we analyze the drivers of HUF FX swap spreads (CIP deviation) in the period October 2008 – June 2010. The main aim is to analyze the impact of the FX swap instruments introduced by the central bank of Hungary. A further objective is to answer whether the spreads are moved by risk or foreign currency liquidity related factors. For the calculation of EUR/HUF and USD/HUF FX swap spreads we use a unique dataset which contains FX swap transactions. We find evidence that both short and long FX swap spreads are affected by variables related to global risk aversion, to counterparty risk and to the availability of foreign currency liquidity. The effect of the central bank instruments is also significant, the application of both 1-day and long-term FX swaps contributed to the decline of market-traded FX swap spreads.

JEL: F31, G13, E52

Keywords: FX swap, Covered interest parity, FX swap spread, Crisis, Central bank instruments

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1. Introduction

After the onset of the subprime crisis in summer 2007, forward exchange rates deviated from the covered interest parity (CIP) in several developed and emerging currency pairs. FX swap spreads (denoted also as CIP deviations or FX swap basis) turned out to be different from zero, reflecting that the forward rates of FX swaps were higher or lower than the forward rates calculated from domestic and foreign interbank interest rates. After the bankruptcy of Lehman Brothers in September 2008, dislocations in FX swap markets became more serious.

On the Hungarian forint (**HUF**) FX swap markets similar phenomena was observed. After the Lehman crisis, FX swap spreads became positive i.e. the swap-implied HUF interest rates fell below the interbank HUF rates. As a consequence, banks were able to receive foreign currency (**FCCY**) liquidity via FX swaps only with a premium compared to EUR and USD interbank market rates.

The dynamics of FX swap spreads are important not only for market participants, but also for central banks, especially in an open emerging economy. The FX swap is a main instrument for domestic and foreign banks to manage foreign currency liquidity. A decline in the swap-implied interest rate compared to the short term money market yield can distort the efficacy of the interest rate transmission mechanism. The well-functioning of the FX swap market is also essential from financial stability perspectives.

The main objective of this paper is twofold. First, we analyze the main drivers of HUF FX swap spreads. Though the initial rise in FX swap spreads was a direct consequence of the global market turmoil caused by the Lehman bankruptcy, it is important to know which factors drove the spread throughout the following period. Second, and more importantly, we test whether the new FX swap instruments introduced by the central bank of Hungary (**MNB**) had any effect on the spreads.

Our contribution to the existing empirical literature on the determinants of FX swap spreads is double. First, we analyze spreads on an emerging European currency, the HUF. To our knowledge, there are no references in the empirical literature about FX swap spreads of emerging European currencies (only on e.g. Brazilian real, Hong Kong dollar, South Korean won). Second, instead of using market quotes which is common in the literature, we calculate the spreads based on a unique dataset containing all FX swap transactions of Hungarian banks. Price information obtained from realized transactions can be regarded more reliable compared to market quotes which do not constitute firm offers.

In the empirical literature about FX swap deviations there are two main factors found to be important: risk and liquidity. For example, Baba-Packer (2009a) highlights the role of increased counterparty risk embedded in FX swaps. They find the difference in banks' CDS as significant in explaining FX swap spreads. Other explanations are related to capital constraints/funding liquidity constraints. Mancini-Ranaldo (2010) argues that the main reason for the violation of the CIP condition was that arbitrageurs left excess profits unexploited because of the lack of sufficient dollar funding. Coffey et al. (2009) also emphasize the role of capital constraints faced by arbitrageurs as a key driver of FX swap deviations.

Based on the literature we distinguish three types of potential variables which can explain CIP deviations: risk factors, liquidity factors and policy variables, i.e. indicators which are related to the central bank's FX swap instruments. We expect that the perceived risk of the potential arbitrage strategy (i.e. a position composed of an FX swap, a borrowing transaction in one currency and lending in the other currency) could be rather elevated during the crisis. On the other hand, we expect that the limited supply of foreign currency liquidity could also have an important role. Hungarian banks roll over a huge position of FX swaps, receiving FCCY liquidity from foreign banks. Regarding the third variable, the question is whether the use of central bank instruments has a significant contribution to the decline of the spreads.

The main results are the following. For the period October 2008 – June 2010, we find that variables related to global risk aversion, the riskiness of Hungary and demand/supply effects of foreign currency liquidity are significant in explaining the 1-day and long-term HUF FX swap spreads. Variables which measure the use of the MNB's O/N and long-term FX swap instruments are also significant. When the MNB reduced the spread of the O/N instrument over the euro interbank rates, market-implied HUF FX swap spreads also declined. On the days of 3-month and 6-month FX swap auctions, spreads were also lower.

The paper is organized as follows. In Section 2 we present the data and describe the calculation of FX swap spreads. Section 3 provides stylized facts about the Hungarian FX swap market. Section 4 summarizes the main findings of the theoretical and empirical literature on the determinants of FX swap spreads. In Section 5 we lay down the hypotheses regarding the drivers of HUF FX swap spread, present the empirical results and perform robustness checks. Section 6 concludes.

2. Dataset and measurement of FX swap spreads

An FX swap consists of a simultaneous spot and forward FX transaction in opposite directions. Hungarian banks report all their FX swap transaction to the MNB (Daily Report on FX transaction, D01). The database contains the most important characteristics of the trades:

- name of the reporting bank,
- name of the counterparty,
- code of the sold as well as the purchased currency (both for the spot and the forward leg),
- spot and forward exchange rate,
- transaction date (deal date),
- value date (settlement day) of the spot and the forward legs,
- value (notional amount) of the swap.

For each transaction, FX swap spread is calculated by the following formulas:

$$spread_{i,t,T}^{EUR/HUF} = r_{i,t,T}^{HUF} - \left(\frac{F_{i,t,T}^{EUR/HUF}}{S_{i,t,T}^{EUR/HUF}}\left(1 + r_{i,t,T}^{EUR}\right) - 1\right) \quad (1)$$

$$spread_{j,t,T}^{USD/HUF} = r_{j,t,T}^{HUF} - \left(\frac{F_{j,t,T}^{USD/HUF}}{S_{j,t,T}^{USD/HUF}}\left(1 + r_{j,t,T}^{USD}\right) - 1\right) \quad (2)$$

F is the forward exchange rate, S is the spot rate of the currency pair in question; r^X denotes the interbank rate on the currency X. The notation F/S is also called the 'implied FX swap interest rate differential' (expressed in gross terms). Combining this with the foreign interest rate, the implied HUF rate is obtained. Thus, FX swap spreads are defined as the difference between the interbank and the implied HUF interest rates. All interest rates (as well as the implied interest rate differential) are expressed in **annualized** terms.

Interbank money market yields are the following. For 1-day FX swaps[1], the HUF rate is the HUFONIA, the O/N interest rate calculated by the MNB (weighted average rate of Hungarian banks' uncollaterized deposit transactions). For the euro, EONIA rates are used which are computed by the European Central Bank and represent O/N deposit rates from transactions between euro area banks. Regarding the US dollar, the daily effective federal funds rate is used which is also calculated from transactions.

For the swaps of longer maturity, BUBOR, EURIBOR and USD LIBOR rates are used. Given that these rates are available only for discrete maturities, for each FX swap, the yield of the closest maturity is used.

Next, we calculate the weighted average of FX swap spreads:

$$spread\_one\_day_t = \sum_{i,T=1} w_{i,t,T} \cdot spread_{i,t,T}^{EUR/HUF} + \sum_{j,T=1} w_{j,t,T} \cdot spread_{j,t,T}^{USD/HUF} \quad (3)$$

$$spread\_long_t = \sum_{i,T>1} v_{i,t,T} \cdot spread_{i,t,T}^{EUR/HUF} + \sum_{j,T>1} v_{j,t,T} \cdot spread_{j,t,T}^{USD/HUF} \quad (4)$$

W and *v* represents the weights calculated from the notional amount of the transactions, the sum of the weights are 1 for each day. By averaging EUR/HUF and USD/HUF FX-swaps, we can account for the changing share of the two currency pairs (see the next Section). The motivation for using only the two currency pairs is that these represent more than 95 percent of the total turnover.

Notice that the data are not synchronized since FX swaps and 1-day money market interest rates are daily averages, while interbank rates of longer maturities are quotes for a point in time. The database does not contain information about the exact time when FX swaps are conducted within the day, thus our calculation can be considered only as estimates for FX swap spreads. Nevertheless, this observation error should not cause systematic bias to our estimates.

