Peso-Dollar Forward Market Analysis: Explaining Arbitrage Opportunities during the Financial Crisis

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Abstract

Using a vector error correction model I test whether shocks in the funding liquidity conditions in the U.S. and Europe separately explain deviations from the covered interest parity (CIP) between the U.S. Dollar and the Mexican Peso. I find that: (1) Apparent deviations from the CIP seem to be persistent, unless a closer measure to the true costs of funding for the agents is considered. (2) A stable long-run equilibrium relation emerges when I include the effects of funding liquidity shocks stemming from the U.S. and Europe. (3) The exchange rate forward premium adjusts towards a long-run equilibrium relation given by the CIP. (4) Surprisingly, the yield on 1-month Mexican CETEs has its own stochastic trend despite the strong relation between the U.S. and Mexico's economies. (5) Analysis confirms that both future and spot exchange rates are affected by shocks stemming from the U.S. Treasury Bills, the funding liquidity in the U.S. and Europe, and the Mexican CETEs.

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1 Introduction

In this paper, I test the hypothesis that an important friction causing apparent deviations from the covered interest parity (CIP) between the U.S. Dollar (USD) and the Mexican Peso (MXN) stemmed from the reduced liquidity conditions -defined as (i) the availability of funds to undertake financial transactions in assets that are perceived riskier than those with highest rate by rating agencies, and (ii) higher quality or quantity collateral demands- in the largest financial markets. The CIP is defined with a forward contract on the value of the currencies. Thus, a second source of frictions, might be found in the risk for the counterpart fulfilling his part of the contract. I test whether shocks in funding liquidity generate deviations from the CIP, and whether they persist in the long run.

Using a vector error correction model (VECM) with five variables ((i) the 1-month exchange rate forward premium, (ii) the yield on 1-month U.S. Treasuries, (iii) the yield on 1-month CETEs, (iv) the LIBOR-OIS[1] spread in USD and (v) the analogous measure for Europe) I find first that apparent deviations from the CIP are persistent. Second, it is necessary to include the effects of funding liquidity shocks in the U.S. and Europe to have a stable long-run equilibrium relation. This means that apparent arbitrage opportunities do not remain after considering a closer measure to the true costs of funding for the agents. Third, only the exchange rate forward premium is adjusting towards the long-run equilibrium relation that explains deviations from the CIP.

As a fourth, and surprising finding, the yield on 1-month Mexican CETEs has its own stochastic trend despite the strong relation between the U.S. and Mexico's economies. Finally, the analysis with a structural vector error correction model (SVECM) confirms that both, spot and forward, exchange rates are affected by shocks stemming from the U.S. Treasury Bills and the two measures of funding liquidity.

The financial crisis born in the summer of 2007 -labelled Great Recession- caused high volatility in a number of markets for commodities and securities. The futures market for the Mexican currency did not escape this event. In particular, apparent deviations from the fundamental equilibrium condition of the CIP are observed consistently after August of 2007 and through mid-2012. The consensus among economists and market analysts points to the wealthiest economies as a source of several financial frictions induced to the emerging market economies, including Mexico (see Rajan (2011) and Admati and Hellwig (2013) for a comprehensive account of the Great Recession).

Mexico is an interesting case to analyse since its economy presents solid macroeconomic indicators and has shown a quick recovery after the financial shock. Computation of

[1] Overnight Index Swap.

deviations from the CIP[2] involving USD-MXN future contracts, the yields on U.S. Treasury Bills and Mexico's CETES, all for 1-month is shown in figure 1. The figure also shows the dates of major shocks from the start of the Great Recession in the summer of 2007 as dated by Eichengreen, Mody, Nedeljkovic, and Sarno (2012).

The displayed behaviour of the deviations from the CIP is consistent with economic theory -since it is around zero- for the period January 2003 to August 2007, with a slump in 2003 and a slight change around 2006. Major disruptions generated by severe financial stress events such as the Bear Stearns buyout, the Lehman Brothers failure, the TARP process within the U.S. Congress and the AIG's bailout are represented by extremely large deviations from the CIP. Finally, after the second half of 2009, the mean of the deviations is positive. In this period the main sources of financial stress were the fragility of Europe's banking sector and the difficulties of Greece, Spain and Italy to roll-over their debt.

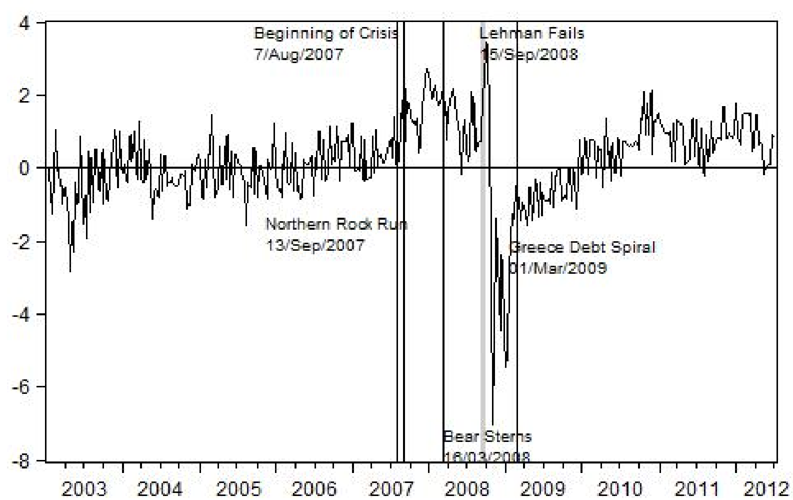

Figure 1: Deviations from the CIP in percentage points for period January 2nd 2003 to July 11th 2012. Own calculations for weekly averages with expresion (2.3) shown below. Source: Bloomberg.

The following example provides some intuition and motivates the hypothesis. An investor -a trader- in New York wakes up with one of the following news: (1) Greece has announced that two of its major banks have borrowed funds from the emergency window of the European Central Bank. (2) Spain has announced that it will fail to reduce its budget deficit as GDP percentage to its goal. (3) The U.S. economy created less new jobs than the market expected in the previous quarter. *A priori*, it seems plausible that each of the previous events will cause funding liquidity in financial markets to fall. In particular, think

[2]Expression (2.3) below details the computation of the CIP.

of a trader that will see its margin credit reduced.[3] This tighter constraint will reduce his trading on "riskier" assets such as emerging markets' currencies, thus the interest rate differential will no longer be the only determinant of the transaction costs involved. This trader would only trade in the USD-MXN market if the premium is "high enough", thus affecting the arbitrage transactions as explained in Brunnermeier and Pedersen (2009).

The sequence of financial shocks observed from the summer of 2007 all the way through the summer of 2012 suggests that there were two main sources or types of shocks: (1) U.S.-born and (2) Europe-born. Thus, I divide funding liquidity shocks in two types which proves to be useful since both types seem to play a relevant role in explaining deviations from the CIP. Shocks born in the U.S. are straightforward to relate to deviations from the CIP provided, among other reasons, that: (i) The U.S. economy is Mexico's exports main destiny -changes in the demand for goods made in Mexico affects the risk premium firms must pay when they look into sources of funding. (ii) The largest Mexican firms have access to credit valued in USD -provided by U.S. based financial firms. (iii) There is relatively high mobility of labour between the two economies -which changes the relative prices of production inputs, among them the interest rate. *A priori*, however, Europe-born shocks are not as directly related to deviations from the CIP but they are still relevant as I argue below.

Despite the interconnectedness of financial markets, relating events in Europe to deviations from the CIP deserves a deeper analysis. The lack of a clear relation between deviations in the CIP and Europe-born shocks can bias analysts and economists' judgement towards the claim that these shocks have only a short-run effect. A formal test of long-run effects should provide sound information regarding the persistence of the *a priori* labelled short-run shocks.

Tests of the CIP have been present in the literature for many years. Aliber (1973) is among the pioneers of testing its validity along with Frenkel and Levich (1975) and Frenkel and Levich (1977). For the particular case of the CIP involving the USD-MXN market, Carstens (1985) is the earliest reference I found. The focus of his PhD dissertation is on the period 1980-1982. He analyses the determination of the forward exchange rate for delivery after three months. In that period Mexico had a fixed (spot) exchange rate and observed considerable external imbalances concerning both its current account and outstanding external debt. This led to a generalized belief that a devaluation of the MXN with respect to the USD was about to take place. In a way, the present paper updates Carstens' analysis of the CIP for the USD-MXN market and is the first to use a SVECM.

[3] Even if systemic liquidity is not an issue in itself in the financial markets of the largest economies, financial stress on a firm level would prevent the traders to take advantage of arbitrage opportunities if the asset underlying the transaction is out of bounds in internal risk management policy.

A further important difference with respect to Carstens' work is that, for the period I consider, Mexico has a floating exchange rate.

Khor and Rojas-Suarez (1991)[4] test the CIP for Mexican internal debt denominated in USD but payable in MXN and external debt. They use cointegration analysis to assess the sovereign risk indirectly through a long-run relation between the aforementioned debt instruments. Their work includes three main findings. First, the CIP is satisfied for most of the period studied. Second, there is indeed a long-run relation between the interest rate on USD denominated bonds and the yield to maturity of the bonds issued in the external market. Finally, a policy implication in which they suggest that by improving internal economic conditions, the interest rate of the Mexican debt will decline sensibly. Khor and Suarez-Rojas's work sheds light on the history of the CIP for Mexico in the period 1987-1991, which as Carstens' work has a fixed exchange rate regime and the econometric methods are single-equation based.

Within the liquidity theory literature, the work of Brunnermeier and Pedersen (2009) studies the link between its two forms: (i) Market Liquidity of a particular asset -how easily an asset can be sold. And (ii) Funding Liquidity -how easily a trader can get funding to trade. The latter form of liquidity is the one I use in the present paper to explain deviations from the CIP. Brunnermeier and Pedersen's model shows how under particular conditions market liquidity: "dries up", is common across assets, relates to volatility, suffers flight-to-quality, and co-moves with the market.

Regarding the use of multivariate econometric tools[5] in the literature of CIP, using a VECM, Peel and Taylor (2002) address the validity of the Keynes-Einzig conjecture which can be stated as follows: Given deviations from the CIP, arbitrage opportunities will only be taken if the premium is high enough (5% in the USD-Sterling exchange rate during the 1920's). Their analysis confirms the existence of the Keynes-Einzig conjecture for the 1920's and provides a good description of the data needed to undertake research in the topic.

Peel and Taylor's work inspired the notation and the use of the econometric model for the present paper. Since the CIP and its deviations are concerned with a fundamental equilibrium condition, the VECM is a suitable tool to tests its validity in the long run. The VECM also allows the use of the economic interpretation of its parameters for the cointegrating relation, the loading matrix and the short-run dynamics. A key difference is that I do not estimate bands *a la* Keynes-Einzig which would require nonlinear estimation

[4] I thank the anonymous referee for bringing to my attention this work.

[5] General issues involving Time Series Econometrics are well covered in Hamilton (1994). Estimation of the Cointegrated VAR or VECM are thoroughly contained theoretically in Johansen (1996) and Lütkepohl (2005). Empirical issues are covered in Juselius (2006).

techniques.

To produce a survey of the vast literature around the CIP would require a great amount of space, but among the relevant work for this paper I can include Clarida and Taylor (1997), who test the Risk Neutral Efficient Market Hypothesis using a VECM, where they find that forward markets do contain relevant information for forecasting. Also important is the work of Shigeru and Shu (2006), who consider in their work a structural vector autoregression (SVAR) model to identify various macroeconomic shocks to the uncovered version of the CIP. Gonzalo and Ng (2001) propose a new way to estimate a SVECM in which it is possible to identify the effects of permanent and transitory shocks. Faust, Swanson, and Wright (2004) estimate the same SVAR as Christiano, Eichenbaum, and Evans (1999) do. The difference lies in the identification strategy of the monetary policy structural shocks.

Closely related literature also includes the work of Roll, Schwartz, and Subrahmanyam (2007) where they argue that liquidity and the law of one price are related by double Granger causation. Chordia, Roll, and Subrahmanyam (2008) explore a link between liquidity and asset prices. In particular they study whether liquidity is associated with an enhanced degree of intra-day market efficiency. Fong, Valente, and Fung (2010) use a single-equation econometric model to assess whether liquidity of the Hong Kong Dollar - U.S. Dollar market (USD-HKD) or changes in credit risk cause deviations from the CIP.

To develop the analysis I divide the paper in 5 further sections. Section 2 presents briefly the theory behind the CIP. In section 3 I provide the details of the data set. The econometric model and the empirical results are outlined in section 4. The concluding remarks are found in section 5. Finally, two appendices contain information on data and estimation output.

2 Theory

2.1 Covered Interest Parity

Economic theory predicts a number of stable relations among variables through time. Of particular interest in the field of international finance is the covered interest rate parity, or covered interest parity (CIP).[6] This relation predicts that, in equilibrium, the difference between the forward exchange rate and the spot exchange rate -the forward premium- must be equal to the interest rate differential among the countries plus some transaction costs -or minimum risk premium as discussed below. Formally, let S_t be the spot exchange rate

[6]Regarding the theory of the CIP and international finance in general, Sarno and Taylor (2002) is the main reference.

of U.S. Dollars (USD) per 1 Mexican Peso (MXN) and let F_t^k be the Forward contract agreed at period t with maturity of k months.[7] Also, let $i_{us,t}^k$ and $i_{mex,t}^k$ be the interest rate on the sovereign bond with maturity of k months issued by the U.S. and Mexico, respectively.[8] Assuming individuals are rational and in the absence of financial frictions and costs, the CIP says

$$\frac{F_t^k}{S_t} = \frac{1 + i_{us,t}^k}{1 + i_{mex,t}^k}. \tag{2.1}$$

When deviations from the CIP occur, economic theory predicts that demand and supply forces will re-establish (2.1) through arbitrage. This is, inequalities provide risk-less profitable opportunities in a friction-less set-up. An example of the latter is as follows. Assume

$$\frac{F_t^k}{S_t}(1 + i_{mex,t}^k) > 1 + i_{us,t}^k. \tag{2.2}$$

If an investor in the home country borrows B USD for k months at rate $i_{us,t}^k$, he can buy B/S_t MXN. Then he can lend his B/S_t MXN at a rate $i_{mex,t}^k$. At the same time he signs a forward contract where he promises to deliver $(1 + i_{mex,t})B/S_t$ MXN at the end of the k months in exchange for $F_t^k B(1 + i_{mex,t}^k)/S_t$ USD. After this series of transactions, the investor has in his hand $F_t^k B(1 + i_{mex,t}^k)/S_t$ USD and he owns $B(1 + i_{us,t}^k)$. Using (2.2) it is clear that he can pocket a profit of $F_t^k B(1 + i_{mex,t}^k)/S_t - B(1 + i_{us,t}^k)$ USD.

