WP/20/141

IMF Working Paper

Who Drains Bond Market Liquidity in an Emerging Market?

by Ricardo Hoyos, Yang Liu, Hui Miao and Christian Saborowski

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INTERNATIONAL MONETARY FUND

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IMF Working Paper

Western Hemisphere Departments

Who Drains Bond Market Liquidity in an Emerging Market

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July 2020

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Abstract

This paper examines the drivers of liquidity shortages in the Mexican government bond market. We use unique transaction- and quote level data with information on end-investors to construct an index of bond market liquidity. We find that liquidity remained stable in recent years, although temporary shortages arose amid domestic and global market stress. The analysis suggests that the largest liqudity squeezes have tended to be driven by foreign investors, whose sell-offs were especially pronounced in less liquid market segments. While domestic banks often absorbed part of the shock, other domestic investors—with the notable inclusion of domestic pension and mutual funds—appeared to take a more opportunistic stance depending on the nature of the shock.

JEL Classification Numbers: G11; G14; G20

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[1] The views expressed in this paper are those of the authors and do not necessarily represent the views of the IMF or the Banco de Mexico, or their respective Executive Boards, or managements. We are grateful for overall guidance on the project by Juan Fernando Avila Embriz and Costas Christou. We are also indebted to Andrea Pérez de Celis López for invaluable help in better understanding the nature of the Mexican bond market. We thank Marco Alfano, Serkan Arslanalp, Bachir Boukherouaa, Aquiles Farias, Helen Li, Milan Nedeljkovic, Gavin Rae, Francisco Roldan, Mamoon Saeed, Manuel Sanchez Valadez and Manmohan Singh for valuable comments and Juan Pablo Cuesta Aguirre for excellent research assistance.

Keywords: Bond markets; Market liquidity; Investor composition

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INTRODUCTION

With bond markets occupying an increasingly central role in emerging financial systems, understanding what drives market liquidity shortages has moved to the forefront of the policy debate (IMF and World Bank, 2018). A lack of liquidity can give rise to disorderly market conditions and magnify shocks. Conversely, a deep and robust market can help absorb disturbances and safeguard stability (Adrian, Fleming and Vogt, 2017). While a burgeoning literature has examined bond market liquidity in advanced economies, little is known about the drivers of market liquidity in emerging markets.

This paper attempts to fill this gap by developing a comprehensive measure of market liquidity in the Mexican government bond market. We use unique transaction- and quote level data to put together a daily time series of liquidity indicators that we combine into a composite index. A unique feature of the data is that it allows identifying end-investors involved in each transaction. Exploiting this feature, the analysis focuses on better understanding liquidity resilience and the role played by different types of domestic and foreign investors in accounting for liquidity shortfalls. We address two main questions: First, what are domestic and external developments that accompany liquidity shifts? Second, can we identify specific types of investors that tend to contribute to selling pressure during episodes of liquidity depletion, and others that tend to stabilize the market?

The first part of the analysis uses daily regressions to examine how our index correlates with different types of financial and economic variables. These include indicators of funding liquidity, price volatility in domestic and U.S. financial markets, as well as surprises in economic news releases. Moreover, we include explanatory variables characterizing US bond market conditions to identify possible spill-over channels. The second part of the analysis examines the behavior of different types of investors during periods of large liquidity declines. We first identify the largest liquidity declines in our sample period and then compare each investor type's net purchases in different market segments to a counterfactual.

Our findings suggest that liquidity in the Mexican government bond market has remained relatively stable during our sample period despite rising foreign ownership and regulatory changes. We also find evidence in favor of a role for both economic news and financial market volatility in driving bond market liquidity. In particular, there appears to be a close correlation between bond market liquidity and volatility in bond and equity as well as foreign exchange markets. Moreover, we also find significant evidence suggesting that stress in U.S. bond markets translates into lower bond market liquidity in Mexico.

The second part of the analysis identifies the ten most dramatic liquidity squeezes in our sample period. Many of the episodes coincide with well-known economic and political stress events. While the COVID-19 shock represents the most dramatic and persistent liquidity shock in our sample period, the underlying drivers appear to be qualitatively very similar to the other episodes of large liquidity squeezes in our sample: we find that foreign investors not only consistently account for much of the selling pressure but also tend to switch from less liquid market segments to on-the-run securities when liquidity dries up. The result appears to rationalize the findings of Christensen and Fischer (2019), among others, that foreign investor presence tends to drive up liquidity premia. Domestic banks, on the other hand, appear to be more likely to absorb pressures during liquidity squeezes, perhaps in line with their responsibility as primary dealers to provide for an orderly exit of non-resident investors. Interestingly, domestic mutual funds contributed to market stability during most of the episodes. Other more long-term oriented domestic investors, including pension and insurance funds, appeared to take more opportunistic positions in response to the shocks, supporting market liquidity at times and, at others, contributing to selling pressure.