The calculation implicitly takes into account the transaction costs of FX swaps. Since we use realized transactions, the prices of these can be viewed as a realization of bid or offer quotes.

For the empirical analysis it will be important to use FX swap spreads which approximate well the profit from an **arbitrage strategy** exploiting positive FX swap spreads.[2] Given that in each transaction, one of the counterparties receives FCCY on the spot leg, the weighted average reflects an average implied yield differential on which banks can receive FCCY.

For this kind of arbitrage strategy, there is need for EUR and USD interest rates on which one can receive FCCY loan. Since O/N interest rates are also calculated from transactions, these fulfil this criterion. Regarding EURIBOR and USD LIBOR rates, these represent quotations of yields on which it is possible to receive financing, given that these are offered rates. With respect to HUF yields, the BUBOR is an offered rate

[1] Within the 1-day maturity, there are two types of swaps: overnight (O/N) and tom next (T/N). O/N FX swaps are those where the spot leg is settled on T and the two currencies are re-exchanged on T+1. Regarding T/N swaps, the spot leg is settled on T+1 date and funds are re-exchanged on T+2.

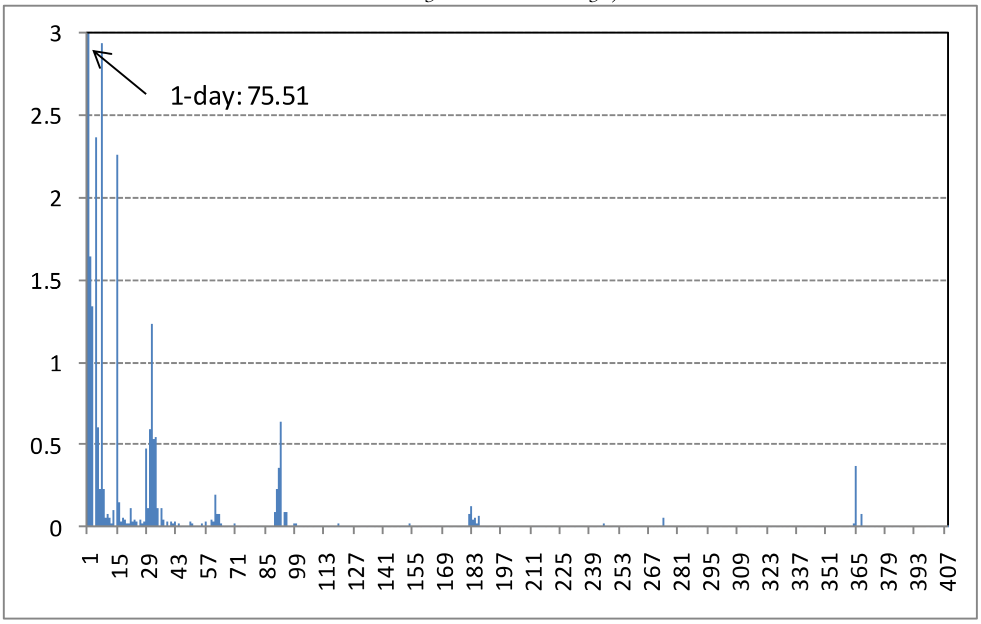
[2] In arbitrage strategy we mean a combined position to explore the non-zero FX swap spreads. More concretely, a bank (either foreigner or domestic) receives HUF on the spot leg of the swap, places it on a bank account of a Hungarian bank and finances this position from euro or USD funding.

but for the shortest maturities it could not cause high estimation error because interest rates were close to the bottom of the MNB's interest rate corridor.

It would be possible to use repo rates instead of yields on uncollaterized loans. However, the HUF repo market is immature, there are trades almost only for the 1-day maturity thus we cannot use repo rates for the long-term swaps. Moreover, for the O/N segment, the difference between uncollaterized and repo rates was small, fluctuating within the 10-40 basis points range.

The motivation for using the 1-day maturity and only an aggregate for all longer maturities is the following. 1-day FX swaps constitute about 80% of the daily turnover, thus it is worth analysing this maturity segment separately. For longer-term swaps, trades are concentrated on specific maturities, but the average number of swaps with a given maturity is small (Chart 1). The maturities of the majority of these swaps are below 1 month, thus these receive higher weights. The averaging makes less severe the problem arising from using long-term money market rates on which there are no trades. Swaps with a maturity longer than 1 day have an average maturity of 38 days.

Chart 1: Distribution of FX swap transactions by maturity (number of trades, daily average, in function of maturity measured in days)



3. Stylized facts on the Hungarian FX swap market

Before the Lehman default (15 September 2008), the HUF FX swap market was considered a rather well functioning segment within Hungarian financial markets. In addition, the HUF FX swap market was among the 10 largest emerging FX swap markets in 2007 (BIS, 2007). The structure of the FX swap market has been also similar to that of developed markets. Most of the trades have been transacted between foreign and Hungarian banks, the latter have been within the most prominent market makers.

Hungarian banks use FX swaps to finance their foreign currency needs. Part of foreign currency loans provided by Hungarian banks to domestic companies and households is financed by HUF denominated liabilities and the resulted open balance sheet position is offset by FX swaps. The Hungarian banking sector is rolling over an FX swap position where they receive foreign currency at the spot leg. The amount of this FX swap position was rather elevated, fluctuating between EUR 7 and 13 billion in the year preceding the

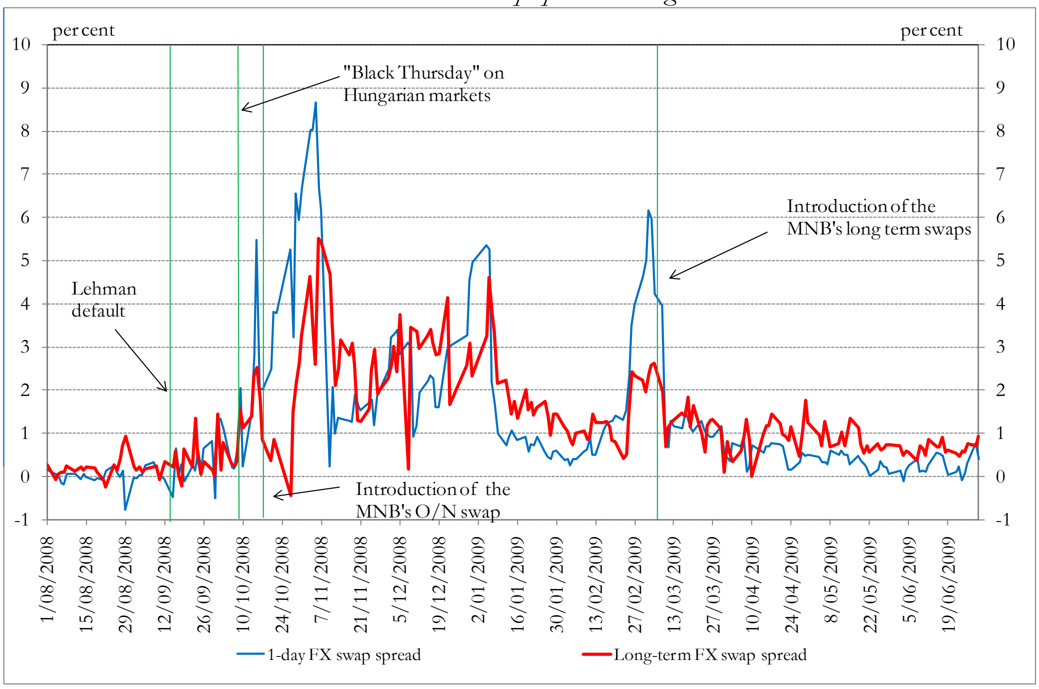
Lehman default (expressed in notional amount). On the other hand, foreign banks also needed HUF liquidity from FX swaps e.g. for financing HUF denominated assets.

Before the Lehman crisis, swap spreads were very close to zero (Chart 2). However, immediately after the default of Lehman, the spreads from USD/HUF transactions began to increase. In the meantime, there was a temporary structural change on the market: USD trades were mostly replaced by EUR trades. Since EUR/HUF FX swap spreads remained roughly unchanged, the average FX swap spread from the two currency pairs continued to fluctuate close to zero (see Páles et al., 2010 for more details in about the structure of market turnover).