The arbitrage process described in the previous example ensures that (2.1) holds in the long run, even if there are deviations in the short run. Empirical tests of the CIP, such as those of Aliber (1973) or Peel and Taylor (2002), are based on the following approximation to expression (2.1)

$$P_k \frac{F_t^k - S_t}{S_t} = i_{us,t}^k - i_{mex,t}^k - c, \tag{2.3}$$

where P_k is a factor that adjusts to annual terms the forward premium and c accounts for possible transaction costs and minimum risk premium. Since I am interested in *deviations* from the CIP, I will denote these by δ_t^k and the forward premium by $\Phi_t^k = P_k \frac{F_t^k - S_t}{S_t}$, that is

$$\delta_t^k = \Phi_t^k - i_{us,t}^k + i_{mex,t}^k + c. \tag{2.4}$$

[7] Throughout the paper I will follow the convention that the investor resides in the US (more generally he can always borrow in USD and is looking to invest in Mexico). Thus, home country is the U.S. and foreign country is Mexico.

[8] In taking $i_{us,t}^k$ to compute the CIP, it is implicitly assumed that the traders have access to loans at this rate. This is may be true for traders at large banks.

Figure 1 above shows relation (2.4) for $k = 1$.

2.2 Funding-Liquidity Measures

Among the key money-market indicators for "liquidity events" is the LIBOR-OIS spread, LOIS. It has been used as a market indicator of interbank liquidity conditions by central bankers as explained by Thornton (2009). In the international finance literature LOIS has served as a proxy for credit risk (e.g. Fong et al. (2010)). It has a relatively simple interpretation: when LOIS increases, the funding liquidity decreases. An excellent description of how both the LIBOR and the OIS are constructed is found in chapter 3 of Smith (2010). She explains how the LIBOR is a rate on a risky loan while the OIS, being an overnight rate -an approximate of the Federal Funds rate expectation- is for practical purposes risk-free. She also provides details on how both rates are constructed, but a clear set of characteristics is given:

"...the longer-term rate {LIBOR} is approximately equal to the probability of default (ignoring liquidity effects) over the time interval [t, T], while the swap rate is the geometric average of the probability of default in the intervals [t, t + 1], [t + 1, t + 2]....,[T-1, T] generated by rolling over each of the spot rates at each time interval."[9]

Thus, in the absence of negative financial events, the spread between the two rates is small. In times of financial distress, however, loans signed in a LIBOR contract are riskier than overnight loans. Thus making the LOIS large. Since my aim is to obtain a measure of the effects from liquidity shocks on the CIP, I use the LOIS for the U.S. banking sector. I also want to compare the effects of said shocks with those stemming from Europe, so I include a measure for this, the LOIS for the European banking sector. Details on the data set are found in the next section.

3 Data

All the analysis is conducted using weekly averages of daily data provided by Bloomberg. Taking weekly averages helps me to avoid problems associated with each day (e.g. Friday is more prone to suffer a sell-off if something important is due to occur during the weekend) which reduces volatility.[10] I consider the period January 2nd 2003 to July 11th 2012. The sample starts 12 months after the end of the previous U.S. recession to the Great Recession which the NBER's Business Cycle Committee dates at November of 2001. This

[9] Smith (2010) pp 36. Content within curly brackets is mine. I thank Carlos Lever for suggesting Smith's work.
[10] Appendix A contains the Bloomberg ticker id of each variable.

allows me to check if deviations from the CIP during a period of "normal" conditions behave according to the theory.

I analyse deviations from the CIP in 1-month sovereign bonds, that is δ_t^1 as defined in (2.3). I choose the 1-month maturity for the analysis since the market for Mexican 1-month sovereign debt has a larger volume than other maturities. Moreover, the future contracts on the exchange rate should be of the same maturity as the debt contracts. To ease notation I skip the super-index $k = 1$ in the variables from now on. F_t is the inverse of exchange rate agreed on the forward contract with maturity $k = 1$ month at date t. I take the inverse because I need USD per 1 MXN and the contracts are in MXN per 1 USD. Analogously, S_t is the inverse of the spot exchange rate at date t. The variable $i_{us,t}$ is the weekly average of the daily yield on the 1-month U.S. Treasury Bill in annual terms. This is obtained from the "constant Maturity Treasury".[11] Finally, $i_{mex,t}$ is the weekly average of the daily yield of the 28-day (1-month) Treasury Certificate known as CETEs in annual terms, and $P_k = 12 \times 100$.

Figures 2 to 5 show the levels and first differences of the main variables. It is worth noting that all four series display a more volatile behaviour after the first semester of 2007. In particular, they show large deviations from the trend at the beginning of the last quarter of 2008. This coincides with events like the Lehman failure and the AIG's rescue. Regarding Figure 3 two main reasons explain the (almost) zero yield of the 1-month Treasury Bills: (1) The monetary stimulus provided by the Federal Reserve; and (2) the flight-to-quality phenomenon where the U.S. received a large capital inflow despite being the center of the financial crisis as detailed in Paulson (2010).[12]

The LOIS for the U.S. banking system, $LOIS_{us,t}$, is computed as the weekly average of the difference between the daily 3-month LIBOR in USD and the Overnight Index Swap. The variable $LOIS_{eur,t}$ stands for the LOIS for Europe and is obtained by taking the weekly average of the daily difference between the 3-month Euribor in Euros and the Overnight Index Swap both published in the Euro Overnight Index Average (EONIA) website.

Behaviour of these two measures of funding liquidity shown in Figures 6 and 7 is stable as expected up to the summer of 2007. In particular, $LOIS_{eur,t}$ in Figure 7 displays several "hump-like" events of financial distress, some of which were associated with sovereign debt

[11] The Constant Maturity Treasury is defined as: "Treasury Yield Curve Rates. These rates are commonly referred to as "Constant Maturity Treasury" rates, or CMTs. Yields are interpolated by the Treasury from the daily yield curve. This curve, which relates the yield on a security to its time to maturity is based on the closing market bid yields on actively traded Treasury securities in the over-the-counter market. These market yields are calculated from composites of quotations obtained by the Federal Reserve Bank of New York. The yield values are read from the yield curve at fixed maturities, currently 1, 3 and 6 months and 1, 2, 3, 5, 7, 10, 20, and 30 years. This method provides a yield for a 10-year maturity, for example, even if no outstanding security has exactly 10 years remaining to maturity." Source: http://www.treasury.gov/resource-center/data-chart-center/interest-rates/pages/textview.aspx?data=yield

[12] As a side note, Paulson also makes several remarks regarding the LOIS as sign of stress in the markets.

problems in southern Europe, provided the main creditors of these countries are European commercial banks.

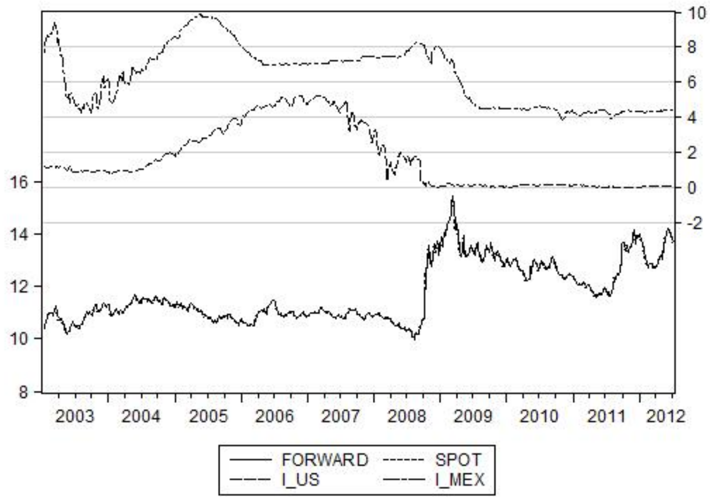

Figure 2: Weekly averages of daily data of the main variables S_t^{-1}, F_t^{-1} (left scale measured in MXN per 1 USD), $i_{us,t}$, $i_{mex,t}$ (right scale in percentage points). Source: Bloomberg.

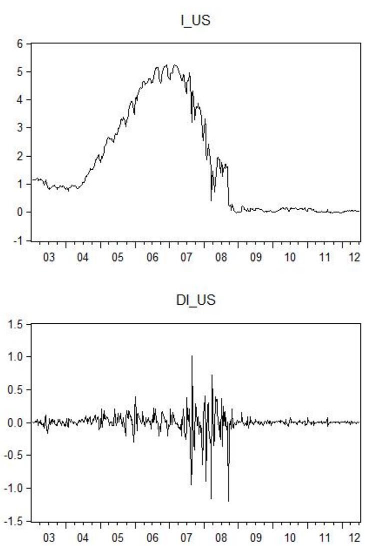

Figure 3: Weekly averages of daily data of the U.S. Treasury Bill yields for 1 month $i_{us,t}$ is in percentage points, and first difference. Source: Bloomberg.

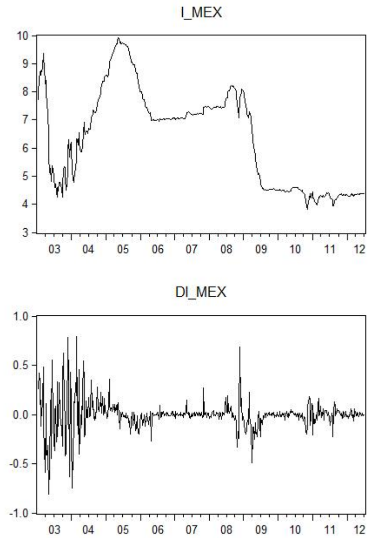

Figure 4: Weekly averages of daily data of the Mexican 28-day CETE $i_{mex,t}$ is in percentage points, and first difference. Source: Bloomberg.

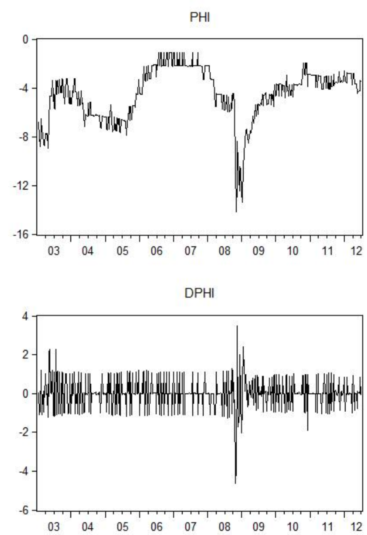

Figure 5: Weekly averages of daily data of the Forward Premium Φ_t is in percentage points, and first difference. Source: Bloomberg.

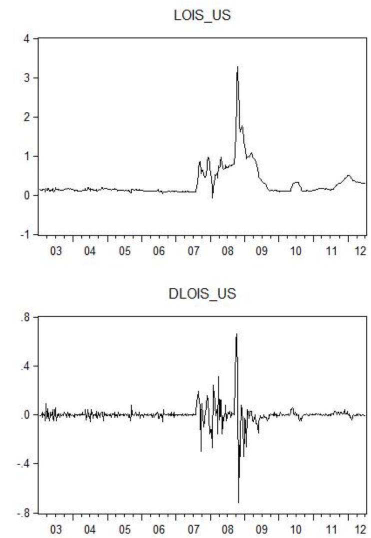

Figure 6: Daily data of the $LOIS_{us,t}$ is in percentage points and first difference. Source: Bloomberg.

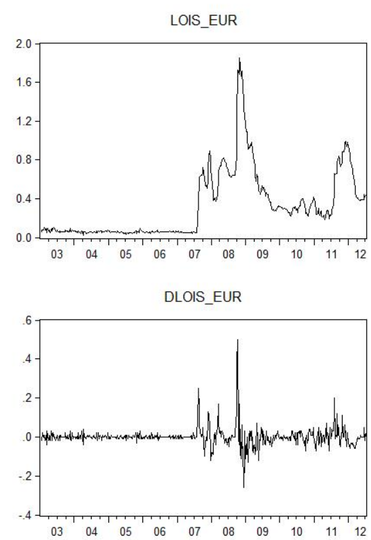

Figure 7: Daily data of the $LOIS_{eur,t}$ is in percentage points and first difference. Source: Bloomberg.

At this point it is worth noting that all variables are $I(1)$, that is, when testing for a Unit Root, I fail to reject the null-hypothesis as Table 1 shows. Borderline cases arise for Φ_t, $LOIS_{us,t}$, and $LOIS_{eur,t}$. In particular, the $DF-GLS$ test proposed by Elliott, Rothenberg, and Stock (1996) with the highest power, applied to the liquidity measures only rejects the null-hypothesis at the 1% level of confidence.

Variable	ADF^{μ}	ERS	PP^{μ}
Φ_t	-2.9675*	-1.5819	-3.3449*
$i_{us,t}$	-0.6385	-0.7106	-0.6908
$i_{mex,t}$	-1.4084	-0.7499	-1.3028
$LOIS_{us,t}$	-2.6793	-2.4908*	-2.7177
$LOIS_{eur,t}$	-2.9590*	-2.3942*	-2.4119
5% Critical Value	-2.8673	-1.9414	-2.8671

Table 1: Unit Root Tests for the main variables and the $LOIS_{us,t}$ and $LOIS_{eur,t}$. Columns show *test-statistic* for the Augmented Dickey-Fuller test with a mean (ADF^{μ}), the Elliot-Rothenberg-Stock (ERS) $DF-GLS$ test with a mean and the Phillips-Perron test with a mean ((PP^{μ}). All tests were carried out in levels with a constant. Null Hypothesis: there is a Unit Root. The lag-length is chosen by E-Views according to the Schwarz Information Criterion with a maximum of 17. * Reject the null hypothesis.