Our paper is related to a growing literature that characterizes bond market liquidity in the aftermath of the global financial crisis. Adrian, Fleming, Shachar and Vogt (2017) describe how regulatory changes have affected dealer-intermediated markets during the post-crisis periods, while the Joint Staff Report (2015) by U.S. regulators on U.S. Treasury market liquidity (2015) analyzes the importance of structural changes such as the increase in electronic trading and risks associated with automated trading. A few papers have documented liquidity disruptions in specific market segments (Engle, Fleming, Ghysels and Nguyen, 2012; Musto, Nini and Schwarz, 2016) or over short time spans (Fleming, 2003; Engle, Fleming, Ghysels and Nguyen, 2012; Adrian, Fleming, Shachar and Vogt, 2017). Adrian et al (2017) construct a daily market liquidity index based on transactions and order book data over a long period, focusing on U.S. treasury securities for 1991-2017. Correlating the index with various macro-economic and financial variables, they find that market liquidity is strongly correlated with funding liquidity at times of market stress. IMF (2015) examines daily data on corporate and government bond transactions in developed markets and finds that market liquidity in developed markets is mostly driven by cyclical factors such as monetary policy changes.

Relatively little work has been done on bond market liquidity in emerging markets. Among the few papers, Hameed et al (2019) construct price- and quantity-based liquidity measures for the Malaysian corporate bond market based on transaction-level data. However, the authors do not have access to order book data and do not provide evidence of the role played by different types of investors. Another strand of the literature has highlighted the importance of a diversified investor base for bond market stability and liquidity (BIS, 2007). In the case of emerging markets, the literature has focused on the relative benefits of a broad foreign investor base and its impact on volatility and risk premia. On the one hand, foreign investors could help develop market infrastructure and trading strategies and diversify the investor base, thereby improving market liquidity and lowering yields (Peiris, 2010); on the other, their behavior could be more driven by external risk factors and prone to sudden stops, thus contributing to market volatility and higher risk premia. In line with the latter view, Christensen and Fischer (2019) find evidence in favor of the argument that foreign holdings drive up liquidity premia using data from the Mexican government bond market. Similarly, Zhou et al. (2014) analyze mutual fund portfolio flows in Mexico and find that foreign investors are more responsive to global shocks than local investors. Ebeke and Lu (2015) examine post-crisis data for 13 emerging market countries and find that increases in the foreign-held share of local currency sovereign bonds tend to be associated both with declines in general yield levels and increases in yield volatility.[2]

This paper contributes to the literature in at least three ways. First, we think we are the first to calculate a fairly complete set of high frequency liquidity indicators based on transaction- and order-flow based data for an emerging bond market. Second, the paper investigates how bond market liquidity in an emerging market correlates with volatility in domestic financial markets and quantifies possible spill-over effects from external markets. Finally, the paper fills a gap by examining the roles played by different types of investors during episodes of large liquidity squeezes.

From a policy perspective, the paper strengthens our understanding of the drivers of bond market liquidity shortages in emerging markets and provides a useful tool for bond market surveillance. It also uncovers some of the drivers of liquidity shortages and the behavior of different types of investors during periods of liquidity depletion, which should help refine regulatory tools and supervisory policies to promote market stability. Our results highlight that domestic and international investors tend to react differently to different types of shocks, and that a diverse investor base is key to ensure that selling pressure on the part of some investors does not translate into a complete drying up of market liquidity.

The remainder of this paper is organized as follows: Section II describes the structure of the Mexican government bond market, and Section III discusses the data sets we use. Section IV presents a set of liquidity indicators for the Mexican government bond market and describes how we construct our composite liquidity index. In Section V, we analyze the drivers of liquidity resilience, both at the macro level and by focusing on the behavior of different types of investors during stress episodes. Section VI concludes.

I. THE MEXICAN GOVERNMENT BOND MARKET

With outstanding securities of about 300 billion U.S. dollars, the Mexican government bond market is one of the largest emerging bond markets (Figure 1). Market development has benefited from strong participation by foreign investors, Mexico's inclusion in major bond indices, a fully convertible and a very liquid currency and the absence of capital controls or any form of entry or exit taxation.