On 9 October 2008, a severe shock affected Hungarian financial markets (hereinafter, we refer to this day as "Black Thursday"). The HUF suffered a huge depreciation, government bond trading stopped, and the stock exchange index plummeted. Apart from increasing global risk aversion, rumours about the default of Hungarian banks also contributed to these events. From this day, anecdotic information arose about the tightening of counterparty credit limits which also affected the FX swap market.

During the following weeks, FX swaps spreads began to skyrocket, this time both for the EUR/HUF and USD/HUF currency pairs. 1-day FX swap spreads reached even 8-9 percent in November as the highest within the examined period. There were several spikes later in both 1-day and long-term FX swap spreads (December 2008; March 2009). In the meanwhile, there was only a moderate decline in the turnover of the FX swap market. FX swap spreads reflected better that something has changed in the functioning of the market.

Chart 2: HUF FX swap spreads during the crisis



Daily average FX swap spreads. For the calculation see equations (3) and (4).

The spreads began to stabilize only in spring 2009, after the recovery in global financial markets. Since summer 2009 the FX swap spreads have been fluctuating close to zero but with higher volatility compared to the pre-Lehman period. This suggests that the original functioning of the market was not restored.

The MNB introduced several FX swap instruments in order to alleviate the pressure on the FX swap market. One of them is an O/N EUR/HUF standing facility allocated since October 2008 (Table 1). In March 2009, the MNB introduced a 3-month and a 6-month FX swap instrument.[3] The former is allocated in a competitive auction, while the latter was targeted only to a limited number of Hungarian banks. In this paper it will be not analyzed which were the exact objectives of the instruments and if these were fulfilled, we will only discuss whether these contributed to the decline of FX swap spreads.

Table 1: Main characteristics of the MNB's FX swap instruments

<table>
<tr><th></th><th>O/N EUR/HUF FX swap standing facility</th><th>3-month EUR/HUF FX swap auction</th><th>6-month EUR/HUF FX swap standing facility</th></tr>
<tr><td>Introduction/termination of instruments</td><td>16 October 2008</td><td>9 March 2009</td><td>2 March 2009/
28 June 2010</td></tr>
<tr><td>Days of bid submission</td><td>Each trading day</td><td>First trading day of each week</td><td>First trading day of each week</td></tr>
<tr><td>Intraday period of bid submission</td><td>1:45PM – 2:00 PM</td><td>10:30AM – 11:00AM</td><td>10:00AM – 10:30AM</td></tr>
<tr><td>Counterparties</td><td>Hungarian credit institutions</td><td>Hungarian credit institutions</td><td>Hungarian credit institutions fulfilling specified conditions related to their balance sheets</td></tr>
<tr><td rowspan="2">Maximum offered amount</td><td rowspan="2">Unlimited standing facility</td><td>Maximum amount determined on each tender</td><td>Up to the swap line established for each counterparty</td></tr>
<tr><td colspan="2">Aggregate outstanding amount
up to EUR 5 billion</td></tr>
</table>

4. Factors affecting FX swap spreads

In this section we provide a brief review on the theoretical and empirical literature dealing with the determinants of FX swap spreads. We do not aim at providing a full literature review, only the most important theoretical explanations will be mentioned. Regarding the empirical literature, we only summarize papers dealing with FX swap spreads after the subprime crisis.

4.1 Why can the CIP condition be violated?

One branch of the literature deals with pricing the **default risk of currency swaps**. The main point of these models is that swaps which are subject to default can be priced similarly as options (Cooper–Mello, 1991; Hull–White, 1995; Duffie–Huang, 1996). A common basic assumption of the models is related to the bankruptcy rules. In the case of default, if the value of the swap is negative for the non-defaulting counterparty, she pays the value to the defaulting counterparty; if its value is positive, the non-defaulting counterparty only receives a fraction of it (Duffie–Huang, 1996). As a result, the value of

[3] The MNB introduced a two-way O/N EUR/HUF FX swap instrument in October 2008 and a 1-week EUR/CHF FX swap instrument in February 2009 (see a brief description in MNB, 2009). The effect of these instruments will not be addressed in this paper.

a defaultable (vulnerable) swap will be always less than the value of a swap without default risk. Swap spread is generally defined as the rate paid in the swap over risk-free interest rate at which the value of the swap would be equal to the value of a swap without default risk. The spread depends on several parameters, e.g. the credit spread of the bond issued by the risky counterparty, the volatility of the exchange rate or the association between default probability and the value of the underlying assets. Some authors present simulations about the magnitude of swap credit spread. Based on the results of Hull–White (1995) and Duffie–Huang (1996), if the bond credit spread (yield compared to the risk-free rate) is 100 basis points, the swap spread is between 2 and 23 basis points. That is, a currency swap carries lower default risk compared to a credit of the risky counterparty with the same notional amount.

Another strand of the literature investigates through **arbitrage models** why the covered interest rate parity is violated. There are two main explanations for this: the arbitrage requires capital and it is typically risky (Shleifer–Vishny, 1997). Arbitrage models generally assume that there are two risky assets with the same cash flow and risk profile but funding constraints impede arbitrageurs. **Market segmentation** is also present in these models, not all agents can trade in the same assets. Models are based on different kind of constraints. In Shleifer–Vishny (1997), for example, it comes from that only arbitrageurs (funds) can trade in both assets but not their investors. Investors can withdraw capital from the funds, depending on their part performance. As a conclusion of the model, arbitrageurs become more constrained when the prices of the two assets differ more thus when arbitrage would be more profitable.

In the models of Gârleanu–Pedersen (2007) or Gromb–Vayanos (2001), funding constrains are related to the **margining** of the assets. Though at initiating the arbitrage there is no need for capital to invest, both the long and the short position require margining during the arbitrage. The received margin cannot be used as collateral for the other asset. The two assets in the model of Gârleanu–Pedersen (2007) have the same cash flows but require different margins. In equilibrium, the spread between the prices of the two assets depends on the arbitrageurs' shadow cost of financing, the riskiness of the assets (β) and the margin of the two assets as a fraction of the notional amount. Higher margin requirement, which can be changed over time, can cause higher spreads.

The risk embedded in the FX swap arbitrage strategy is also related to **funding liquidity risk**. Funding liquidity is defined as the ability to settle obligations on time. Funding liquidity risk is related to the possibility that a bank will become unable to settle obligations with immediacy. This risk stems from the uncertainty of future cash flows and the price of funding liquidity in the future (Drehmann–Nikolaou, 2009). Though funding liquidity is understood from the perspective of a specific bank, it can explain why the prices of two assets traded between the same banks can differ. For example, in the arbitrage strategy of HUF FX swaps, the FX swap can entail higher **counterparty risk** than a euro bank account and also the uncollaterized HUF loan is subject to default risk. If the default is realized, this affects the available funding of the non-defaulting counterparty thus causing higher funding liquidity risk. Even if default risk is unchanged, higher uncertainty of other cash flows i.e. higher funding liquidity risk can affect FX swap spreads. (See Heider et al., 2009 for more details about the counterparty risk of interbank loans.)

The arbitrage strategy can also entail **market liquidity risk**, both that of the FX swap or the purchased asset. If the liquidity of the FX swap market is lower, it is more difficult to trade, thus constructing the arbitrage strategy. However, if market liquidity is defined as the cost or price effect when closing the positions, liquidity does not play any role assuming the arbitrage strategy is held until maturity. Nevertheless, if default is realized in any of the assets in the arbitrage strategy, the remaining position should be closed, which potentially can be done only at a higher cost. Moreover, even without default it can happen that the arbitrageur has to close the position before maturity, if e.g. the liquidity used in the strategy is required for other purposes (about early closure of transactions see Mancini-Ranaldo, 2010). In this case, the arbitrage strategy also involves **interest rate risk** since interest rates of the assets used can change over time.

4.2 Empirical literature review

In this section we give an overview of the empirical literature of FX swap spread dislocations. There are only a few studies searching for empirical evidence for the drivers of dislocation on the swap markets focusing on the post-Lehman period. We summarize the most relevant methods and explanatory variables of the analyses of Baba-Packer (2009 a,b), Genberg et al.(2009), Hui et al. (2009), Mancini Griffoli-Ranaldo (2010), Coffey et al. (2009), Stone-Walker (2009).

In the empirical studies regarding the swap spreads the used variables, methods and results are similar and could be well categorized. Therefore, our aim is not to list every variable used by empirical analysis of spreads, nor to summarize each study. We review the most frequently used variables and summarize their different interpretations and relationships to the swap spread, as a guidance and background to the variables we use in our research.