Note however, that if I test for a unit root on the period of the crisis onwards, this is, from August 3rd of 2007 to July 6th 2012, all variables are $I(1)$ as shown in Table 2. This is fairly direct to explain. The $LOIS_{\cdot,t}$ observations were very stable before the crisis since there were no major liquidity strains before the summer of 2007. Thus, I will treat all variables as $I(1)$. This has some consequences in terms of the end-results for this paper, which I will discuss below.

Variable	ERS
Φ_t	-1.6523
$i_{us,t}$	0.4254
$i_{mex,t}$	0.0918
$LOIS_{us,t}$	-1.7426
$LOIS_{eur,t}$	-1.8605
5% Critical Value	-1.9414

Table 2: Unit Root Tests for the main variables and the $LOIS_{us,t}$ and $LOIS_{eur,t}$ for the sub-sample August 3rd of 2007 to July 6th 2012. Columns show the Elliot-Rothenberg-Stock (ERS) $DF-GLS$ test with a mean. Null Hypothesis: there is a Unit Root. The lag-length is chosen by E-Views according to the Schwarz Information Criteria with a maximum of 15.

A final word on why I choose to work with weekly averages is relevant here. There is a great deal of autocorrelation induced by the fact that the frequency of the original data is daily whereas F_t matures in 30 days. This is why, contrary to what is typically observed, taking weekly averages reduces autocorrelation. This issue is important when specifying the model below.

4 Econometric Model and Estimates

There are several reasons that made the VECM and SVECM suitable tools for the analysis. (1) The VECM model allows the explicit analysis of $I(1)$ variables and tests the existence of a long-run stationary relation among them, in this case, the CIP. (2) The VECM allows the estimation of Impulse Response Functions (IRFs) with the corresponding orthogonalization of the residuals. (3) The VECM can be transformed into its "common trends representation" which allows me to write each equation of the system as a linear combination of residuals from the VECM (i.e. a Moving Average form). (4) Finally, it is possible to obtain a SVECM that allows me to distinguish between short-run shocks and long-run shocks, producing IRFs without the Choleski decomposition. All estimations in the rest of the paper are made in Dennis, Hansen, Johansen, and Juselius (2005) CATS in RATS, version 2 through Maximum Likelihood, unless stated otherwise.

To start the econometric analysis, let $n = 5$ and define the $n \times 1$ variable vector

$$X_t = (\Phi_t, i_{us,t}, i_{mex,t}, LOIS_{us,t}, LOIS_{eur,t})',$$

and the vector autoregressive model in its vector error correction form of order p, VECM(p),

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{s=1}^{p-1} \Gamma_s \Delta X_{t-s} + \varepsilon_t, \tag{4.1}$$

$$\varepsilon_t = (\varepsilon_{\Phi,t}, \varepsilon_{i_{us},t}, \varepsilon_{i_{mex},t}, \varepsilon_{LOIS_{us},t}, \varepsilon_{LOIS_{eur},t})', \tag{4.2}$$

$$\varepsilon_t \sim N(0, \Sigma), \tag{4.3}$$

where $\Pi = \alpha\beta'$ is a $n \times n$ matrix, α and β are $n \times r$ matrices, Γ_s are $n \times n$ short-run effect matrices, ε_t is the vector containing the reduced form errors, and the $n \times n$ matrix Σ is symmetric and is allowed to be non-diagonal. Note that all elements of X_t are $I(1)$ as shown in Tables 1 and 2, thus, a model such as (4.1) involves simultaneously $I(1)$ and $I(0)$ variables. The latter means that a necessary condition for the model to work is the presence of $r(= rank(\Pi))$ cointegrating relations.

4.1 Specification

Lag-Length

The first step in specifying a VECM(p) is to choose the number of lags, p, used in estimation. In general, I can either follow an information criterion such as the Bayesian

Information Criterion (BIC), the Hannan-Quinn Criterion (H-Q), or an autocorrelation criterion. In this paper I follow the latter since the data has a high degree of autcorrelation on the levels of the variables, and if this is not corrected the inference analysis would be biased. Table 3 shows the BIC, the H-Q, and the Lagrange Multiplier Test (LM) for autocorrelation for values of $p = 1, ..., 10$.

p	reg	BIC	H-Q	LM(1)	LM(p)
10	51	-18.490	-19.824	0.160	0.612
9	46	-18.682	-19.885	0.000	0.000
8	41	-18.917	-19.990	0.148	0.454
7	36	-19.148	-20.089	0.025	0.232
6	31	-19.421	-20.231	0.777*	0.489
5	26	-19.631	-20.311*	0.005	0.394*
4	21	-19.760	-20.309	0.000	0.000
3	16	-19.885	-20.304	0.000	0.000
2	11	-19.888*	-20.176	0.000	0.000
1	6	-19.528	-19.685	0.000	0.000

Table 3: BIC is the Bayesian Information Criterion on lag length determination. H-Q is the Hannan and Quinn Criterion. LM(p) is the Lagrange Multiplier Test of autocorrelation including p lagged residuals, for $p = 1, ..., 10$. *Is the suggested lag according to each criterion.

From Table 3 I conclude that $p = 6$, which will "clean" the autocorrelation issue since both LM tests fail to reject the null of no-autocorrelation. In economic terms, the absence of autocorrelation amounts to the individuals behaving accordingly to a rational expectations set-up. I am not concerned with issues of over-parametrization since the sample size is 496 observations.

Residual Tests

The canonical VAR analysis requires the residuals to satisfy two additional characteristics, normality and homoskedasticity. These, however, are superseded by somewhat recent advances in econometrics. On the one hand, Normality is no longer a necessary condition for one to be able to estimate through Maximum Likelihood, I can always rely on Quasi-Maximum Likelihood techniques. Moreover, the CATS software contains the methods proposed by Rahbek, Hansen, and Dennis (2002), so that Heteroskedasticity is no longer an issue in estimating a VAR.

The next step is to check if the specification suggested in Table 3 is indeed free from autocorrelation. Table 4 shows the results for the Ljung-Box and LM tests. In all cases I fail to reject the null hypothesis of no-autocorrelation.

Tests for Autocorrelation(lags)	χ^2	$p - value$
Ljung-Box(122):	2951.809	0.247
LM(1):	17.983	0.843
LM(2):	20.700	0.709
LM(5):	33.120	0.128
LM(10):	29.216	0.255

Table 4: Autocorrelation tests. χ^2 statistic and $p - value$. The null hypothesis is no-autocorrelation.

Rank Test

One of the appealing features of model (4.1) is that it allows me to test whether the long-run relations predicted by the economic theory are satisfied by the data. In particular, when each of the equations $\beta' X_{t-1}$ is $I(0)$ the long-run relations are satisfied, this is, a subset of elements of X_t are cointegrated. In fact, each row, $(\beta' X_{t-1})_j$, is known as a cointegrating relation. Note that $j = 1, 2.., r < n$. Another appealing feature of the model (4.1) is that it allows me to impose restrictions on the matrix β. Moreover, if the number of restrictions in each row β_j' is larger than $r - 1$ then these are testable.

The latter means that knowledge of r, the cointegrating rank, is a necessary condition for inference on the cointegrating relations and the $n - r$ common trends. Johansen (1988) tests provide a reliable way to select r.

$n - r_0$	r_0	Trace-Stat	Trace-Stat*	Crit-5%	$p - value$	$p - value*$
5	0	103.795	103.795	76.813	0.000	0.000
4	1	46.272	46.272	53.945	0.208	0.208
3	2	20.281	20.281	35.070	0.709	0.709
2	3	9.120	9.120	20.164	0.727	0.727
1	4	1.326	1.326	9.142	0.890	0.890

Table 5: $n - r$ is the number of Common Trends. r is the cointegrating rank (i.e. the number of cointegrating relations). Trace-Stat is Johansen's Trace Statistic. Crit 5% is the critical value for the size of 5%. Trace-Stat* is Johansen's small sample corrected Trace Statistic. The null hypothesis is: cointegrating rank $= r_0$.

Table 5 contains the tests for several possible values of r denoted r_0. The table must be read from the top and r is determined when we fail to reject the null of r_0 cointegrating relations. In this particular case, Johansen's Trace Test suggests $r = 1$. Estimation imposing $r = 1$ and normalizing on the first element of $\widehat{\beta}$ yields[13]:

$$\widehat{\beta}' X_t = \Phi_t \underset{[-11.786]}{-1.032}\, i_{us,t} + \underset{[8.145]}{0.815} i_{mex,t} + \underset{[6.405]}{5.385} LOIS_{us,t} \underset{[-4.952]}{-4.344}\, LOIS_{eur,t} + \underset{[1.360]}{0.785}. \quad (4.4)$$

Equation (4.4) presents the cointegrating relation where all coefficients are statistically significant at the 5% level except the constant.[14] At this point it is not possible to interpret the estimates. I can, however, discuss the stationarity of the cointegrating relation. Figure 8 presents $\widehat{\beta}' X_t$ and suggests that it is stationary, as desired. In Table 6 I show several unit root tests confirming the latter. I include two versions of the Augmented Dickey Fuller and Phillips-Perron tests, with and without a mean. The Table also shows the Elliott-Rothenberg-Stock test $DF - GLS$ test with a mean. Results show unambiguous support for the absence of a unit root, both with no deterministic terms and when considering the mean. The unit root analysis confirms the existence of one cointegrating relation and the validity of Johansen's Test.

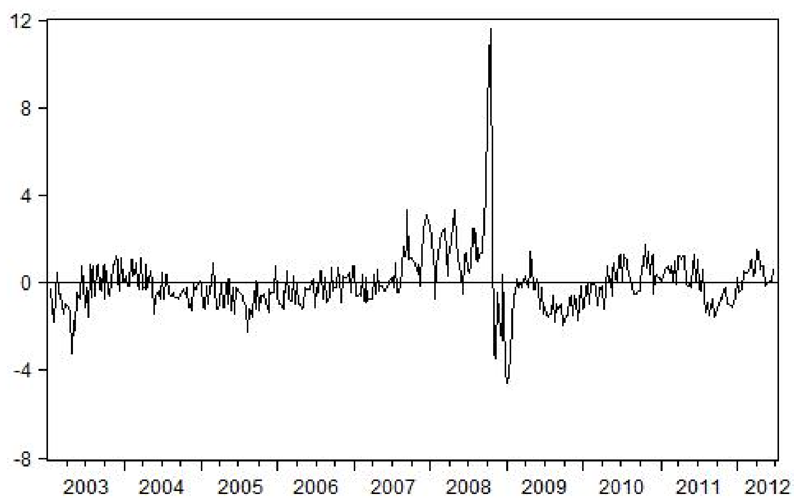

Figure 8: Cointegrating Relation $\widehat{\beta}' X_t$.

[13]The interested reader can find full estimates of the long-run matrix $\widehat{\Pi}$ loading $\widehat{\alpha}$, and short-run matrices $\widehat{\Gamma}_j$ for $j = 1, , ...5$ in Appendix B.1. In particular, Tables 13 - 19.

[14]Throughout the paper $t - statistics$ are presented in square brackets unless stated otherwise.

Variable	ADF	PP	ADF^{μ}	ERS	PP^{μ}
$\widehat{\beta}' X_t$	-7.7722	-7.7895	-7.7641	-7.2881	-7.7814
5% Critical Value	-1.9414	-1.9414	-2.8671	-1.9409	-2.8671

Table 6: Unit Root Tests for the cointegrating relation $\widehat{\beta}' X_t$. Columns show *test-statistic* for the Augmented Dickey-Fuller test (ADF) and the Phillips-Perron test (PP) with no mean or trend. ADF^{μ} and PP^{μ} include a mean and ERS is the Elliot-Rothenberg-Stock test with a constant. Null Hypothesis: there is a Unit Root. The lag-length is chosen by E-Views according to the Schwarz Information Criteria with a maximum of 17.

4.2 Testing the Theoretical Relation

Assuming that a Data Generating Process can be modelled by a VECM(p) entails the *a priori* conjecture that relations among the elements of X_t are stationary on the long-run. I use the economic theory outlined in Section 2 to justify the only cointegration relation: the CIP.[15] Economic theory predicts a stable relation among its components, which in econometric terms means that δ_t as defined in equation (2.4) is stationary. Let $\beta = (\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, c)'$ define the parameters of the CIP to be estimated. If the data obey the CIP in the long run, then the estimate $\widehat{\beta}$ will satisfy:

1. $\widehat{\beta}_1 \approx -\widehat{\beta}_2$.
2. $\widehat{\beta}_1 \approx \widehat{\beta}_3$.
3. $\widehat{\beta}_4$ and $\widehat{\beta}_5$ not statistically different from zero.

Results displayed in equation (4.4) more or less satisfy conditions (1) and (2), however, condition (3) is far from being observed. The VECM(p) allows me to test whether I can impose (3). The theory of the VECM states that by imposing the over-identification restrictions on β, I can test whether these restrictions are valid statistically. I need $r-1$ restrictions on β to have just-identification.

Thus, by imposing at least one restriction, I can have over-identification. Define $\widetilde{\beta}^R$ as the restricted estimate of β, for the set of restrictions R. The first set of restrictions to

[15] In general, if r had turned out to be larger than one, at least a second cointegrating relation could be justified using the inherent relation between the U.S. yields and interbank lending conditions.

test, $R = A$, is defined as

$$\widetilde{\beta}_1^A = -\widetilde{\beta}_2^A, \tag{4.5a}$$
$$\widetilde{\beta}_1^A = \widetilde{\beta}_3^A, \tag{4.5b}$$
$$\widetilde{\beta}_4^A = 0, \tag{4.5c}$$
$$\widetilde{\beta}_5^A = 0. \tag{4.5d}$$

Imposing the restriction set (4.5a)-(4.5d), I obtain the following estimates

$$\widetilde{\beta}^{A\prime} X_{t-1} = \Phi_{t-1} - i_{us,t-1} + i_{mex,t-1} \underset{[-1.643]}{-0.252} = \delta_{t-1}. \tag{4.6}$$

Before continuing the analysis, I test whether the restrictions imposed in (4.6) are valid. As it turns out they are not. Table 7 presents the test which rejects the null hypothesis of $\widetilde{\beta}^A$ being valid.[16]

Test set A	χ^2	$p - value$
Test of Restrictions	28.905	0.000
Bartlett Correction	23.231	0.000

Table 7: Test for the validity of the Restricted Model A versus the unrestricted model. Null hypothesis: Restrictions are valid.