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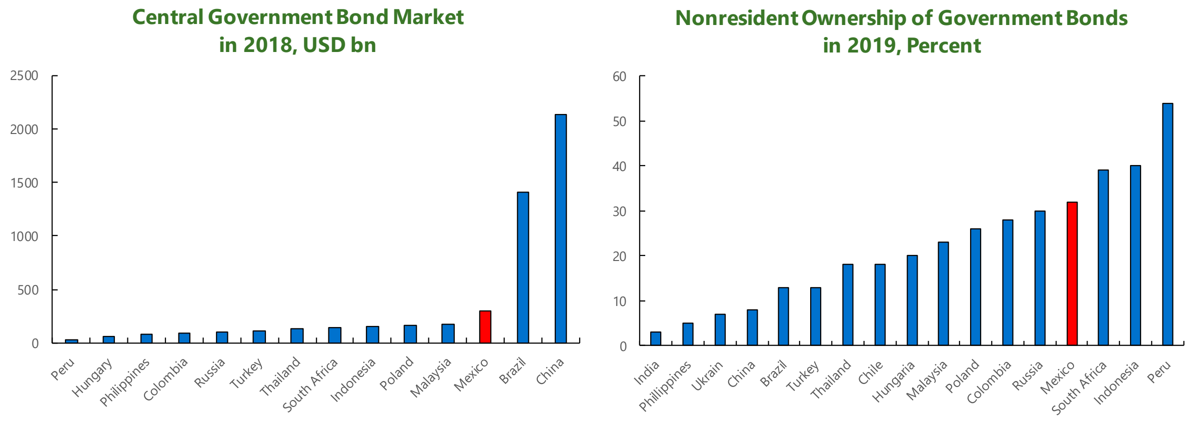
[2] Grigorian (2019) argues for the case of Malaysia that foreign investor presence does not increased foreign exchange volatility.

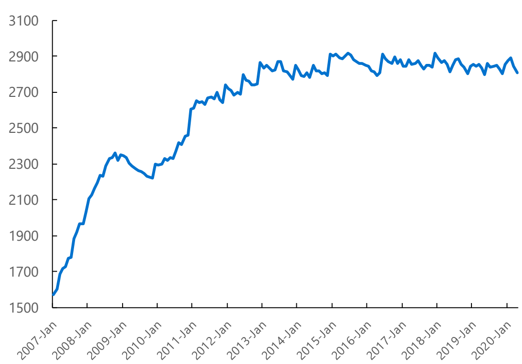
Figure 1: Emerging Bond Markets



Source: BIS, IMF and Author's Calculations

The average maturity of Mexican government debt has increased significantly since the global financial crisis in the context of generally strong macro policies and successful debt management (Figure 2). The authorities issue bills (Cetes), fixed rate bonds (Mbonos), inflation linked bonds (Udibonos) and floating rate bonds (Bondes D). Mbonos make up the largest portion of local government debt securities, at around 45 percent, compared to 13 percent for Cetes, 23 percent for Udibonos and 19 percent for Bondes D.

Figure 2: Average Maturity of Mexican Government debt in days



Source: Haver

Issuances of government debt securities are very transparent and predictable. The Ministry of Finance publishes an annual borrowing plan for both local and external issuances and, at the beginning of each quarter, sends the central bank a list of all securities to be issued during each quarter, with detailed information on amounts, maturities and auction dates. Primary auctions take place two working days before their settlement on Thursdays. Short Cetes tenors (182 days and less) are issued every week, Bondes D every two weeks, long Cetes tenors, Udibonos and medium Mbono tenors (3-5 years) every four weeks, and long Mbono tenors (10-30 years) every six weeks. In addition to the regular auctions, there are also syndicated auctions designed to place new issuances among a broader universe of investors.

Secondary market trading of Mexican government bonds is supported by primary dealers selected by the Ministry of Finance from qualified banks and brokerage houses (who typically do not take positions themselves).[3] Currently there are 7 primary dealers for Mbonos and 4 for Udibonos who also invest into government bonds on their own account. Traditionally, most secondary market trades were conducted on the OTC market between banks and its customers, with an increasing share intermediated by brokers on electronic platforms where quotes are centralized in a network that discloses on-screen information. The Mexican market is open from 7:00 a.m. to 2:30 p.m. local time, with higher concentration from 1pm to 2pm. Since Mexico's inclusion into several bond indices, some trading offices implemented 24-hour trading services, but their activity after 2:30 p.m. tends to be insignificant (Garcia-Padilla, 2014). Institutions outside Mexico deal with Mexican financial institutions via phone calls or brokers outside Mexico, for example, on the MarketAxess platform.