In the empirical analyses of the FX swap spread in some cases OLS regression is applied, though mostly an EGARCH model is introduced to account for stochastic volatility, and to handle GARCH effects. This way, the effect of several variables on the volatility of the spread can also be analyzed.

The **currency pairs** included in the mentioned empirical tests are: USD against the euro, the British pound, the Swiss franc, the Japanese Yen, the Australian dollar, the Brazil real, the Hong Kong dollar, the New Zealand dollar and the Singapore dollar. Most papers on FX swap spreads examine major currencies or developed market currencies.

The effect of the failure of Lehman Brothers quickly spilled over to the swap markets, pronounced in severe dislocations at the swap spreads. Thus the analyses concentrate on two separate periods apostrophized as pre- and post-Lehman phase.

As to the explanatory variables used in the regressions, the studies are varied. Regarding the financial institutions' **perception of higher credit and funding liquidity risk** during the turmoil, **credit default swap (CDS)** quotes are commonly used to measure the effect of increased counterparty risks on the swap spreads. Baba-Packer (2009a,b) states that an increase in European or US banks' CDS quotes is one of the main forces that drive the FX swap spreads higher (away from CIP). Coffey et al. (2009) back up this result, showing evidence that the average CDS of non-US banks is in a significant positive connection with the spread. They also outline the importance of other aspects behind this variable, like global dollar shortage during the turbulence.

The **LIBOR-OIS** spread is frequently used, apart from measuring liquidity shortage, to quantify market perceptions of potential banking insolvency (Baba-Packer, 2009a, b; Genberg et al., 2009; Mancini Griffoli-Ranaldo, 2010). Higher spread could imply that participants on the interbank market are more reluctant to lend to each other, perceiving higher counterparty risk and reflecting worsening liquidity conditions (liquidity hoarding).

To illustrate the effect of **LIBOR-OIS**, we follow the explanation proposed by Hui et al. (2009). Say that eurozone banks are less willing to offer interbank loans. In this case, the LIBOR(euro)-OIS(euro) can be a proxy for the funding liquidity risk of the eurozone banking system. That drives up the LIBOR(euro)-OIS(euro) spread, and those seeking liquidity to cover their dollar needs will turn to the FX swap market. The additional demand for liquidity will increase the cost of swaps for the dollar borrowers, the swap-implied dollar rates. Therefore a higher LIBOR-OIS(local currency) leads to higher FX swap spreads, a **positive** connections is expected. Similarly to this, an increase in the **LIBOR(dollar) – OIS(dollar)** variable indicates banks are less willing to lend in the interbank market (unsecured loans). As the two counterparties in an FX swap exchange the principals of the two underlying currencies, the counterparty risk is small compared with an interbank loan. Therefore banks turn to the FX swap market, the additional dollar supply reduces the implied dollar rate, and thus this has a **negative** effect on swap spreads.

Generally, the empirical analyses find evidence that in those markets where financial institutions are considered relatively riskier (like eurozone), the implied foreign currency funding rate departs from the CIP implied levels (indicating the presence of a counterparty risk premium). Baba-Packer (2009a) uses these two measures as a single variable (double spread, [LIBOR-OIS(euro)]-[LIBOR-OIS(dollar)]); its relationship with the swap spread is, as described before, **positive**. Their interpretation is that LIBOR-OIS double spread is a proxy for market and funding liquidity risk when used together with appropriate CDS quotes, somewhat separating credit risk and liquidity risk measures.

The **TED spread** is also used at e.g. Coffey et al. (2009), Genberg et al. (2009) or Mancini Griffoli-Ranaldo (2010) to control for liquidity and counterparty risk. However, in these studies TED spread is interpreted as a funding liquidity indicator rather than representing market liquidity. It could also capture the effect of flight-to-quality, when liquid capital is withdrawn from markets and flies to high quality government papers (i.e. T-Bills).

To measure market liquidity risk, Mancini Griffoli-Ranaldo (2010) also introduces **bid-ask spreads** (spot, forward and OIS). This variable could be described as one of the reasons why the CIP is violated; therefore, its expected sign in a regression is positive.

Examining the various currency swap spreads, it is clear that not only the levels increased to previously unseen levels, but also the volatility of the swap spreads. The **spot FX rate** variable is not included as a variable in these regressions, although Genberg et al. (2009) do observe the relationship between spot rates and swap spreads on several charts. It seems that there is a strong negative relationship (the local currency weakening versus the US dollar drives up the FX swap spread) in the case of the euro, the British pound and the Australian dollar. Mancini Griffoli-Ranaldo (2010) also emphasizes the importance of risk connected to exchange rate. The mark-to-market value of an ongoing FX swap is affected by the spot FX rate, therefore counterparty and rollover risk is present. They control for risk deriving from exchange rate changes with introducing FX option implied volatilities to their model. To control for the equity implied volatility the **VIX** is usually used, intending to control for the risk aversion of investors, common factors of money market and equity market funding constraints; higher volatility might lead to higher swap spreads (Coffey et al., 2009).

4.3 Central banks' policy measures

An important aim of these empirical studies is to determine whether the measures introduced by central banks to ease liquidity problems are successful in reducing the swap market tensions i.e. bringing the seriously widened FX swap spreads to the previously common close to zero level. Two types of variables are used. One type of measure is to mark the days of "commitments" for instance by the Federal Reserve to establish dollar swap lines with other central banks. Other variables are to mark the day of direct market action, e.g. bid submission date for local central bank dollar auctions and other direct instruments providing dollar liquidity.

The findings are controversial. Generally the results of empirical tests show that the **policy measures** (Baba-Packer, 2009a,b; Coffey et al., 2009; Stone-Walker 2009) did help to narrow the swap spread, but the significances show great variety upon modifying the inspected time period. Plausible explanations are that policy actions are infrequent and the timing of auctions is a response to market anomalies. The estimates may be affected by simultaneity problems. In some cases, interventions and announcements were an intra-day reaction to a sudden increase in the spreads. Such an intervention could bring down, or limit the widening of spreads, but if the end-of-the-day spread is higher than that of the previous day, the impact of the intervention could appear to be widening the spread. As a result, a regression might show that an **action dummy** actually increases the swap spreads (significant variable, but „wrong" sign) or the effect of policy actions reducing spreads is counterbalanced by the market anomaly (no effect compared to normal state, insignificant variable). This is supported by the observation that policy action variables show stronger effect (significance) in the pre-Lehman period.

The post-Lehman phase with its excessive volatility drove the implied rates farther from CIP indicated, so it is harder to draw conclusions on the success/effect of policy measures. This experience might have induced the authors to use EGARCH models. Additionally to the mean equation, in an EGARCH model a variance equation is also estimated. The use of EGARCH to estimate the effectiveness of policy actions proves that **central bank measures reduce the volatility** of swap spread both prior to and after the Lehman failure, even when the effect on the level of the spread is not significant. So there is evidence that the liquidity-providing operations of the central banks play a role in stabilizing the FX swap market (see Baba-Packer, 2009a,b; Coffey et al., 2009; Stone-Walker, 2009).

5. Drivers of HUF FX swap spreads

In this section, first, we lay down the hypotheses which will be tested in the course of the empirical analyses. Next, we provide a description about the explanatory variables of the regressions on HUF FX swap spreads. It will be also described why we expect these variables to affect the spreads. Then, the empirical results will be presented. Finally, we perform robustness check.

5.1 Hypotheses

Based on the empirical and theoretical literature discussed above, we distinguish three types of explanatory variables. First, the potential risk involved in the arbitrage strategy can impact movements in the FX swap spread. Second, the limited availability of foreign currency liquidity could also affect the swap spread. Third, the introduction and use of the above mentioned FX swap instruments of the MNB are also expected to contribute to the decline of the spreads. Since one of our main goals is to detect the effect of the policy variables, we wish to control for many potential variables falling in the first two categories.

Regarding the risk factors, a potential explanation is the default risk of FX swaps. Based on the models mentioned in Section 4.1, the default risk of swaps is less than ¼ part compared to an uncollaterized loan. Assuming these figures hold also for HUF FX swaps, the highest FX swap spreads observed in the examined period (5-8%) would be consistent with at least 20% credit spread of Hungarian banks. This would be extremely high, thus we do not consider plausible that this would be the most important determinant of FX swap spreads. Furthermore, market practitioners apply other tools for handling default risk instead of pricing this into the swaps, e.g. counterparty credit limit systems.