Since I want to test whether changes in funding-liquidity are affecting the CIP in the long-run, I define the restrictions set B as a subset of A where B is composed only by (4.5a) and (4.5b). That is, define $\widetilde{\beta}^B$ as the restricted estimate of β, where $\widetilde{\beta}_1^B = -\widetilde{\beta}_2^B$ and $\widetilde{\beta}_1^B = \widetilde{\beta}_3^B$ are imposed and both $\widetilde{\beta}_4^B$ and $\widetilde{\beta}_5^B$ are left free. Estimating the model under the restriction set B yields

$$\begin{aligned}
\widetilde{\beta}^{B\prime} X_{t-1} &= \Phi_{t-1} - i_{us,t-1} + i_{mex,t-1} + \underset{[5.977]}{3.93} LOIS_{us,t-1} \underset{[-3.977]}{-2.78} LOIS_{eur,t-1} \underset{[-3.307]}{-0.502} \\
&= \delta_{t-1} + \underset{[5.977]}{3.93} LOIS_{us,t-1} \underset{[-3.977]}{-2.78} LOIS_{eur,t-1} \underset{[-3.307]}{-0.502} \\
&= \delta_{t-1}^B.
\end{aligned} \tag{4.7}$$

As shown in Table 8, I failed to reject the Null Hypothesis stating that restriction set B is valid at the 5%. This means that there is a stationary long-run relation that includes

[16]Since the restrictions are not valid I do not include estimates for the long-run matrix $\widetilde{\Pi}$ loading and short-run matrices, $\widetilde{\alpha}$ $\widetilde{\Gamma}_j$ for $j = 1, , ...5$.

the liquidity measures and has a mean different from zero.

Test set B	χ^2	$p-value$
Test of Restrictions	5.681	0.058
Bartlett Correction	4.442	0.109

Table 8: Test for the validity of the Restricted Model B versus the unrestricted model. Null hypothesis: Restrictions are valid.

Once the validity of equation is established, I can test whether δ_{t-1}^B is stationary. Figure 9 provides a suggestive hint of δ_{t-1}^B being stationary. This is confirmed by the results of several unit root tests included in Table 9.[17] This is, δ_t^B, as defined in equation (4.7), is indeed stationary, thus confirming cointegration. With δ_t^B in hand I can now provide an economic interpretation for the econometric results obtained so far.

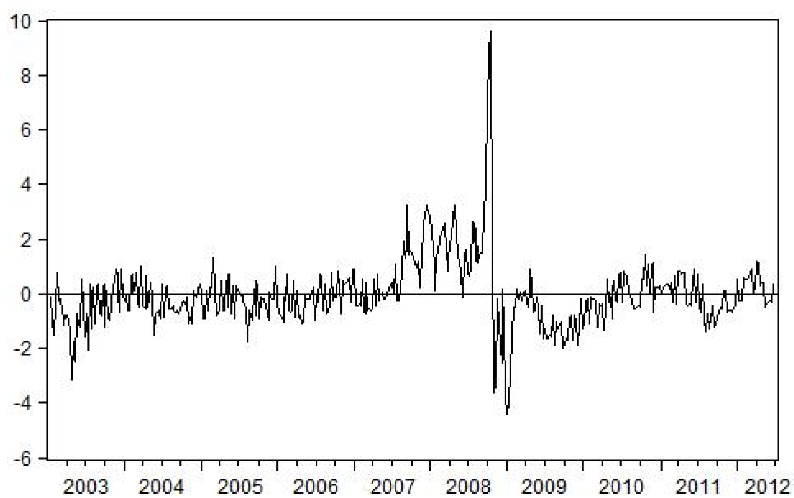

Figure 9: Cointegrating Relation $\widehat{\beta}^{B'} X_t = \delta_t^B$.

Variable	ADF	PP	ADF^μ	ERS	PP^μ
$\widetilde{\beta}^{B'} X_t = \delta_t^B$	-7.9589	-7.8918	-7.9508	-7.5363	-7.8835
5% Critical Value	-1.9414	-1.9414	-2.8671	-1.9409	-2.8671

Table 9: Unit Root Tests for the cointegrating relation $\widehat{\beta}' X_t = \delta_t^B$. Columns show *test-statistic* for the Augmented Dickey-Fuller test (ADF) and the Phillips-Perron test (PP) with no mean or trend. ADF^μ and PP^μ include a mean and ERS is the Elliot-Rothenberg-Stock test with a constant. Null Hypothesis: there is a Unit Root. The lag-length is chosen by E-Views according to the Schwarz Information Criteria with a maximum of 17.

[17] Appendix B.2, Tables 21 - 27 contains estimates for the short-run parameters. These are discussed below.

4.3 Economic Interpretation

Long-Run

Equation (4.7) should be interpreted as a stable long-run relation between the five elements of X_t. In particular, I can write said equation as

$$\delta_t = -\underset{[5.977]}{3.93}\, LOIS_{us,t} + \underset{[3.977]}{2.78}\, LOIS_{eur,t} + \underset{[3.307]}{0.502} + \nu_t \tag{4.8}$$

where ν_t is a mean zero stationary random variable as implied by Table 9, and the units are in percentage points (100 basis points).

In the long run, the relation between δ_t and $LOIS_{us,t}$ is negative, which can be rationalized in the following way: (1) An increase in the $LOIS_{us,t}$ spread signals an increase of the perception of credit risk -and thus a decrease in funding-liquidity- in the U.S. (2) The increase in $LOIS_{us,t}$ will cause δ_t to decrease since a flight-to-quality appreciates the USD diminishing Φ_t.

The relation between δ_t and $LOIS_{eur,t}$ is positive since: (1) An increase in $LOIS_{eur,t}$ signals a decrease in funding-liquidity in Europe. (2) There is a flight-to-quality to the U.S.s' assets. (3) This causes: (a) An appreciation of the USD, thus Φ_t increases (closer to zero); or (b) $i_{us,t}$ decreases; or (c) both.

Finally the constant means that there is a minimum profit investors demand to trade MXN and Mexican Treasuries. It is worth noting that despite the similar nature of changes in liquidity funding conditions, the source of the effect matters. In particular, the two sources of liquidity shocks have opposite sign on δ_t. Now I move on to analyse short-term effects and relations.

Short-Run

In general, short-run effects are more difficult to reconcile with theory since the model is only a partial representation of reality. It is illustrative, however, to let the data speak and use these estimates to construct a narrative around them since all specification and significance tests are valid. Think of the VECM(6) as a system that has an equilibrium in which $\Delta X_j = 0$. Estimates of the short-run parameters can prove useful for forecasting or fitting the model to special circumstances. To save space I will write only the statistically significant coefficients of each equation. The interested reader can find the full set of estimates in Appendix B.2.

Now I will use results from Tables 21 and 23-27 to construct the short-run equations. The estimate for the short-run adjustment equation for Φ_t is given by

$$\begin{aligned}\Delta\Phi_t &= \underset{[-6.744]}{-0.235}\delta^B_{t-1} \underset{[-6.268]}{-0.302}\,\Delta\Phi_{t-1} \underset{[-3.875]}{-0.767}\,\Delta i_{mex,t-1} + \underset{[4.646]}{2.457}\Delta LOIS_{us,t-1} \\ &- \underset{[4.644]}{0.229}\Delta\Phi_{t-2} \underset{[-2.992]}{-0.618}\,\Delta i_{mex,t-2} - \underset{[-3.484]}{0.170}\,\Delta\Phi_{t-3} - \underset{[-2.690]}{1.407}\,\Delta LOIS_{us,t-3} \\ &- \underset{[-2.288]}{1.965}\,\Delta LOIS_{eur,t-3} - \underset{[-2.240]}{0.482}\,\Delta i_{us,t-4}, \end{aligned} \tag{4.9}$$

note that if all elements expressed as differences are zero -as they should be in the long run- then the only element left is δ^B_{t-1}. Assume that we are looking at the short-run horizon and differences are not necessarily zero. Inspection of expression (4.9) shows that $\Delta\Phi_t$ responds negatively to δ^B_{t-1}, that is, the forward premium is "pulled" back to the equilibrium by the cointegrating relation.

Autocorrelation of Φ_t shows up as three lags of $\Delta\Phi_t$. Interestingly, there is no effect from $i_{us,t}$ of the previous three weeks. A few possible explanations include, on the one hand, that all the short-run effects coming from $i_{us,t}$ are already included in $LOIS_{us,t}$. The reason for this is the extensive use of U.S. Treasury Bills as collateral in the interbank loan market. On the other hand, as the time path of $i_{us,t}$ shows, the zero lower-bound of the interest rates could be down-playing its role here. All the adjustment related to $i_{mex,t}$ has a negative sign. Finally, shocks to the liquidity measures appear to be important, in particular those stemming from the U.S. This is confirmed by the variance decomposition analysis shown below.

The short-run adjustment of $i_{us,t}$ as shown in equation (4.10) surprisingly includes the long-run equilibrium relation towards which it is adjusting. The magnitude, however, is very small,

$$\begin{aligned}\Delta i_{us,t} &= \underset{[-2.199]}{-0.018}\delta^B_{t-1} + \underset{[3.650]}{0.173}\Delta i_{us,t-1} \underset{[-2.797]}{-0.522}\,\Delta LOIS_{eur,t-1} \\ &- \underset{[6.678]}{0.332}\Delta i_{us,t-2} + \underset{[3.061]}{0.598}\Delta LOIS_{eur,t-2} - \underset{[-2.387]}{0.118}\,\Delta i_{us,t-4}. \end{aligned} \tag{4.10}$$

Also of interest is the fact that only $LOIS_{eur,t}$ is relevant in explaining short-run deviations from equilibrium. As mentioned above, since banks intensively use U.S. Treasuries as collateral, then stress events of funding liquidity in Europe could be playing a large role in the yield of these securities. The absence of $LOIS_{us,t}$ may be reflecting the duplicity of information.

Regarding the short-run behaviour of $i_{mex,t}$ in equation (4.11), it is surprising that only the lagged LOIS variables in the system play a role in its adjustment. This is a possible case of weak exogeneity and it is discussed in the next section.

$$\Delta i_{mex,t} = \underset{[7.076]}{0.329}\Delta i_{mex,t-1} + \underset{[2.143]}{0.432}\Delta LOIS_{eur,t-3} - \underset{[-4.055]}{0.480}\Delta LOIS_{us,t-4}. \tag{4.11}$$

A priori the dynamics of $LOIS_{us,t}$ and $LOIS_{eur,t}$ in equations (4.12) and (4.13) should only depend on themselves and $i_{us,t}$. However, a very small effect from the second lag $\Delta\Phi_{t-2}$ appears, this may be due to some feed-back effect between $LOIS_{us,t}$ and the spot exchange rate.

$$\begin{aligned}
\Delta LOIS_{us,t} \quad = \quad & \underset{[-6.056]}{-0.123}\Delta i_{us,t-1} + \underset{[5.595]}{0.290}\Delta LOIS_{us,t-1} + \underset{[6.797]}{0.542}\Delta LOIS_{eur,t-1} \\
+ \quad & \underset{[2.328]}{0.011}\Delta\Phi_{t-2} - \underset{[-2.350]}{0.050}\Delta i_{us,t-2} + \underset{[1.912]}{0.101}\Delta LOIS_{us,t-2} \\
- \quad & \underset{[-4.328]}{0.362}\Delta LOIS_{eur,t-2} - \underset{[-2.526]}{0.130}\Delta LOIS_{us,t-3} - \underset{[-3.350]}{0.166}\Delta LOIS_{us,t-4} \\
+ \quad & \underset{[2.682]}{0.058}\Delta i_{us,t-5},
\end{aligned} \tag{4.12}$$

$$\begin{aligned}
\Delta LOIS_{eur,t} \quad = \quad & \underset{[4.957]}{0.158}\Delta LOIS_{us,t-1} + \underset{[6.512]}{0.319}\Delta LOIS_{eur,t-1} + \underset{[4.473]}{0.145}\Delta LOIS_{us,t-2} \\
- \quad & \underset{[-5.644]}{0.290}\Delta LOIS_{eur,t-2} + \underset{[2.219]}{0.115}\Delta LOIS_{eur,t-3} + \underset{[4.847]}{0.063}\Delta i_{us,t-4} \\
- \quad & \underset{[-2.282]}{0.069}\Delta LOIS_{us,t-4} + \underset{[5.050]}{0.151}\Delta LOIS_{us,t-5}.
\end{aligned} \tag{4.13}$$

4.4 Weak Exogeneity and the Common Trends Representation

Weak Exogeneity

A further advantage provided by the model (4.1) is the test for "weakly exogenous variables". As defined by Juselius (2006) pp. 193, a variable $x_{j,t} \in \{X_t\}$ is said to be weakly exogenous if it affects other variables in the system X_t while it is not affected by them. This is, if the row j of matrix α contains only zeros. Since α is a $n \times r$ matrix, and $r = 1$ in this paper, then a weak exogeneity test is equivalent to testing for each of the five rows of α for being different from zero. To this end, a simple $t - test$ statistic is not suitable since strictly speaking I am comparing across models, so a Likelihood-Ratio statistic is computed. I show the weak exogeneity test output from CATS in Table 10.

r	5% Crit-val	Φ_t	$i_{us,t}$	$i_{mex,t}$	$LOIS_{us,t}$	$LOIS_{eur,t}$
1	3.841	31.515 [0.000]	3.848 [0.050]	3.469 [0.063]	0.001 [0.973]	2.200 [0.138]

Table 10: Weak Exogeneity Test. LR-Test statistic, $\chi^2(r)$, $p-values$ in brackets. Null Hypothesis: The variable is weakly exogenous.