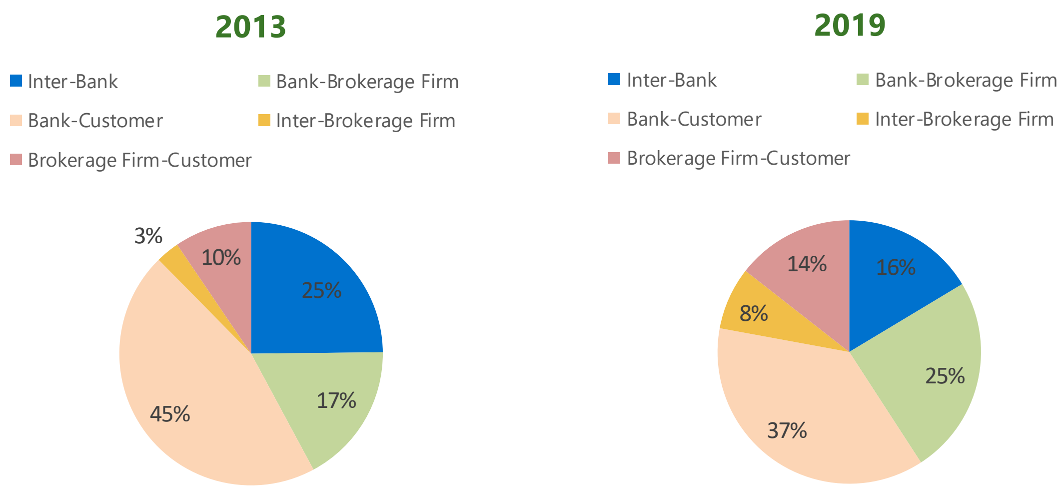
II. THE DATA

We use data compiled by Banco de Mexico on both primary and secondary markets for government securities in Mexico. The first dataset contains transactions of on-the-run and off-the-run Cetes, Mbonos, Udibonos and Bondes D since 2004. Each record comprises information on the trade date, trade time, settlement date, security name, security maturity date, executed price, par value, trade volume and end investor entities. We grouped investors into the following types: authorities (Ministry of Finance, Banco de Mexico etc.), domestic banks, domestic brokerage houses, domestic development banks, domestic insurance companies, domestic mutual funds, domestic pension funds, other domestic investors, and foreign investors.

As shown in Figure 3, banks remain the dominant primary dealers although brokerage houses have grown in importance. Around half of the transactions take place between primary dealers, with the other half between primary dealers and their clients. The only transactions not covered by our data set are those that are either executed abroad, or do not involve domestic banks, development banks or brokerage houses on at least one side of the transaction. We estimate that the data accounts for 98 percent of total transactions on the Mexican local currency government bond market.

[3] Government securities are 'Euroclearable'.

Figure 3: Secondary Market Transaction Types 2013 and 2019



Source: Authors' calculations based on the two data sets discussed in Section 3.

The second dataset contains quotes of on-the-run and off-the-run Cetes, Mbonos, Udibonos and Bondes D since 2011 from domestic electronic platforms. Based on our two data sets, we estimate that, from 2011 to 2019, some 30-40 percent of domestic secondary market transactions were executed via these platforms. Each record comprises information on quote date, quote initial time, quote final time, settlement date, security type, security term days, amount, quoted rate, whether this quote is a bid or ask and whether this quote is executed or not. We identify the security name using the included information on security type and maturity date. The dataset contains both inter-dealer quotes and dealer-to-client quotes. In order to include only competitively quoted rates, we exclude those quotes that are not from interbank brokers. Moreover, we also exclude a small share of the records containing obviously off-market quotes that are far (more than 25 basis points) from the same day's median traded rates.[4]

For the remainder of the analysis we largely focus on the sample period January 2013-March 2020 as particularly the order flow and pricing data appear to be of lower quality prior to that.[5] A first look at the data confirms that the investor base in Mexico's government bond market is well diversified (Tapia-Rangel, 2014). In addition to domestic banks and brokerage houses, which as market makers account for particularly large shares in total transactions, a wide array of investors account for notable shares over our sample period (Figure 4). Foreign investors (11 percent), in particular, are among the most important players. Among domestic