We believe that concerning counterparty risk, the default risk stemming from the HUF denominated asset in the arbitrage strategy is more important. Our definition of FX swap spreads implicitly assumes that the HUF asset is a deposit. Though we have seen that the yield difference between a short-term uncollaterized HUF deposit and a repo transaction is small, these are traded almost exclusively by Hungarian banks, foreign participants can consider the Hungarian banking sector more risky.

The HUF denominated asset in the arbitrage strategy can be also a HUF denominated government paper. If only the default risk of the government papers goes up but the default risk of the banking system remains unchanged, this should not affect the spreads.

The market liquidity risk of FX swaps can also be a determinant of FX swap spreads since lower liquidity could reduce the application of arbitrage strategies. Nevertheless, we try to avoid using variables which are in a possible simultaneous relationship with the spreads. Market turnover, for example, can be affected indirectly by changes in FX swap spreads. When the spread goes up, it is more costly for banks to receive FCCY liquidity via swap thus they prefer to search for other kind of financing (e.g. from parent banks) which can reduce the turnover.

Apart from risk factors, other explanation for the non-zero FX swap spread is the presence of liquidity constrains. For the arbitrage strategy which exploits positive spreads, there is need for FCCY liquidity. A part of the theoretical literature relates these constrains to margining. Given that in the HUF FX swap market not all banks apply margining, this should not be the only explanation. In practice, liquidity constrains can be generated by the presence of counterparty limits, after reaching the limit there are no more new transactions with the same counterparty.

Since not all FX swap transactions are used in arbitrage strategy (FX swaps are used for other purposes), not only the liquidity constrains related to the arbitrage strategy can affect the spreads. If FX swaps are traded alone and FCCY liquidity constrains strengthen, participants are less willing to provide FCCY liquidity via FX swaps. Thus, we define FCCY liquidity factors in a more generalized way, as demand/supply pressures of FCCY liquidity. We expect the FX swap spread to rise in periods when banks are more reluctant to provide FCCY liquidity and/or banks need more FCCY.

5.2 Definition of explanatory variables

As a risk variable, we use a proxy for global risk aversion, the **euro TED spread**. This is the difference between the 3-month EURIBOR and the AAA-rated 3-month euro government paper yield. Since the arbitrage strategy is risky, a rise in risk aversion, especially that of European banks can affect the price of all risky assets. If foreign banks become more risk averse, they require higher compensation for it, which can be reflected also in the price of the arbitrage strategy, i.e. the swap spread. The TED spread can also reflect funding liquidity risk in the eurozone banking system which can also affect the spreads. Its use is also motivated by the fact that many authors use this (Coffey et. al., 2009) or similar variables (Libor-OIS spread) for explaining FX swap spreads.

Regarding counterparty risk, generally banks' CDSs are used in the literature (e.g. Baba-Packer, 2009). However, CDS quotes for the Hungarian banking sector are not available except from one bank. Thus we use the **CDS** related to the foreign currency debt of the **Hungarian government**. These two risks possibly commove, thus the CDS can be a proxy for the default risk of an interbank deposit placed at a Hungarian bank.

As a variable reflecting the global foreign currency liquidity, we include the amount of the **O/N deposit facility at the ECB**. Since autumn 2008 euro area banks have placed much higher amount of funds at the ECB than earlier. This reflected that banks preferred to hold a high buffer at the ECB instead of trading with each other on the interbank market. When euro area banks were more reluctant to lend funds in euro, it is expected that they also wanted to provide a lower amount of funds to Hungarian banks via FX swaps. However, since June 2009 the motivation behind maintaining high O/N deposit has been changed. That time the ECB introduced a 1-year lending operation with unlimited amount which contributed to the rise of O/N deposits. Later on, the declining trend of deposits reflected the redemption of shorter refinancing operations i.e. eurozone banks restructured their funding between long-term and shorter-term ECB financing. Thus, this variable was much less related to the willingness of banks to lend to each other than earlier. Consequently, we use this variable only up to 22 June 2009, for the later period 0 values are attached to this measure. A similar variable (deposits with Federal Reserve Banks other than reserve balances) is used by Mancini-Ranaldo (2010) for analyzing the spreads against US dollar.

We use **daily percentage changes in the EUR/HUF** exchange rate as a proxy for liquidity effects arising from the risk management of FX swaps. Foreign banks have been applying margining of FX swap positions versus Hungarian banks. When the HUF depreciated against the euro, some of the big Hungarian banks needed to place certain amount of FCCY at their foreign counterparties' margin accounts. A possible tool for raising extra FCCY liquidity was to trade in FX swaps which could contribute to the increase in swap spreads. On the other hand, the depreciation of the exchange rate could contribute to the market tension by a mechanism related to counterparty credit limits. As a consequence of the depreciation, the market value of swaps became higher from foreigners' point of view. For this reason, the existing FX swaps absorbed a higher part of the counterparty limits thus it was more difficult to trade in new FX swaps. (See more details about margining and counterparty limit system during the crisis in Páles et.al, 2010). A further motivation for using this variable is that Genberg et al. (2009) reports co-movements between exchange rates and FX swap spreads.

The next variable to capture FCCY liquidity factors is the daily **change in foreigners' holding of HUF governments bonds**. A part of foreigners' government bonds is financed by FX swaps. When foreigners sell HUF bonds and close their FX swap positions with Hungarian banks, the latter need an extra amount of FCCY liquidity. As another explanation, foreigners selling government bonds - earlier financed by spot FX transactions - can decide not to sell the HUF on the spot market but to place the HUF liquidity at Hungarian banks in the form of new FX swaps. This can cause higher demand for FCCY liquidity which also drives the spreads up.

As another quantity-based explanatory factor, we use the **net amount of FX swap redemptions** against foreign banks. Positive values mean that on a certain day Hungarian banks should repay more amount of FCCY from maturing swaps than they receive from foreigners. Supposing they have to roll over their positions at least partly, they demand for new FX swaps thus for more FCCY liquidity. Consequently, we expect higher net redemption to raise FX swap spreads. The net amount of maturing swaps is measured at notional value, taking into account both directions with an opposite sign.

In the literature generally dummy variables are used to capture the effect of central bank instruments on FX swap spreads. The O/N FX swap of the MNB is a standing facility which can be allotted each day, thus we define this policy variable in a different way, based on its price. To measure how 'expensive' this instrument is, we use the **implied euro interest rate** of the MNB's O/N swap facility **minus EONIA**.[4] This spread (**MNB spread**) can be considered as a ceiling for spreads of market-traded FX swaps. When swap-implied euro interest rates from market trades are higher than the implied euro rate of the MNB's instrument, it is worth for market participants turning to the MNB. The MNB spread has been narrowed gradually by the MNB since its introduction which we expect to contribute to the decline of market FX swap spreads.

Regarding the long-term FX swaps of the MNB, we generate a different kind of variable. Given that the 3-month and 6-month FX swap instruments are auctioned only once a week, using spreads as above would reduce the sample size substantially. Instead, we measure these instruments by a dummy variable where 1 is attached to each day when these were auctioned, not depending on whether there was any allotment (**swap dummy**).

Defining this way the policy variables, we can avoid potential simultaneous relationship with FX swap spreads. If we used variables such as the auctioned amount or a dummy variable reflecting days of allotment, an opposite direction of causality could appear. For example, higher need for FCCY can raise FX swap spreads which forces banks to trade more FX swaps with the MNB.

5.3 Empirical results

We estimate the effect of the above-described explanatory variables on both the 1-day and the long-term HUF FX swap spreads. Spreads are measured as described in Section 2 and we estimate regressions separately. Explanatory variables are identical, except from the policy variables. The MNB spread is inserted only in the first regression, while the swap dummy is included only in the second one.

The sample ranges from 16 October 2008 until 11 June 2010, data frequency is daily. The beginning of the sample coincides with the day when the MNB introduced the O/N FX swap instrument.[5] The end of the period was chosen in order to have long enough time series to check the robustness by splitting the whole sample into two equally sized parts. While until spring 2009 the spreads were rather volatile, in the second sub-period the volatility was substantially lower (see the whole sample time series of the spreads in the Appendix).

The two regressions will be estimated by OLS. Newey-West HAC standard errors are used in order to handle the potential serial correlation in the error term. All variables can be considered stationary according to standard unit root tests.