At a first glance the test allows me to conclude that $i_{mex,t}$, $LOIS_{us,t}$ and $LOIS_{eur,t}$ are weakly exogenous. Note, however, that the $p-value$ for $i_{us,t}$ is right on the margin. As a tie-breaker, let me put forward two arguments to favour taking $i_{us,t}$ as weakly exogenous. First, a statistical argument, the value of the estimate $\widetilde{\alpha}_{2,1} = -0.018$ corresponding to regression (4.10) is very small. Second, an intuitive argument regarding the characteristics of the U.S. Treasuries. Taking $i_{mex,t}$ as weakly exogenous at the same time that rejecting the Null of weak exogeneity for $i_{us,t}$, would imply that $i_{mex,t}$ is a determinant of $i_{us,t}$ which is at odds with reality. In this way in the rest of the analysis I take $i_{us,t}$ as weakly exogenous. This is, I assume

$$\widetilde{\alpha} = \Big(\underset{[-6.744]}{-0.235}, 0, 0, 0, 0\Big)'. \tag{4.14}$$

The restricted estimate for α in equation (4.14) means that, the only variable of the system that adjusts in response to deviations from the long-run relation $\widetilde{\beta}' X_{t-1} = \delta^B_{t-1}$, is Φ_t. Moreover, the coefficient means that it takes almost four weeks for deviations from the previous period long-run relation to dissipate for Φ_t. This is important. Suppose there is a *stationary* one-time shock to δ^B_{t-4}, thus creating arbitrage opportunities. Their effect on Φ_s will take four weeks to dissipate.

Common Trends Representation

The VECM set-up also allows me to write (4.1) in its common trends representation or Moving Average (MA) form, as proved in the Granger Representation Theorem. This allows the identification of the $n-r$ common trends in the system X_t and has a very intuitive interpretation. The MA form is written as

$$X_t = C\sum_{s=1}^{t}\varepsilon_s + \sum_{j=0}^{\infty} C^*_j \varepsilon_{t-j} + X_0 \tag{4.15}$$

$$C = \beta_\perp \left[\alpha'_\perp \left(I_n - \sum_{s=1}^{p-1}\Gamma_s\right)\beta_\perp\right]^{-1} \alpha'_\perp = \widetilde{\beta}_\perp \alpha'_\perp \tag{4.16}$$

where $\beta_\perp$ is the orthogonal complement of β, defined as the $(n-r)\times r$ matrix satisfying $\beta'_\perp\beta = 0$ and similarly for $\alpha_\perp$.[18] The first component of equation (4.15) deserves special attention, in particular note that the product $C\sum_{s=1}^{t}\varepsilon_s$ is $\widetilde{\beta}_\perp\alpha'_\perp\sum_{s=1}^{t}\varepsilon_s$ using (4.16). It is possible to think of $\widetilde{\beta}_\perp$ as matrix measuring the importance (weight) that each of the common trends $\alpha'_\perp\sum_{s=1}^{t}\varepsilon_s$ has on X_t.

The $n\times n$ matrix C defined in (4.16) is known as the "long-run impact matrix" and it is interpreted in two possible ways. Column-wise, the element c_{ij}, if statistically significant, means the cumulated effect $\sum_{s=1}^{t}\varepsilon_{j,s}$ has a relevant effect of c_{ij} on x_i. Row-wise, the element c_{ij} means that x_i has been permanently influenced by $\sum_{s=1}^{t}\varepsilon_{j,s}$ in some measure c_{ij}. The matrices C_j^* are the current and previous "one-time" effects of each element of ε_t on the system X_t and X_0 is its initial value.

For the present model, restricted estimates of the long-run impact matrix yield the following common trend representations. The interested reader can find the full estimation output in Appendix B.3. Recall that Σ is a full matrix as described in (4.3), Table 11 shows the corresponding correlations for a restricted version, Σ_B.

	ε_Φ	$\varepsilon_{i,us}$	$\varepsilon_{i,mex}$	$\varepsilon_{LOIS,us}$	$\varepsilon_{LOIS,eur}$
S.E.	0.410	0.163	0.231	0.096	0.081
ε_Φ	1.000				
$\varepsilon_{i,us}$	0.677	1.000			
$\varepsilon_{i,mex}$	−0.661	−0.053	1.000		
$\varepsilon_{LOIS,us}$	−0.729	−0.553	0.172	1.000	
$\varepsilon_{LOIS,eur}$	−0.568	−0.469	0.150	0.921	1.000

Table 11: Residual Standard Errors and Cross-Correlations. Since the covariance matrix Σ_B is symmetric, I omit the upper triangular elements.

The advantage of the MA form is the representation of each variable as the sum of the history of previous shocks, which although correlated, are useful in explaining changes in each element of system X_t. Here I use the restricted estimate $\widetilde{C}$ given in Table 28 in Appendix B.3 to construct the estimated MA expressions -omitting stationary terms. Let $C^*_{[k,\cdot]j}$ be the kth row of matrix C^*_j. Start with Φ_t, which has a MA representation given by

$$\Phi_t = \underset{[-1.924]}{-0.217}\sum_{j=1}^{t}\varepsilon_{\Phi,j} + \underset{[3.920]}{1.568}\sum_{j=1}^{t}\varepsilon_{i,us,j} \underset{[-5.276]}{-1.667}\sum_{j=1}^{t}\varepsilon_{i,mex,j} \underset{[-4.656]}{-3.677}\sum_{j=1}^{t}\varepsilon_{LOIS,us,j} + \sum_{j=0}^{\infty}C^*_{[1,\cdot]j}\varepsilon_{t-j}. \tag{4.17}$$

[18]The proof of (4.15) and (4.16) is contained in Lütkepohl (2005).

In line with the weak exogeneity test, equation (4.17) shows all the stochastic trends have a non-negligible effect on Φ_t. $LOIS_{eur,t}$ is present through the correlation between $\varepsilon_{LOIS,us}$ and $\varepsilon_{LOIS,eur}$ which is very close to 1, as shown in Table 11.

For $i_{us,t}$, equation (4.18) shows a result in line with its "marginal" weak exogeneity status that only shocks to itself and $\varepsilon_{LOIS,us}$ explain its behaviour,

$$i_{us,t} = \underset{[6.922]}{1.099} \sum_{j=1}^{t} \varepsilon_{i,us,j} \underset{[-2.291]}{-0.718} \sum_{j=1}^{t} \varepsilon_{LOIS,us,j} + \sum_{j=0}^{\infty} C^{*}_{[2,\cdot]j} \varepsilon_{t-j}. \tag{4.18}$$

The estimation outcome for $i_{mex,t}$ in (4.19) is surprising. I would have expected that at least a second stochastic trend could be explaining changes in the Mexican Treasury yield. This issue deserves a deeper study, since the correlations between $i_{mex,t}$ and the rest of the variables is not high enough to justify some second order effect from a different variable in the system. Although said second order effects should be present since the reduced form errors ε_t are contemporaneously related. The structural analysis below shows more light on this issue,

$$i_{mex,t} = \underset{[8.739]}{1.558} \sum_{j=1}^{t} \varepsilon_{i,mex,j} + \sum_{j=0}^{\infty} C^{*}_{[3,\cdot]j} \varepsilon_{t-j}. \tag{4.19}$$

Finally, the MA forms of $LOIS_{us,t}$ and $LOIS_{eur,t}$ in (4.20) and (4.21) show no surprises, the variables behave as two weakly exogenous elements, with a high correlation among them

$$LOIS_{us,t} = \underset{[-2.374]}{-0.223} \sum_{j=1}^{t} \varepsilon_{i,us,j} + \underset{[7.439]}{1.377} \sum_{j=1}^{t} \varepsilon_{LOIS,us,j} + \sum_{j=0}^{\infty} C^{*}_{[4,\cdot]j} \varepsilon_{t-j}, \tag{4.20}$$

$$LOIS_{eur,t} = \underset{[4.989]}{0.776} \sum_{j=1}^{t} \varepsilon_{LOIS,us,j} + \underset{[4.277]}{1.117} \sum_{j=1}^{t} \varepsilon_{LOIS,eur,j} + \sum_{j=0}^{\infty} C^{*}_{[5,\cdot]j} \varepsilon_{t-j}. \tag{4.21}$$

So far, I have been able to show the relevance of both $LOIS_{us,t}$ and $LOIS_{eur,t}$ in explaining the behaviour of the variables that define δ_t. The previous analysis comes a long way in separating effects from each shock into the behaviour of each element of X_t. There is a shortcoming, however, and that is related to the covariance matrix of the reduced form errors, Σ_B contained in Table 11, not being diagonal. Shocks between $LOIS_{us,t}$ and $LOIS_{eur,t}$ cannot be distinguished clearly. To accomplish this, a structural analysis is required, which is undertaken in the next section.

4.5 Structural VECM

The SVECM(p) can be readily derived from expression (4.15). The only additional element I need is a "rotation" matrix relating the reduced-form errors vector ε_t, to the "structural" errors vector u_t. The latter are called structural since they are contemporaneously uncorrelated among each other. This is, they have a diagonal covariance matrix Ω. Formally, assume there exists a $(n \times n)$ non-singular rotation matrix M such that

$$u_t = M\varepsilon_t, \tag{4.22}$$

note that the Choleski decomposition provides a matrix that is a particular case of M. One of the advantages of estimating the IRFs in a SVECM and not through a Choleski decomposition matrix is that I can label the shocks as transitory or permanent.[19] Juselius (2006) pp. 278 outlines the conditions that the matrix M must satisfy which I reproduce here:

1. A distinction between $r = 1$ transitory and $n - r = 4$ permanent shocks is made (i.e. $u_t = \left(u_{tr,t}, u'_{pr,t}\right)'$, where "tr" stands for transitory and "pr" for permanent).
2. Transitory shocks have no long-run impact on the system.
3. Either $\Omega = I_n$; or
4. $E\left[u_{pr,t}u'_{pr,t}\right] = I_{n-r}$ with $E\left[u_{tr,t}u'_{pr,t}\right] \neq 0$.

For estimation purposes, it is necessary to assume some causal direction among the variables that have permanent shocks associated, in this case the weakly exogenous variables. Thus, I assume that $i_{us,t}$ is independent from other permanent shocks and affects $LOIS_{us,t}$. In turn, $LOIS_{eur,t}$ is affected by permanent shocks in $LOIS_{us,t}$. Finally, $i_{mex,t}$ is subject to changes in all permanent shocks. This order obeys the economic logic behind the variables in the system. That is, structurally, the $i_{us,t}$ follows its own shocks; the banking system of the U.S. is larger than the European one however interconnected; the European banking sector is independent of the structural shocks in $i_{mex,t}$ -given that Mexico is a small open economy. Finally, there is one transitory shock in the system causing the variables to deviate only for a finite period of time.

Estimation in CATS requires me to change the order of the variables in the system, which I can do without any consequences for the previous results. In particular, let $\overline{X}_t$ be

[19] Empirical applications of the SVECM are found in Mellander, Vredin, and Warne (1992) and Hansen and Warne (2001).

the reordered X_t, where now $\overline{X}_t = (\Phi_t, i_{us,t}, LOIS_{us,t}, LOIS_{eur,t}, i_{mex,t})'$. Using (4.22) in (4.15) I get

$$\overline{X}_t = D\sum_{s=1}^{t} u_s + \sum_{j=0}^{\infty} D_j^* u_{t-j}, \tag{4.23}$$

where $D = CM^{-1}$ and $D_j^* = C_j^* M^{-1}$. CATS produces restricted estimates of D, D_0^*, D_K^* and M. Where the sub-index K is the number of periods that the system takes to converge back after a transitory shock. Here I have to include the restriction set B, as detailed in expression (4.7), in the estimation. The full estimation output can be found in Appendix B.4.

Transitory Shocks

Restricted estimation of the model (4.23) yields the following transitory shock, constructed as the product of the first row of the restricted matrix estimate $\widetilde{M}$ given in Table 33 and ε_t,

$$u_{tr,t} = -0.435\varepsilon_{\Phi,t} - 0.569\varepsilon_{i,us,t} + \varepsilon_{LOIS,us,t} + 0.162\varepsilon_{LOIS,eur,t} + 0.390\varepsilon_{i,mex,t}, \tag{4.24}$$

after normalizing on the largest coefficient. At this point, I can only state that a structural transitory shock to the system $\overline{X}_t$ is a linear combination of elements of ε_t. It is important, however, that I have found the weight of each reduced-form error in the structural shock. I will come back to this point.

Permanent Shocks

The four permanent shocks are defined by the last four rows of the normalized matrix $\widetilde{M}$ of Table 33,

$$u_{pr,1,t} = \varepsilon_{i,us,t} - 0.653\varepsilon_{LOIS,us,t} + 0.487\varepsilon_{LOIS,eur,t}, \tag{4.25}$$

$$u_{pr,2,t} = 0.12\varepsilon_{i,us,t} + \varepsilon_{LOIS,us,t} + 0.345\varepsilon_{LOIS,eur,t}, \tag{4.26}$$

$$u_{pr,3,t} = -0.331\varepsilon_{LOIS,us,t} + \varepsilon_{LOIS,eur,t}, \tag{4.27}$$

$$u_{pr,4,t} = -0.627\varepsilon_{LOIS,us,t} + 0.491\varepsilon_{LOIS,eur,t} + \varepsilon_{i,mex,t}. \tag{4.28}$$

I have discarded from equations (4.25) to (4.28) all coefficients that are lower than 0.1 following the practice of Juselius (2006). This may seem arbitrary but three comments should comfort the reader: First, the software does not provide the standard errors for estimates of the SVECM, so an educated guess for the relevance of each shock is necessary. Second, considering that standard deviations of ε_t are low as presented in Table 11, the absolute magnitude of the estimated parameter for each shock should be a useful indicator. Third, this elimination makes the labelling of the structural shocks possible.

Labelling the Structural Shocks

As suggested in Juselius (2006), allocating labels to the structural shocks is a "hazardous" task, but here I have information on the causality orders. Since $\varepsilon_{i,mex,t}$ only shows up in $u_{pr,4,t}$ as constructed in equation (4.28), I can associate this shock with $i_{mex,t}$. According to the MA equation for $LOIS_{eur,t}$ (4.21), only shocks to itself and $LOIS_{us,t}$ are relevant to its time path, thus I can associate $u_{pr,3,t}$ to $LOIS_{eur,t}$. Finally, the absolute magnitude in coefficients associated with $LOIS_{us,t}$ in equations (4.25) and (4.26) suggests that $i_{us,t}$ can be associated with $u_{pr,1,t}$, and $LOIS_{us,t}$ to $u_{pr,2,t}$.

It is important to point out the downsides associated with the labelling process. It is still somewhat arbitrary, just as the Choleski decomposition. In the absence of clear directions of causality and without more information on the possible simultaneous effects among the elements of $\overline{X}$, the labelling should be taken with some reserve. The labels proposed above are supported by the normalized rotation matrix in Table 33.

Structural Representation

Analysis of the IRFs is the ultimate tool when analysing the dynamics of a VAR model. To obtain the IRFs of the SVECM, I use the structural long-run impact matrix with restricted estimates $\widetilde{D}$ from Table 36. The full estimation output is given in Appendix B.4 for the interested reader. Let $D^*_{[k,\cdot]j}$ be the $k-th$ row of matrix D^*_j. The structural equation for Φ_t is given by

$$\Phi_t = 1.707\sum_{j=1}^{t} u_{pr,1,j} - 2.181\sum_{j=1}^{t} u_{pr,2,j} + 3.007\sum_{j=1}^{t} u_{pr,3,j} - \sum_{j=1}^{t} u_{pr,4,j} + \sum_{j=0}^{\infty} \widetilde{D}^*_{[1,\cdot],j} u_{t-j}. \quad (4.29)$$

Note that the first four elements on the right are a linear combination of stochastic trends constructed out of permanent structural shocks. Assuming the labelling of the shocks is correct, expression (4.29) allows me to conclude that the forward premium Φ_t has a positive relation with the permanent shocks from $i_{us,t}$ and $LOIS_{eur,t}$, while negatively related to those of $LOIS_{us,t}$ and $i_{mex,t}$. Transitory shocks on Φ_t are contained in the last element of the right of (4.29). It is interesting to note that, in line with expression (4.7), the effects on Φ_t from liquidity shocks have a different sign, conditionally on the source of the shock.

The structural equation for $i_{us,t}$ is estimated as

$$i_{us,t} = \sum_{j=1}^{t} u_{pr,1,j} + \sum_{j=0}^{\infty} \widetilde{D}^{*}_{[2,\cdot],j} u_{t-j}, \tag{4.30}$$

this expression is independent of the rest of stochastic trends by construction. Transitory shocks implied by the presence of $\widetilde{D}^{*}_{[2,\cdot],j} u_{t-j}$ in (4.30) do play a role, however small, on the behaviour of $i_{us,t}$ as shown by the IRFs below.

The liquidity measure for the banking sector of the U.S. given by (4.31) is negatively related to permanent shocks associated to $i_{us,t}$, in particular I can write

$$LOIS_{us,t} = -0.327 \sum_{j=1}^{t} u_{pr,1,j} + \sum_{j=1}^{t} u_{pr,2,j} + \sum_{j=0}^{\infty} \widetilde{D}^{*}_{[3,\cdot],j} u_{t-j}. \tag{4.31}$$

The analogous measure of liquidity for the European banking sector contains information that is in line with intuition. Note the positive sign of $u_{pr,2,t}$, the permanent shocks on $LOIS_{us,t}$. This is, when there is a shock to liquidity in the U.S., liquidity in Europe is also under stress,

$$LOIS_{eur,t} = -0.233 \sum_{j=1}^{t} u_{pr,1,j} + 0.802 \sum_{j=1}^{t} u_{pr,2,j} + \sum_{j=1}^{t} u_{pr,3,j} + \sum_{j=0}^{\infty} \widetilde{D}^{*}_{[4,\cdot],j} u_{t-j}, \tag{4.32}$$

where the estimate from the structural long-run impact matrix is 0.802 -close to 1. As I mentioned in the subsection containing the labelling, the banking sector in Europe is smaller than the U.S.'s and this explains the one-way dependence assumption for identification. Note that both (4.31) and (4.32) account for transitory shocks within the last term of each expression. Finally, I have the structural equation for $i_{mex,t}$. This will depend on both the benchmark interest rate of the world and the liquidity conditions in the U.S. and Europe. The estimation output yields

$$i_{mex,t} = -0.075 \sum_{j=1}^{t} u_{pr,1,j} + 0.496 \sum_{j=1}^{t} u_{pr,2,j} - 0.208 \sum_{j=1}^{t} u_{pr,3,j} + \sum_{j=1}^{t} u_{pr,4,j} + \sum_{j=0}^{\infty} \widetilde{D}^{*}_{[5,\cdot],j} u_{t-j}. \tag{4.33}$$

Expression (4.33) shows that the common trend representation (4.19) hides the contemporaneous relation between $i_{mex,t}$ and the rest of the variables since it is given in terms of the reduced form errors. In particular, I find that permanent shocks to liquidity conditions in the U.S. and Europe have opposite effects on $i_{mex,t}$, although the former more than duplicates the latter. The negative sign on the relation with $i_{us,t}$ is something that deserves further study. It is at odds with the rationale where $i_{us,t}$ is the benchmark rate. I propose here a direct explanation. The aforementioned flight-to-quality phenomenon will provide an environment where, simultaneously, the demand for U.S.'s. debt increases pushing down its yield and Mexico's $i_{mex,t}$ increases since capital flows from Mexico towards the U.S..

Impulse Response Analysis

Figure 10 presents the IRFs in subplots. Each subplot shows the value of the relevant variable immediately after a one-standard deviation shock given by Table 37 at t_0. Table 38 presents the value after $K = 60$ weeks -the number of weeks $u_{tr,t}$ takes to convergence back to zero. Some interesting results arise from the column-wise inspection of Figure 10.

The transitory shock $u_{tr,t}$ affects considerably the three variables that define δ_t and $LOIS_{eur,t}$. The shock has a negative effect on Φ_t and $i_{us,t}$. It is worth noting that the shock pushes up $LOIS_{us,t}$ and $LOIS_{eur,t}$ for several periods before they gradually crawl back to their level previous to the shock. This observation leads to conclude that $u_{tr,t}$ causes the liquidity measures to "overshoot" before its effects dissipate.

Regarding $u_{pr,1,t}$, a structural permanent shock to the system associated to $i_{us,t}$, note that the initial negative pull on Φ_t becomes a permanent positive shock. The effect of $u_{pr,1,t}$ on $i_{mex,t}$ is immediately positive, then it turns negative for a few periods, then becomes positive for a non-negligible period, and finally sinks to a negative value. This "swing" behaviour may be a result of the deep connection between the U.S. and Mexico's economies. Finally the effects on $LOIS_{us,t}$ "overshoot" but stabilize while the effects on $LOIS_{eur,t}$ are almost monotonically decreasing.

The structural permanent shock related to $LOIS_{us,t}$, $u_{pr,2,t}$, pushes up Φ_t instantaneously but then its effects sink considerably to become permanently negative. For $i_{mex,t}$, the impulse heads upwards, then it dips and later tends upwards again before stabilizing. This "swing" behaviour reflects how distressing is a funding liquidity shock in the U.S. banking sector to $i_{mex,t}$.

When the system suffers a structural permanent shock $u_{pr,3,t}$, associated with $LOIS_{eur,t}$, it affects Φ_t in the form of extreme swings for the first few weeks. After that, the value of the impulse converges steadily to a permanent positive value. Similar volatility is present in the effect of $u_{pr,3,t}$ on $i_{mex,t}$ with a considerable overshooting before converging definitely to a level closer to zero. This is, the shock creates some "turbulence" on $i_{mex,t}$, but its effects eventually stabilise at a small negative level. Finally, the permanent shock $u_{pr,4,t}$, associated to $i_{mex,t}$, causes a response of Φ_t that is negative at the beginning but quickly turns positive and permanent.

It follows from the analysis of the IRFs that the elements of δ_t, except $i_{us,t}$, are very sensible to the structural shocks u_t. In particular, Φ_t is the most sensible in line with its non-weak exogenous nature. A caveat of the analysis arises here. To compute deviations from the CIP I need to use $i_{us,t}$; this, however, is not only the yield on a sovereign debt instrument, but it also stands for the yield of one of the safest assets in the world. The latter makes it possible to assume that it is not affected by any permanent shock but its own. However, it also forces the analysis to be mute on shocks to it, allocating all the dynamic corrections on δ_t to Φ_t and $i_{mex,t}$.

Variance Decomposition Analysis

After I have established that liquidity shocks born in Europe have a role in explaining deviations form the CIP, here I quantify the relative importance of changes in $LOIS_{us,t}$ and $LOIS_{eur,t}$ with a variance decomposition analysis. Appendix B.5 contains Tables 39 - 41 with a summary of the decomposition for 60 steps.[20] Inspection of Table 39 reveals that the liquidity conditions in the U.S.'s banking sector play a much more important role in changes in $i_{us,t}$ than Europe's. Surprisingly, they are less important in accounting for changes in $i_{mex,t}$ as shown in Table 40. Accordingly with Mexico's status as a small open economy, the source of the liquidity changes is not relevant in explaining changes on $i_{mex,t}$.

Finally, Table 41 shows that shocks to $LOIS_{us,t}$ are at least twice as important in period 1 and, at most, 27 times in period 25 when looking at Φ_t. Note that this estimate is accounting for several particular features. First, the U.S.'s banking sector is the largest in the world. Second, I am analysing the CIP involving the USD, the currency in which $LOIS_{us,t}$ is traded. This should help the case that, however small when compared with $LOIS_{us,t}$, changes in $LOIS_{eur,t}$ are important in determining deviations from the CIP.

5 Concluding Remarks

Several implications and remarks can be drawn from this work. First, expressions (4.7), (4.17), and (4.29) show that $LOIS_{eur,t}$ has a long-run effect on deviations from the CIP, however small -as revealed by the variance decomposition analysis. Second, IRFs quantify the effect of a shock on the interest rate in Mexican debt on the forward premium.

Third, by looking at the dynamics of the forward premium in expression (4.9), shocks to the CIP augmented with liquidity measures take about four periods to dissipate. That is, the forward premium is on a self-correcting path. The fourth implication stems from the

[20] I thank the anonymous referee for suggesting the variance decomposition analysis. This was estimated in EViews for the VECM(6) with restrictions set B and a Choleski matrix with order as follows: $i_{us,t}, LOIS_{us,t}, LOIS_{eur,t}, i_{mex,t}, \Phi_t$.

prevailing opposite sign of the coefficients on the liquidity measures in expressions (4.7), (4.11) and (4.28), which can be interpreted as follows: Mexican assets, its sovereign debt in particular, seem to be substitutes for European assets within the sample period. Thus, the analysis implies that shocks in liquidity in Europe could precede a fall in the interest rate on Mexican instruments and refinancing debt strategies could take advantage of this.

This work provides an additional tool to form an expectation regarding the duration and importance of shocks to funding liquidity. The analysis points to the existence of arbitrage opportunities -which will be taken only if the premium is high enough- for any market participant that was able to obtain funding as close to U.S. treasury interest rate as possible. The above said opportunities remained since 2009 up-to the end of the sample period and may be explained by funding liquidity constraints. Another way of looking at this conclusion is: there should be no deviations from the CIP once truer liquidity conditions are considered.

There are some caveats in the analysis to consider. First, the borderline conclusion of the liquidity measures being $I(1)$ should be present before making further conclusions. Second, the labelling of the structural shocks remains as arbitrary as a Choleski decomposition. Third, many market participants are not able to fund their liquidity at LIBOR or OIS rates, but at higher ones, future analysis should aim to find a liquidity measure for non-prime borrowers.

Further research should focus on testing different models that account for the borderline stationarity of the $LOIS_{\cdot,t}$ and test other measures associated with market liquidity, such as Credit Default Swaps or Volatility indexes. The financial series present considerable ARCH-like behaviour, this may be a source of information to explore. Continuous time models could prove to be a natural way to model high frequency financial series. Finally, structural breaks can be considered to account for “once-and-for-all” events, such as Lehman’s demise.

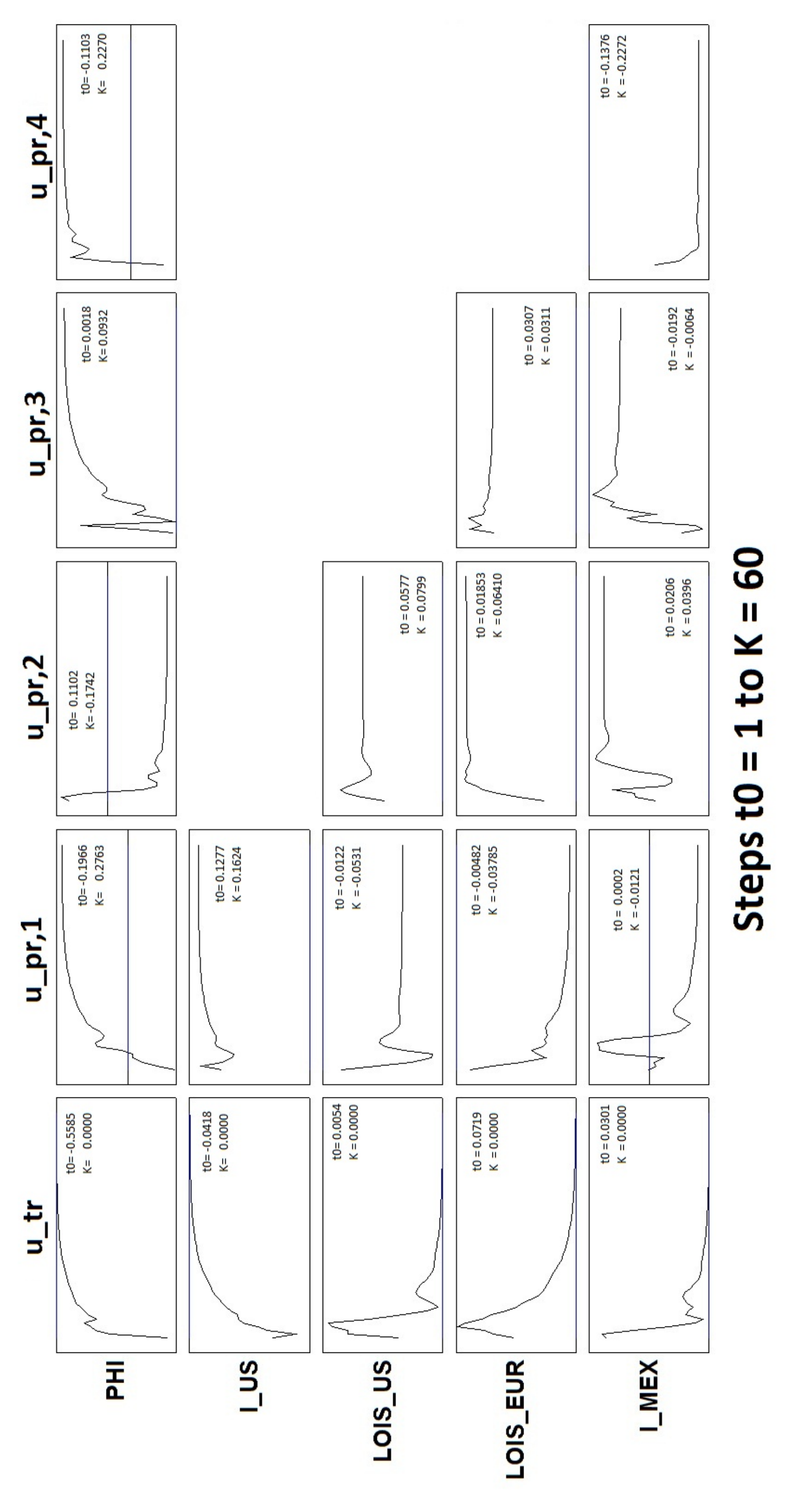

Figure 10: IRFs from the SVECM.