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[4] The MNB spread is calculated similarly as market based spreads, using the spot and forward rate of the MNB's swap. The only difference is that the same HUF interest rate is that of used by the MNB for pricing the swaps (instead of HUFONIA). This is generally the interbank O/N HUF interest rate available in the morning.

[5] This choice was motivated by methodological issues. The variable MNB spread cannot be calculated before the introduction of the MNB's instrument. By inserting zero values for this variable for earlier sample elements, the significance of this variable may only reflect the rise of the FX swap spread near the time when the MNB's FX swap was introduced.

We use the logarithm of the dependent variable for two reasons. First, the log form is common in the literature about the determinants of sovereign spreads (e.g. Edwards, 1984). Second, we assume a non-linear relationship stemming from the fact that many of our explanatory variables try to capture FCCY liquidity effects. If banks are willing to provide more FCCY liquidity at an increasingly higher price, the relationship can become non linear. This can be explained by the existence of counterparty limits. Even if the supply curve of all banks is linear, but individual supply is bounded, the aggregate supply curve can be convex (see an illustration about it in the Appendix). Because of the log form, observations related to negative FX swap spreads are omitted. Since we are interested more in the question of why swap-implied rates deviated from the CIP in a positive direction, we do not consider this as a significant loss of information. As a result of taking the log, we have 340 observations for the 1-day spread and 394 for the long-term spreads (the number of trading days is 408).

To facilitate the interpretation of the results, we use the log of explanatory variables which are measured in basis points (the two risk-related variables and the MNB spread).

Lagged values of all explanatory variables are also inserted into the regressions where these are significant. We expect that the lag of liquidity related variables have a role given the time lag between the trade date and the settlement date of FX swaps. After a liquidity shock, banks have one or more days to raise FCCY liquidity via FX swaps.

Table 2: Regression results on the determinants of FX swap spreads

Dependent variable	LOG(SPREAD_ONE)	LOG(SPREAD_LONG)
LOG(TED_EURO)	0.1410**	0.1567***
LOG(CDS_HUNGARY)	0.3172***	-0.0505
ECB_DEPOSIT	0.0013***	0.0015***
FX_RETURN	0.0668***	–
FX_RETURN(-1)	–	0.0220**
FOR_BOND_PURCHASE	-0.0032***	–
FOR_BOND_PURCHASE(-1)	–	-0.0007*
SWAP_REDEMPTION	-0.0007***	-0.0003**
SWAP_REDEMPTION(-1)	-0.0006**	-0.0002*
LOG(MNB_SPREAD)	0.4226***	–
DUM_SWAP	–	-0.0445**
DUM_SWAP(-1)	–	-0.0448**
C	-3.1432***	-0.4945**
R-squared	0.6955	0.6408
Adjusted R-squared	0.6881	0.6325
Observations	340	408

*Coefficients are estimated by OLS, Newey-West HAC Standard Errors & Covariance. Sample: 16 Oct. 2008 – 11 June 2010. Significance level: *** (1%), ** (5%), * (10%). Abbreviations: SPREAD_ONE: average of EUR/HUF and USD/HUF 1-day FX swap spreads, basis point;*
SPREAD_LONG: average of EUR/HUF and USD/HUF longer than-1-day FX swap spreads, basis point;
FOR_BOND_PURCHASE: foreigner's purchase of HUF gov. bonds, billion HUF. CDS_HUNGARY: 5Y CDS on Hungary, basis point;
FX_RETURN: daily change in the EUR/HUF exchange rate, per cent; SWAP_REDEMPTION: net redemption of FX swaps where Hungarian banks repay the foreign currency to foreign banks, HUF billion;

ECB_DEPOSIT: daily amount of ECB O/N deposit facility until 22/06/2009, EUR billion;
TED_EURO: 3M EUR TED spread, basis point;
MNB_SPREAD: difference between the implied EUR interest rate of the MNB's O/N swap facility and the EONIA, basis point;
DUM_SWAP: dummy variable for days when the 3-month or 6-month MNB swap is auctioned.

Estimation results are summarized in the Table 2. Almost all coefficients are significant and most of them do even at the 5-percent significance level. The explanatory power is relatively high for both spreads, which is in line with the findings of the literature for the post-Lehman period (e.g. Coffey, 2009).

The coefficients related to log explanatory variables can be interpreted as the percentage changes of the spreads as a response to 1 percent change in the explanatory variables. For explanatory variables measured in units, the coefficients reflect the percentage change of the spreads to one unit changes. Since it is difficult to interpret the relative change of a variable measured in percentages or basis points, we use the sample averages of the spreads in order to highlight the magnitude of the coefficients (SPREAD_ONE: 103 basis points; SPREAD_LONG: 72 basis points).

Risk related variables (**TED spread, CDS**) have positive sign, except from that of the CDS in the second regression where it is insignificant. Higher risk aversion and counterparty risk contribute to the rise in FX swap spreads. The lower-than-one parameters of the CDS reflect that counterparty risk is not the most important determinant of the spreads.

The amount placed at the **ECB's O/N deposit** has a positive coefficient. Ceteris paribus EUR 1 billion higher amount of deposit raises the spreads by 0.13-0.15 percent. Based on the sample averages of the FX swap spreads, these are equivalent to less than one basis point.

Exchange rate changes also have a role in explaining FX swap spreads. On days when the HUF depreciates against the euro, the spread goes up. It has a relatively small effect, 1 percentage depreciation yields to 2-6 percentage increases in the spreads (2-7 basis points in nominal terms).

The coefficient related to the daily change in **foreigners' HUF government bonds** is negative. On days when foreigners are selling bonds, the FX swap spreads are higher. A HUF 1 billion sale has an effect of approximately 0.07-0.3 percent which is less than one basis point in nominal terms.

The variable capturing the **redemption of FX swaps** has a negative sign, differently from our earlier expectations. On the one hand, when Hungarian banks had to return a high amount of FCCY to foreigners, FX swap spreads were lower. On the other hand, when the net redemption of FX swaps was negative – Hungarian banks received FCCY – , the spreads were generally higher.

Below, we provide a detailed explanation for the puzzling result. Our interpretation is related to the HUF leg of maturing swaps. In the first case, when Hungarian banks return FCCY to foreigners and foreigners intend to renew maturing swaps, Hungarian banks are willing to lend HUF against FCCY only at a higher implied HUF rate since they are in a quasi monopolistic position against foreign banks regarding HUF liquidity. Only Hungarian banks can use the HUF instruments of the MNB which is a form of market segmentation. We assume that foreign banks want to renew to some extent the swaps because the HUF liquidity they return is used to finance a HUF denominated asset (e.g.

government bond) or a short synthetic forward HUF position. Closing the positions, it is possible that they could suffer losses. When foreigners do not want to roll over the financed position, this can be reflected in the variables government bond sale or exchange rate changes.

In the second case, when Hungarian banks receive FCCY from maturing swaps and return the HUF, also their quasi monopoly causes that they want to roll over the swaps – borrow HUF against FCCY – only at a lower HUF implied rate. Hungarian banks had sufficient HUF liquidity also at individual level except from a short period in the whole sample. Here the same argument holds why foreigners want to roll over the swap positions at least partly; these are used to finance e.g. a long synthetic forward HUF position. Furthermore, foreign banks prefer to place HUF liquidity in the form of an FX swap because its counterparty risk is lower than that of an uncollaterized bank deposit.

To sum up, we argue that the redemptions of swaps reflect higher demand/supply pressure of HUF liquidity. This explanation implicitly assumes that those Hungarian banks which had to return FCCY did not have FCCY liquidity problem at that time. Indeed, high swap redemptions were concentrated to a few Hungarian banks.

One of our policy variables, the **MNB spread** has a positive and significant sign. The positive sign suggests that when the MNB lowered implied euro interest rate of the instrument, this pointed to the decrease of the FX swap spread. Notice that this variable was not only determined by the MNB but also affected by changes in the EONIA. When this latter went up, the MNB spread became lower. The magnitude of the parameter is relatively high, 1 percent cut in the MNB spread contributed to 0.42 percent lower 1-day FX swap spread.

Regarding the **long-term swap instruments of the MNB**, on days when these instruments were auctioned, the market-implied long-term FX swap spreads were significantly lower. Though the effect was relatively small (5 percent), the lag of the dummy is also significant.

The significance of the policy variables raises the question of which mechanism causes the reduction of the spreads. The most common explanation is that injecting FCCY liquidity directly reduces market tensions (e.g. Hui et al., 2009). However, policy variables can exert their effect via reducing risk: Fung et al. (2009) argues that central bank measures can reduce counterparty risk in the banking system.

Stemming from the definition of our policy variables, it can be tested whether the instruments of the MNB affected the FX swap spreads only based on liquidity factors. Since in the regression for the 1-day swap not the allocated amount was used, we can run the regression for periods when the instrument was announced but not allocated. Between 29 April 2009 and 11 June 2010, the allocated amount of the O/N FX swap facility was zero. Despite of this, the policy variable (MNB spread) was significant and positive (Table 3).[6]

[6] Regarding the long-term swap instruments, similar exercises are not feasible since there were only 40 days in the sample when the instruments were announced but there was no allocation.

Table 3: Regression results on the determinants of 1-day FX swap spreads

Sample period	16/10/2008 – 11/06/2010	29/04/2009 – 11/06/2010
LOG(TED_EURO)	0.1410**	0.2175***
LOG(CDS_HUNGARY)	0.3172***	-0.1529
ECB_DEPOSIT	0.0013***	0.0053***
FX_RETURN	0.0668***	0.1399***
FOR_BOND_PURCHASE	-0.0032***	-0.0037***
SWAP_REDEMPTION	-0.0007***	-0.0004
SWAP_REDEMPTION(-1)	-0.0006**	-0.0008*
LOG(MNB_SPREAD)	0.4226***	0.3793**
C	-3.1432***	-0.8529
R-squared	0.6955	0.2260
Adjusted R-squared	0.6881	0.1954
Observations	340	211

*Coefficients are estimated by OLS, Newey-West HAC Standard Errors & Covariance. Significance level: *** (1%), ** (5%), * (10%). For abbreviations see Table 2.*

This result provides evidence for channels not related to liquidity effects. A potential explanation is that the announcement of the MNB's facility got incorporated into the expectations of market participants. When the FX swap spread began to increase thus the difference between market spreads and that of the MNB's instrument became smaller, the market-implied spread rose less than justified by other explanatory variables. It is worth mentioning that indirectly, the central bank could affect the spreads also via other explanatory variables, e.g. by stabilizing the exchange rate.

In order to interpret the parameters of policy variables as an evidence for the effect of the central bank instruments, it is necessary to exclude potential multicollinearity. If policy variables are highly correlated with other variables, ceteris paribus changes are infrequent. The swap dummy is not correlated with the others, but the MNB spread has a high correlation with risk variables. However, for the second examined period the correlation with other explanatory variables disappears.

We also run the two regressions in a system so as to compare the effect of the same variables to the two dependent variables (Seemingly Unrelated Regression, SUR). This way, the significance of the differences between the parameters can be tested by Wald-tests. Only the coefficients of the swap redemption variables are different, significantly higher in absolute terms for the 1-day FX swap spread. This observation confirms that this variable affects the spreads through a different mechanism compared to other explanatory variables.

We have seen that the estimated coefficients are rather low for most explanatory variables. In order to assess the relative importance of the regressors, we run standardized regressions (i.e. subtracting the mean from all variables and then dividing them by their sample standard deviations). As a result, most of the variables have a similar contribution to the spread for 1 standard deviation changes. For the 1-day swap spread, the effect of the MNB spread is higher than that of the others, while for the long-term swap the effect of risk-related variables is the most pronounced.

An important point in the interpretation of the result is that even if we divided the variables into two groups - risk and liquidity -, it is difficult to analyze the relative importance of the two factors since these are strongly interrelated. On the one hand, variables used to capture liquidity effects can also reflect risk related factors. For example, changes in the exchange rate or in foreigners' bond holding can be a pure consequence of changes in global risk aversion. On the other hand, proxy variables for risk factors can also be affected by liquidity factors. For example, one reason for the increasing TED spread was the liquidity shortage in the interbank euro market which contributed to higher counterparty risk.

Nevertheless, there is one variable which is not affected by risk factors. The net redemption of FX swaps depends on FX swaps traded much earlier than the date of maturity: on average, maturing FX swaps were 25 days old.[7] Consequently, day-to-day changes in risk aversion cannot have an effect on this variable. Thanks to this, we can interpret this variable as a pure consequence of liquidity effect. Note, we argued that this variable is related to demand/supply pressure of HUF liquidity. Multicollinearity is neither an issue for this variable, it is not correlated with other variables thus its ceteris paribus changes can be interpreted.

One of our questions is whether FCCY liquidity demand and supply pressures affected the FX swap spreads. There is an observation which suggests that apart from risk factors, FCCY liquidity effects have an important role in determining FX swap spreads. For the long-term swap regression, the lag of two variables (foreigners' bond purchase and exchange rate changes) is significant. If these variables had an impact exclusively through risk factors, the contemporaneous values would be significant, differently from our findings. We think that that these variables do not have an impact via the lagged effect of risk factors because the lags of risk related variables are insignificant.

The significance of the lagged variables can be explained by the following. After foreigners' bonds sale, settlement takes place generally on T+2 thus it is sufficient for Hungarian banks to trade a new swap for receiving FCCY liquidity only on the following day (many long-term FX swaps' spot leg is settled on T+1). Regarding the exchange rate, given that positions are revalued only at the end of the day, tighter counterparty limits become effective only from the next day at the earliest. Again, multicollinearity does not affect our interpretation since the two lagged variables do not correlate with risk variables.

It is also interesting to categorize our variables in a different way. There are two variables which are driven by global factors: the O/N deposit of ECB and the TED spread. Regarding these variables it can be excluded almost with certainty that events in Hungary would affect them. These two variables are able to explain about 50% of the variances in both FX swap spreads. Since other variables can also be affected indirectly by global factors, this percentage can be regarded as a minimal share of global impact. Nevertheless, it does not mean that other variables have only a moderate effect on the swap spreads. Omitting the two aforementioned variables, the R-squareds remain high, 0.67 for the 1-day and 0.38 for the long-term swap spread regression. Nonetheless, these figures cannot be considered as lower estimates for the effect of local factors because all remaining variables (except from the FX swap redemption) are affected to some extent by changes in global risk aversion.

To summarize our findings, apart from risk-related variables, liquidity factors also contributed to changes in FX swap spreads. We found evidence that both the 1-day and

[7] For each maturing FX swap, we calculated how many days earlier these were transacted. For each maturity date, a weighted average of the days was calculated using the notional amount as weights. Absolute values were used without taking into account the direction of the swaps. For the whole period, an unweighted average of daily figures was calculated.

long-term FX swap instruments of the MNB helped to reduce FX swap spreads significantly.

5.4 Robustness checking

We divided the whole sample into two, almost equally sized samples (16 Oct. 2008 – 27 July 2009; 28 July 2009 – 11 June 2010). For the first period, results remained qualitatively the same. All variables remain significant for the 1-day spread while for long-term spreads only the foreigners' bond variable is insignificant and the R-squareds remain high. For the second period, some of the parameters are insignificant but only that of the CDS loses its significance in both regressions. The significance of the swap dummy is also lower. R-squareds are much lower for the second period (between 0.12 and 0.18) when the variability of dependent variables is much lower.

The beginning of the sample in the original specification coincides with the introduction of the MNB's O/N swap. In order to use sample elements before that time, we generate values for the MNB spread, simply assuming that it is the same as on the day of its introduction (4.38%). Using a sample from 9 October 2008, results are broadly unchanged, only the Ted spread is not significant.

During the first months of the examined period, both FX swap spreads and some explanatory variables followed a declining trend, amongst them the policy variables. The MNB spread had a significant decreasing trend partly because the MNB took into consideration past levels of market-implied spread when pricing the instrument. Regarding the swap dummy variable, there was an increasing trend since long-term swap instruments were introduced in March 2009. Thus it cannot be excluded that the significance of the policy variables stems only from regressing trending variables. However, inserting a trend variable into the regressions, it is not significant for the 1-day FX swap spread and it does not affect the significance of the variables for long-term spreads.

The effect of the serial correlation in the error term was handled by Newey-West errors in the original specification. It is possible that the significance of the lagged explanatory variables was caused only by the serial correlation in the variables. However, inserting an AR(1) term into the regression, all the lagged variables remain significant. Other parameters remain qualitatively the same, though some of them (including the swap dummy) are no more significant.

We also test the robustness of the result regarding the functional form. Using a linear model instead of log forms, some of the parameters lose their significance, among them the risk variables. However, the policy variables and the net redemption of FX swaps remain significant, thus the functional form does not affect the main conclusions. The remaining variables (exchange rate changes, foreigners' bond purchase) can also capture the effect of global risk aversion, thus the main point of the interpretation also remains valid.