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Appendices

A Data

This appendix contains the Bloomberg ticker of each variable. To ease the exposition, I divide the variables in 2 groups:

1. Main Variables:
   - Spot Exchange Rate USD per 1 MXN: $(S_t)^{-1}$ =MXN Curncy.
   - Forward Exchange Rate USD per 1 MXN at maturity 1 month: $(F_t)^{-1}$=MXN1M Curncy.
   - Interest Rate of U.S. Treasury Debt 1-month constant maturity: $i_{us,t}$ =USGG1M Index.
   - Interest Rate of Mexican Debt in MXN of 1-month maturity: $i_{mex,t}$ =MPTBA Curncy.
2. LIBOR-OIS
   - LIBOR-OIS Spread for the U.S.: $LOIS_{us,t}$ =(US0003M Index) - (USSOC Curncy).
   - LIBOR-OIS Spread for Europe: $LOIS_{eur,t}$ =(EUR003M Index) - (EUSWEC Curncy).

B Estimation Results

B.1 Unrestricted VECM(6) with $r = 1$

This section presents the full estimation output of the VECM(6) corresponding to the cointegrating equation (4.4).

$\widehat{\beta}'$					
Φ_{t-1}	$i_{us,t-1}$	$i_{mex,t-1}$	$LOIS_{us,t-1}$	$LOIS_{eur,t-1}$	c
1.000	-1.032	0.815	5.385	-4.344	0.785
$[NA]$	$[-11.786]$	[8.145]	[6.405]	$[-4.952]$	[1.360]

Table 12

$\widehat{\alpha}$	
ΔPhi_t	-0.239
	$[-7.175]$
$\Delta i_{us,t}$	-0.017
	$[-2.186]$
$\Delta i_{mex,t}$	0.015
	[1.974]
$\Delta LOIS_{us,t}$	-0.000
	$[-0.044]$
$\Delta LOIS_{eur,t}$	0.003
	[1.665]

Table 13

$\widehat{\Pi}$						
	Φ_{t-1}	$i_{us,t-1}$	$i_{mex,t-1}$	$LOIS_{us,t-1}$	$LOIS_{eur,t-1}$	c
$\Delta\Phi_t$	−0.239 [−7.175]	0.247 [7.175]	−0.195 [−7.175]	−1.288 [−7.175]	1.039 [7.175]	−0.188 [−7.175]
$\Delta i_{us,t}$	−0.017 [−2.186]	0.017 [2.186]	−0.014 [−2.186]	−0.091 [−2.186]	0.073 [2.186]	−0.013 [−2.186]
$\Delta i_{mex,t}$	0.015 [1.974]	−0.016 [−1.974]	0.013 [1.974]	0.083 [1.974]	−0.067 [−1.974]	0.012 [1.974]
$\Delta LOIS_{us,t}$	−0.000 [−0.044]	0.000 [0.044]	−0.000 [−0.044]	−0.001 [−0.044]	0.001 [0.044]	−0.000 [−0.044]
$\Delta LOIS_{eur,t}$	0.003 [1.665]	−0.003 [−1.665]	0.003 [1.665]	0.018 [1.665]	−0.015 [−1.665]	0.003 [1.665]

Table 14

The Short-Run Matrices

$\widehat{\Gamma}_1$					
	$\Delta\Phi_{t-1}$	$\Delta i_{us,t-1}$	$\Delta i_{mex,t-1}$	$\Delta LOIS_{us,t-1}$	$\Delta LOIS_{eur,t-1}$
$\Delta\Phi_t$	−0.307 [−6.500]	−0.284 [−1.388]	−0.773 [−3.943]	2.654 [4.993]	−0.009 [−0.011]
$\Delta i_{us,t}$	0.017 [1.602]	0.174 [3.683]	0.069 [1.529]	−0.085 [−0.691]	−0.533 [−2.851]
$\Delta i_{mex,t}$	0.003 [0.235]	0.024 [0.502]	0.325 [7.045]	−0.120 [−0.962]	0.115 [0.604]
$\Delta LOIS_{us,t}$	0.007 [1.406]	−0.126 [−6.249]	−0.007 [−0.386]	0.301 [5.728]	0.539 [6.746]
$\Delta LOIS_{eur,t}$	−0.001 [−0.235]	−0.019 [−1.556]	−0.014 [−1.139]	0.154 [4.786]	0.322 [6.562]

Table 15

$\widehat{\Gamma}_2$					
	$\Delta\Phi_{t-2}$	$\Delta i_{us,t-2}$	$\Delta i_{mex,t-2}$	$\Delta LOIS_{us,t-2}$	$\Delta LOIS_{eur,t-2}$
$\Delta\Phi_t$	−0.237 [−4.878]	0.058 [0.270]	−0.651 [−3.180]	0.380 [0.704]	−0.508 [−0.599]
$\Delta i_{us,t}$	0.014 [1.240]	−0.333 [−6.677]	−0.005 [−0.101]	−0.036 [−0.285]	0.590 [3.013]
$\Delta i_{mex,t}$	0.008 [0.731]	0.036 [0.702]	−0.042 [−0.879]	−0.171 [−1.343]	0.103 [0.516]
$\Delta LOIS_{us,t}$	0.012 [2.563]	−0.053 [−2.495]	0.026 [1.309]	0.110 [2.069]	−0.368 [−4.388]
$\Delta LOIS_{eur,t}$	−0.001 [−0.208]	−0.014 [−1.064]	0.003 [0.225]	0.141 [4.299]	−0.287 [−5.581]

Table 16

$\widehat{\Gamma}_3$					
	$\Delta\Phi_{t-3}$	$\Delta i_{us,t-3}$	$\Delta i_{mex,t-3}$	$\Delta LOIS_{us,t-3}$	$\Delta LOIS_{eur,t-3}$
$\Delta\Phi_t$	-0.179 [-3.717]	-0.161 [-0.713]	0.063 [0.308]	-1.215 [-2.316]	-2.111 [-2.470]
$\Delta i_{us,t}$	0.020 [1.796]	-0.063 [-1.205]	0.034 [0.706]	0.110 [0.910]	-0.238 [-1.204]
$\Delta i_{mex,t}$	0.021 [1.864]	0.018 [0.347]	0.060 [1.232]	-0.116 [-0.938]	0.442 [2.196]
$\Delta LOIS_{us,t}$	0.005 [1.033]	-0.039 [-1.771]	0.010 [0.502]	-0.122 [-2.357]	0.089 [1.055]
$\Delta LOIS_{eur,t}$	-0.005 [-1.651]	0.005 [0.395]	-0.007 [-0.534]	0.002 [0.070]	0.117 [2.261]

Table 17

$\widehat{\Gamma}_4$					
	$\Delta\Phi_{t-4}$	$\Delta i_{us,t-4}$	$\Delta i_{mex,t-4}$	$\Delta LOIS_{us,t-4}$	$\Delta LOIS_{eur,t-4}$
$\Delta\Phi_t$	-0.094 [-2.072]	-0.506 [-2.360]	-0.121 [-0.595]	0.208 [0.412]	0.752 [0.880]
$\Delta i_{us,t}$	0.006 [0.534]	-0.119 [-2.399]	-0.009 [-0.190]	0.002 [0.015]	0.172 [0.870]
$\Delta i_{mex,t}$	0.012 [1.090]	0.070 [1.378]	0.061 [1.279]	-0.496 [-4.170]	-0.137 [-0.679]
$\Delta LOIS_{us,t}$	0.001 [0.181]	-0.009 [-0.417]	0.004 [0.182]	-0.160 [-3.211]	-0.115 [-1.367]
$\Delta LOIS_{eur,t}$	-0.005 [-1.769]	0.064 [4.890]	-0.008 [-0.649]	-0.072 [-2.361]	0.039 [0.763]

Table 18

$\widehat{\Gamma}_5$					
	$\Delta\Phi_{t-5}$	$\Delta i_{us,t-5}$	$\Delta i_{mex,t-5}$	$\Delta LOIS_{us,t-5}$	$\Delta LOIS_{eur,t-5}$
$\Delta\Phi_t$	0.068 [1.671]	-0.205 [-0.937]	-0.189 [-0.968]	0.205 [0.411]	-0.510 [-0.637]
$\Delta i_{us,t}$	0.005 [0.518]	0.058 [1.142]	0.015 [0.338]	0.037 [0.321]	-0.072 [-0.390]
$\Delta i_{mex,t}$	0.009 [0.956]	-0.035 [-0.683]	0.010 [0.217]	0.175 [1.490]	0.216 [1.149]
$\Delta LOIS_{us,t}$	0.000 [0.051]	0.054 [2.522]	0.016 [0.852]	-0.027 [-0.542]	0.096 [1.217]
$\Delta LOIS_{eur,t}$	-0.004 [-1.525]	0.011 [0.829]	-0.005 [-0.459]	0.148 [4.894]	-0.046 [-0.955]

Table 19

B.2 VECM(6) with $r = 1$ Restriction Set B

	$\widetilde{\beta}^{B'}$					
	Φ_{t-1}	$i_{us,t-1}$	$i_{mex,t-1}$	$LOIS_{us,t-1}$	$LOIS_{eur,t-1}$	c
$\widetilde{\beta}^{B'}$	1.000	−1.000	1.000	3.929	−2.799	−0.502
	$[NA]$	$[NA]$	$[NA]$	[5.977]	[−3.997]	[−3.307]

Table 20

	$\widetilde{\alpha}$
$\Delta\Phi_t$	−0.235
	[−6.744]
$\Delta i_{us,t}$	−0.018
	[−2.199]
$\Delta i_{mex,t}$	0.013
	[1.554]
$\Delta LOIS_{us,t}$	0.002
	[0.675]
$\Delta LOIS_{eur,t}$	0.003
	[1.439]

Table 21

	$\widetilde{\Pi}$					
	Φ_t	$i_{us,t}$	$i_{mex,t}$	$LOIS_{us,t}$	$LOIS_{eur,t}$	c
$\Delta\Phi_t$	−0.235	0.235	−0.235	−0.924	0.658	0.118
	[−6.744]	[6.744]	[−6.744]	[−6.744]	[6.744]	[6.744]
$\Delta i_{us,t}$	−0.018	0.018	−0.018	−0.069	0.049	0.009
	[−2.199]	[2.199]	[−2.199]	[−2.199]	[2.199]	[2.199]
$\Delta i_{mex,t}$	0.013	−0.013	0.013	0.050	−0.036	−0.006
	[1.554]	[−1.554]	[1.554]	[1.554]	[−1.554]	[−1.554]
$\Delta LOIS_{us,t}$	0.002	−0.002	0.002	0.009	−0.006	−0.001
	[0.675]	[−0.675]	[0.675]	[0.675]	[−0.675]	[−0.675]
$\Delta LOIS_{eur,t}$	0.003	−0.003	0.003	0.012	−0.008	−0.002
	[1.439]	[−1.439]	[1.439]	[1.439]	[−1.439]	[−1.439]

Table 22

The Short-Run Matrices for Restrictions B

	$\widetilde{\Gamma}_1$				
	$\Delta\Phi_{t-1}$	$\Delta i_{us,t-1}$	$\Delta i_{mex,t-1}$	$\Delta LOIS_{us,t-1}$	$\Delta LOIS_{eur,t-1}$
$\Delta\Phi_t$	-0.302 [-6.268]	-0.278 [-1.346]	-0.767 [-3.875]	2.457 [4.646]	0.163 [0.200]
$\Delta i_{us,t}$	0.018 [1.664]	0.173 [3.650]	0.071 [1.566]	-0.094 [-0.777]	-0.522 [-2.797]
$\Delta i_{mex,t}$	0.004 [0.341]	0.020 [0.414]	0.329 [7.076]	-0.097 [-0.783]	0.101 [0.531]
$\Delta LOIS_{us,t}$	0.005 [1.070]	-0.123 [-6.056]	-0.011 [-0.578]	0.290 [5.595]	0.542 [6.797]
$\Delta LOIS_{eur,t}$	-0.001 [-0.194]	-0.020 [-1.592]	-0.013 [-1.103]	0.158 [4.957]	0.319 [6.512]

Table 23

	$\widetilde{\Gamma}_2$				
	$\Delta\Phi_{t-2}$	$\Delta i_{us,t-2}$	$\Delta i_{mex,t-2}$	$\Delta LOIS_{us,t-2}$	$\Delta LOIS_{eur,t-2}$
$\Delta\Phi_t$	-0.229 [-4.644]	0.081 [0.376]	-0.618 [-2.992]	0.163 [0.304]	-0.356 [-0.418]
$\Delta i_{us,t}$	0.015 [1.314]	-0.332 [-6.678]	-0.002 [-0.035]	-0.047 [-0.379]	0.598 [3.061]
$\Delta i_{mex,t}$	0.009 [0.770]	0.031 [0.608]	-0.043 [-0.880]	-0.147 [-1.167]	0.087 [0.436]
$\Delta LOIS_{us,t}$	0.011 [2.328]	-0.050 [-2.350]	0.025 [1.215]	0.101 [1.912]	-0.362 [-4.328]
$\Delta LOIS_{eur,t}$	-0.001 [-0.203]	-0.015 [-1.116]	0.003 [0.204]	0.145 [4.473]	-0.290 [-5.644]