The presence of simultaneity bias cannot be excluded for some explanatory variables. While this is not the case for e.g. the Ted spread, the parameters of exchange rate and foreigners' bond purchase can suffer from simultaneity bias. A decrease in the FX swap spread can have a causal effect on the exchange rate: lower FX swap spread is consistent with higher swap-implied HUF interest rate which can cause the appreciation of the HUF. Despite of this, we argue that this direction of causality cannot be considered strong. Based on the results of Rezessy (2005), 1 percent surprise interest rate hike of the MNB causes HUF appreciation of about 0.5-0.6 percent (the method of the cited author takes into account simultaneity an refer to the 1-day impact). According to our estimated parameters, 1 percent lower FX swap spreads are related to about 15–63 percent appreciation (the inverse of the parameters shown earlier). Given that the former figures are much higher, it is not probable that our coefficients would reflect the causality running from the swap spread to the exchange rate.

Foreigners' government bond purchase can also be affected by changes in the swap spreads. When FX swap spreads are higher thus implied HUF rates are lower, it is less costly to finance a bond purchase via FX swaps. Accordingly, higher spreads can contribute to the rise in foreigners' bond holding. This effect would justify a positive coefficient in contrast with our findings.

We checked the robustness of the results by inserting more variables. A commonly used variable in the literature is the VIX index that reflects the model-free implied volatility of the S&P500 index. Results change only regarding the parameter of the TED spread which is insignificant. This can reflect that the VIX also describes changes in global risk aversion. Another commonly used variable is currency option-implied volatility. Inserting the 1-month EUR/HUF implied volatility, it is not significant, possibly because it is strongly correlated with the CDS.

It was mentioned in Section 2 that FX swap spreads are computed from data which are not synchronized. This would cause a measurement error in the dependent variable. Consequently, this does not affect the unbiasedness of the estimated parameters, only the estimated standard errors would be higher.

6. Conclusions

In this paper we analyze the main drivers of HUF FX swap spreads, i.e. why forward rates of FX swaps deviate from the CIP. The main question is whether the FX swap instruments introduced by the MNB contributed to the decline of FX swap spreads.

Apart from the policy variables we distinguish two types of explanatory variables: risk and foreign currency liquidity related factors. The risk involved in the arbitrage strategy can impact movements in the FX swap spreads because of the counterparty risk of FX swaps or the counterparty risk related to HUF instruments used in the arbitrage strategy. The limited availability in foreign currency liquidity may also impact the swap spreads because of the limited activity of arbitrageurs.

For the period October 2008 – June 2010 we find that all three types of variables are significant in explaining the 1-day and long-term FX swap spreads. Proxy variables for global risk aversion and the counterparty risk of Hungarian banks have the expected positive sign. Variables reflecting foreign currency liquidity demand/supply also affect the FX swap spreads. When banks are more reluctant to provide foreign currency liquidity and/or other banks need for more, the FX swap spreads tend to rise. Regarding the interpretation of the results, it is important to highlight that many of our variables can capture both risk and liquidity effects since these two factors are interrelated. Despite of this, we find evidence that not only risk factors but liquidity also has a role in the determination of spreads. This is because one of the variables, the net redemption of swaps reflects trades in the past and not actual changes in risk aversion.

We analyze the effect of the 1-day and long-term EUR liquidity providing FX swap instruments introduced by the MNB after the Lehman default. The price of the 1-day instrument has a significant effect on the spread. When the MNB reduces the 1-day swap-implied rate compared to euro interbank rates, market-implied FX swap spreads also decline. Regarding the long-term swap instruments of the MNB, on auction days the long-term FX swap spreads are significantly lower controlled for other explanatory variables.

7. Appendix

Chart 3: HUF FX swap spreads

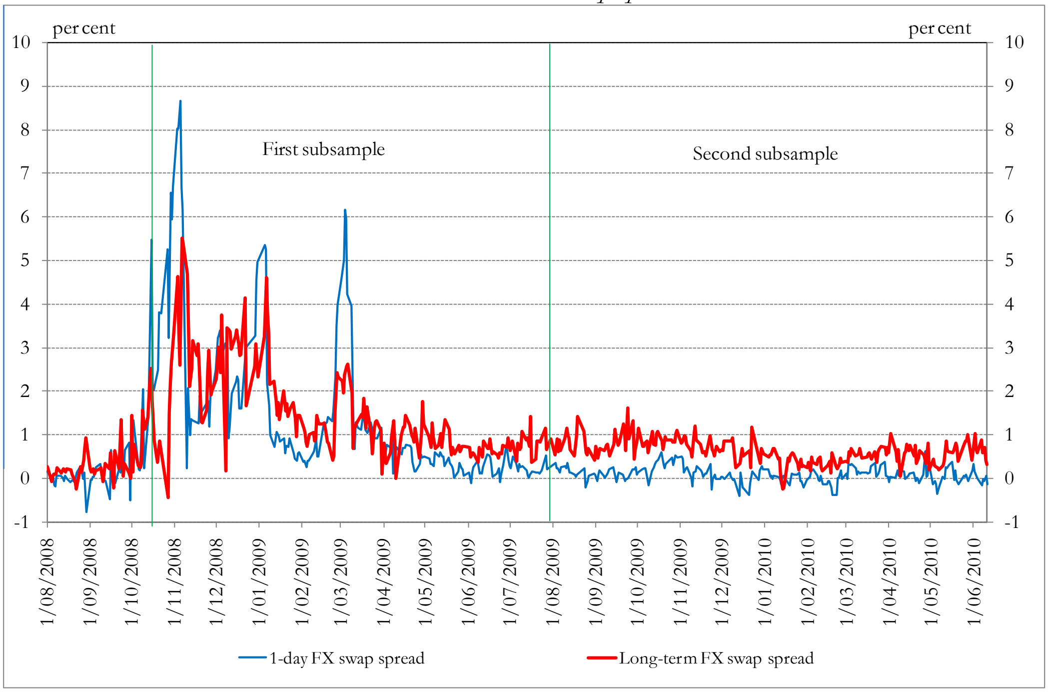
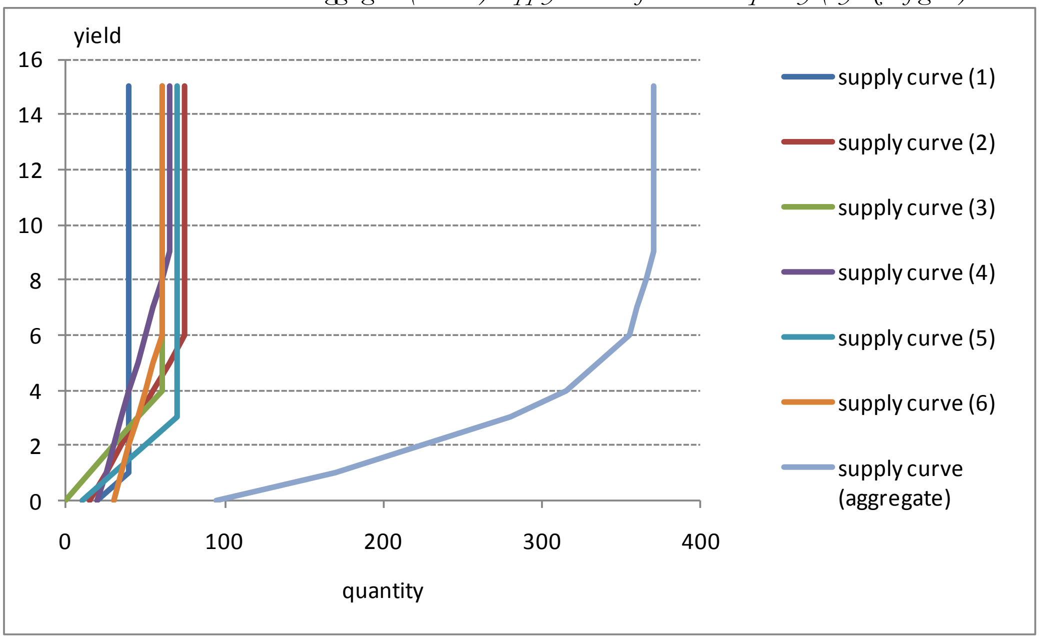


Chart 4: Individual and aggregate (inverse) supply curves of FCCY liquidity (stylized figure)



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