Table 24

	$\widetilde{\Gamma}_3$				
	$\Delta\Phi_{t-3}$	$\Delta i_{us,t-3}$	$\Delta i_{mex,t-3}$	$\Delta LOIS_{us,t-3}$	$\Delta LOIS_{eur,t-3}$
$\Delta\Phi_t$	-0.170 [-3.484]	-0.138 [-0.610]	0.105 [0.508]	-1.407 [-2.690]	-1.965 [-2.288]
$\Delta i_{us,t}$	0.021 [1.867]	-0.062 [-1.199]	0.037 [0.777]	0.100 [0.833]	-0.228 [-1.155]
$\Delta i_{mex,t}$	0.021 [1.847]	0.014 [0.263]	0.058 [1.194]	-0.096 [-0.782]	0.432 [2.143]
$\Delta LOIS_{us,t}$	0.004 [0.915]	-0.037 [-1.643]	0.009 [0.452]	-0.130 [-2.526]	0.090 [1.068]
$\Delta LOIS_{eur,t}$	-0.005 [-1.665]	0.005 [0.348]	-0.007 [-0.570]	0.006 [0.183]	0.115 [2.219]

Table 25

$\widetilde{\Gamma}_4$					
	$\Delta\Phi_{t-4}$	$\Delta i_{us,t-4}$	$\Delta i_{mex,t-4}$	$\Delta LOIS_{us,t-4}$	$\Delta LOIS_{eur,t-4}$
$\Delta\Phi_t$	−0.084 [−1.846]	−0.482 [−2.240]	−0.079 [−0.386]	0.058 [0.116]	0.880 [1.025]
$\Delta i_{us,t}$	0.006 [0.603]	−0.118 [−2.387]	−0.006 [−0.120]	−0.006 [−0.054]	0.180 [0.913]
$\Delta i_{mex,t}$	0.011 [1.041]	0.066 [1.303]	0.059 [1.234]	−0.480 [−4.055]	−0.146 [−0.727]
$\Delta LOIS_{us,t}$	0.001 [0.156]	−0.007 [−0.314]	0.003 [0.147]	−0.166 [−3.350]	−0.114 [−1.351]
$\Delta LOIS_{eur,t}$	−0.005 [−1.811]	0.063 [4.847]	−0.009 [−0.689]	−0.069 [−2.282]	0.038 [0.725]

Table 26

$\widetilde{\Gamma}_5$					
	$\Delta\Phi_{t-5}$	$\Delta i_{us,t-5}$	$\Delta i_{mex,t-5}$	$\Delta LOIS_{us,t-5}$	$\Delta LOIS_{eur,t-5}$
$\Delta\Phi_t$	0.075 [1.824]	−0.160 [−0.729]	−0.129 [−0.658]	0.040 [0.081]	−0.370 [−0.460]
$\Delta i_{us,t}$	0.005 [0.565]	0.059 [1.182]	0.019 [0.433]	0.030 [0.260]	−0.062 [−0.334]
$\Delta i_{mex,t}$	0.009 [0.902]	−0.041 [−0.805]	0.006 [0.135]	0.195 [1.680]	0.209 [1.105]
$\Delta LOIS_{us,t}$	0.000 [0.071]	0.058 [2.682]	0.016 [0.848]	−0.037 [−0.751]	0.095 [1.203]
$\Delta LOIS_{eur,t}$	−0.004 [−1.567]	0.010 [0.756]	−0.006 [−0.530]	0.151 [5.050]	−0.048 [−0.991]

Table 27

B.3 The Common Trends or Moving Average Representation

The Long-Run Impact Matrix, $\widetilde{C}$					
	$\sum\varepsilon_\Phi$	$\sum\varepsilon_{i,us}$	$\sum\varepsilon_{i,mex}$	$\sum\varepsilon_{LOIS,us}$	$\sum\varepsilon_{LOIS,eur}$
Φ_t	−0.217 [−1.924]	1.568 [3.920]	−1.667 [−5.276]	−3.677 [−4.656]	2.085 [1.572]
$i_{us,t}$	−0.081 [−1.810]	1.099 [6.922]	0.028 [0.222]	−0.718 [−2.291]	0.535 [1.016]
$i_{mex,t}$	0.088 [1.383]	0.037 [0.163]	1.558 [8.739]	−0.278 [−0.624]	0.716 [0.957]
$LOIS_{us,t}$	0.035 [1.311]	−0.223 [−2.374]	0.030 [0.409]	1.377 [7.439]	0.219 [0.706]
$LOIS_{eur,t}$	0.032 [1.419]	−0.132 [−1.669]	−0.006 [−0.104]	0.776 [4.989]	1.117 [4.277]

Table 28

Common Trends					
	Φ_t	$i_{us,t}$	$i_{mex,t}$	$LOIS_{us,t}$	$LOIS_{eur,t}$
$\alpha'_{\perp,1}$	0.010 [0.662]	0.000 $[NA]$	0.000 $[NA]$	1.000 $[NA]$	0.000 $[NA]$
$\alpha'_{\perp,2}$	0.054 [1.513]	0.000 $[NA]$	1.000 $[NA]$	0.000 $[NA]$	0.000 $[NA]$
$\alpha'_{\perp,3}$	0.013 [1.417]	0.000 $[NA]$	0.000 $[NA]$	0.000 $[NA]$	1.000 $[NA]$
$\alpha'_{\perp,4}$	−0.075 [−2.106]	1.000 $[NA]$	0.000 $[NA]$	0.000 $[NA]$	0.000 $[NA]$

Table 29

The Loadings to the Common Trends				
	$\alpha'_{\perp,1}$	$\alpha'_{\perp,2}$	$\alpha'_{\perp,3}$	$\alpha'_{\perp,4}$
$\tilde{\beta}_{\perp,1}$	−3.677 [−4.656]	−1.667 [−5.276]	2.085 [1.572]	1.568 [3.920]
$\tilde{\beta}_{\perp,2}$	−0.718 [−2.291]	0.028 [0.222]	0.535 [1.016]	1.099 [6.922]
$\tilde{\beta}_{\perp,3}$	−0.278 [−0.624]	1.558 [8.739]	0.716 [0.957]	0.037 [0.163]
$\tilde{\beta}_{\perp,4}$	1.377 [7.439]	0.030 [0.409]	0.219 [0.706]	−0.223 [−2.374]
$\tilde{\beta}_{\perp,5}$	0.776 [4.989]	−0.006 [−0.104]	1.117 [4.277]	−0.132 [−1.669]

Table 30

Residual S.E. and Cross-Correlations					
	ε_Φ	$\varepsilon_{i,us}$	$\varepsilon_{i,mex}$	$\varepsilon_{LOIS,us}$	$\varepsilon_{LOIS,eur}$
S.E.	0.410	0.163	0.231	0.096	0.081
ε_Φ	1.000	NA	NA	NA	NA
$\varepsilon_{i,us}$	0.677	1.000	NA	NA	NA
$\varepsilon_{i,mex}$	−0.661	−0.053	1.000	NA	NA
$\varepsilon_{LOIS,us}$	−0.729	−0.553	0.172	1.000	NA
$\varepsilon_{LOIS,eur}$	−0.568	−0.469	0.150	0.921	1.000

Table 31

B.4 Structural MA-model

Rotation Matrix, $\widetilde{M}$: $\boxed{u_t = \widetilde{M}\varepsilon_t}$					
	ε_{Φ}	$\varepsilon_{i,us}$	$\varepsilon_{LOIS,us}$	$\varepsilon_{LOIS,eur}$	$\varepsilon_{i,mex}$
u_{tr}	−1.525	−1.996	3.508	0.569	1.368
$u_{pr,1}$	−0.498	6.761	−4.418	3.290	0.171
$u_{pr,2}$	0.102	1.709	14.284	4.929	0.493
$u_{pr,3}$	0.195	0.483	−9.871	29.778	−1.016
$u_{pr,4}$	−0.348	−0.242	4.235	−3.316	−6.751

Table 32

Rotation Matrix, $\widetilde{M}$ (Normalized)					
	ε_{Φ}	$\varepsilon_{i,us}$	$\varepsilon_{LOIS,us}$	$\varepsilon_{LOIS,eur}$	$\varepsilon_{i,mex}$
u_{tr}	−0.435	−0.569	1.000	0.162	0.390
$u_{pr,1}$	−0.074	1.000	−0.653	0.487	0.025
$u_{pr,2}$	0.007	0.120	1.000	0.345	0.035
$u_{pr,3}$	0.007	0.016	−0.331	1.000	−0.034
$u_{pr,4}$	0.052	0.036	−0.627	0.491	1.000

Table 33

Inverse Rotation Matrix, $\widetilde{M}^{-1}$: $\boxed{\varepsilon_t = \widetilde{M}^{-1}u_t}$					
	u_{tr}	$u_{pr,1}$	$u_{pr,2}$	$u_{pr,3}$	$u_{pr,4}$
ε_{Φ}	−0.559	−0.197	0.110	0.002	−0.110
$\varepsilon_{i,us}$	−0.042	0.128	0.036	−0.019	0.000
$\varepsilon_{LOIS,us}$	0.005	−0.012	0.058	−0.008	0.006
$\varepsilon_{LOIS,eur}$	0.007	−0.005	0.019	0.031	−0.002
$\varepsilon_{i,mex}$	0.030	0.000	0.020	−0.019	−0.138

Table 34

Inverse Rotation Matrix, $\widetilde{M}^{-1}$ (Normalized)					
	u_{tr}	$u_{pr,1}$	$u_{pr,2}$	$u_{pr,3}$	$u_{pr,4}$
ε_{Φ}	1.000	0.353	−0.197	−0.003	0.198
$\varepsilon_{i,us}$	−0.327	1.000	0.285	−0.151	0.003
$\varepsilon_{LOIS,us}$	0.095	−0.212	1.000	−0.132	0.107
$\varepsilon_{LOIS,eur}$	0.234	−0.157	0.604	1.000	−0.063
$\varepsilon_{i,mex}$	−0.219	−0.002	−0.146	0.140	1.000

Table 35

Structural Long-Run Impact Matrix, $\widetilde{D} = \widetilde{CM^{-1}}$ (Normalized)					
	$\sum u_{tr}$	$\sum u_{pr,1}$	$\sum u_{pr,2}$	$\sum u_{pr,3}$	$\sum u_{pr,4}$
Φ_t	0.000	1.707	−2.181	3.007	−1.000
$i_{us,t}$	0.000	1.000	−0.000	0.000	0.000
$LOIS_{us,t}$	0.000	−0.327	1.000	−0.000	−0.000
$LOIS_{eur,t}$	0.000	−0.233	0.802	1.000	−0.000
$i_{mex,t}$	0.000	−0.075	0.496	−0.208	1.000

Table 36

100*Contemporaneous Impact, $\widetilde{D}_0^* = \widetilde{C_0^* M^{-1}}$					
	u_{tr}	$u_{pr,1}$	$u_{pr,2}$	$u_{pr,3}$	$u_{pr,4}$
Φ_t	−55.850	−19.688	11.029	0.188	−11.036
$i_{us,t}$	−4.182	12.777	$*$	$*$	$*$
$LOIS_{us,t}$	0.548	−1.222	5.778	$*$	$*$
$LOIS_{eur,t}$	0.719	−0.482	1.853	3.070	$*$
$i_{mex,t}$	3.019	0.027	2.016	−1.927	−13.763

Table 37

100*Impact After $K = 60$ Periods:					
	u_{tr}	$u_{pr,1}$	$u_{pr,2}$	$u_{pr,3}$	$u_{pr,4}$
Φ_t	−0.052	27.673	−17.420	9.329	22.709
$i_{us,t}$	−0.008	16.241	$*$	$*$	$*$
$LOIS_{us,t}$	0.002	−5.310	7.994	$*$	$*$
$LOIS_{eur,t}$	0.003	−3.785	6.410	3.111	$*$
$i_{mex,t}$	0.003	−1.219	3.965	−0.646	−22.720

Table 38

B.5 Variance Decomposition Analysis

Step	Std Error	$LOIS^*_{us,t}$	$LOIS^*_{eur,t}$
1	0.1448	0.0000	0.0000
5	0.3162	3.0547	0.3806
10	0.4417	4.2641	0.3929
15	0.5566	5.5524	0.4791
20	0.6624	6.4054	0.5829
25	0.7603	7.0302	0.6586
30	0.8509	7.4934	0.7182
35	0.9351	7.8408	0.7643
40	1.0137	8.1080	0.8002
45	1.0874	8.3174	0.8288
50	1.1569	8.4847	0.8518
55	1.2228	8.6205	0.8705
60	1.2854	8.7325	0.8861

Table 39: Variance Decomposition for $i_{us,t}$. $LOIS^*_{\cdot,t}$ is in per-cent.

Step	Std Error	$LOIS^*_{us,t}$	$LOIS^*_{eur,t}$
1	0.1479	0.4968	0.0737
5	0.4545	0.2833	0.4759
10	0.6979	0.2291	1.1543
15	0.8788	0.6158	1.5560
20	1.0321	0.7474	1.6184
25	1.1678	0.8716	1.6486
30	1.2901	0.9708	1.6535
35	1.4026	1.0486	1.6512
40	1.5070	1.1117	1.6460
45	1.6049	1.1628	1.6402
50	1.6972	1.2049	1.6345
55	1.7849	1.2399	1.6294
60	1.8685	1.2694	1.6248

Table 40: Variance Decomposition for $i_{mex,t}$. $LOIS^*_{\cdot,t}$ is in per-cent.

Step	Std Error	$LOIS^*_{us,t}$	$LOIS^*_{eur,t}$
1	0.6292	1.8580	0.9556
5	0.8728	7.5661	1.2925
10	1.0871	15.5207	0.9455
15	1.3034	20.7197	0.8764
20	1.5432	24.6402	0.9195
25	1.7865	26.9521	0.9997
30	2.0236	28.3763	1.0756
35	2.2494	29.2796	1.1396
40	2.4627	29.8843	1.1910
45	2.6640	30.3091	1.2322
50	2.8540	30.6205	1.2652
55	3.0339	30.8575	1.2919
60	3.2047	31.0434	1.3139

Table 41: Variance Decomposition for Φ_t. $LOIS^*_{\cdot,t}$ is in per-cent.