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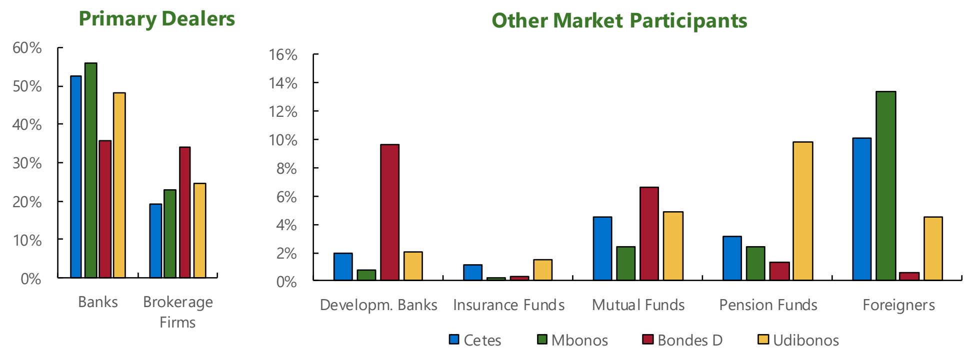
[4] We chose this threshold after plotting the distribution of the differences between the quoted rates and the same day's median traded rates. The 25-basis-point threshold appeared reasonable to cut off a limited number of very noisy quotes.

[5] The electronic quotes data for 2011 and 2012 appear to be of lower quality as some 20 percent of records do not have correct term days to identify security names or have quoted rates significantly different (larger than 25 basis points) from the same day traded rates.

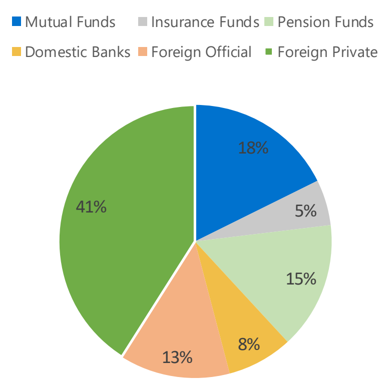
investors, relevant players include, mutual funds (4 percent), pension funds (3 percent), development banks (2 percent) and insurance funds (1 percent). Foreign investors are particularly active in terms of absolute levels in transactions for Mbonos and Cetes, with only minimal shares in inflation linked and floating rate securities. Focusing on actual holdings of securities, foreign investors account for more than half of the total, and thus much more than their share in total trading, suggesting that they are relatively inactive compared to domestic banks and brokerage firms (Figure 5).[6] [7] Important participants in floating rate instruments include development banks and mutual funds while pension funds are important players in inflation linked instruments.

Figure 4: Investor Shares in Total Secondary Market Transactions 2013-Mar2020



Source: Authors' calculations based on the two data sets discussed in Section 3.

Figure 5: Holders of Government Securities by Investor Type, 2017



Source: Estimated based on Abreu et al (2014) and Sovereign investor base estimates by Arslanalp and Tsuda (2014).

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[6] The shares in Figure 4 and Figure 5 cannot be easily compared since much of the trading by primary dealers is not on their own account and would thus not be reflected in statistics of securities holdings (see Figure 5).

[7] Appendix Figure 1 illustrates that net transactions of foreigners across securities correlate highly with IIF statistics on net bond market inflows

Table 1 shows basic summary statistics for transaction volumes, frequencies and sizes for the on-the-run bonds of each maturity.[8] For the full sample period, daily trading volume averaged roughly 3-10 billion pesos per tenor and day. The average number of trades per day ranges from 49 (2-year) to 448 (10-year), and the average trade size ranged from 38 million pesos (30-year) to 119 million (2-year). The 10-year note is the most widely traded with a trading volume of 10 billion pesos per day, followed by the 3-year, 5-year and 30-year notes. The high trading volume of the 10-year note appears driven by a particularly high trading frequency rather than large average trade sizes. The opposite is the case for the 2-year note, for which the trading volume is low despite a very high average trade size.

Table 1: Trade Volume, Frequency and Size Summary Statistics 2013-Jul 2019

	2-Year	3-Year	5-Year	10-Year	20-Year	30-Year
Trade volume	3.8	5.9	5.6	10.5	2.7	4.4
	(5.1)	(5.8)	(4.9)	(8.2)	(2.7)	(3.1)
Trade frequency	49.2	190.0	165.7	448.2	97.4	148.7
	(127.3)	(454.7)	(425.9)	(826.3)	(312.8)	(229.4)
Trade size	118.9	86.9	66.7	44.3	42.5	38.4
	(164.7)	(96.4)	(52.9)	(28.7)	(28.7)	(26.7)

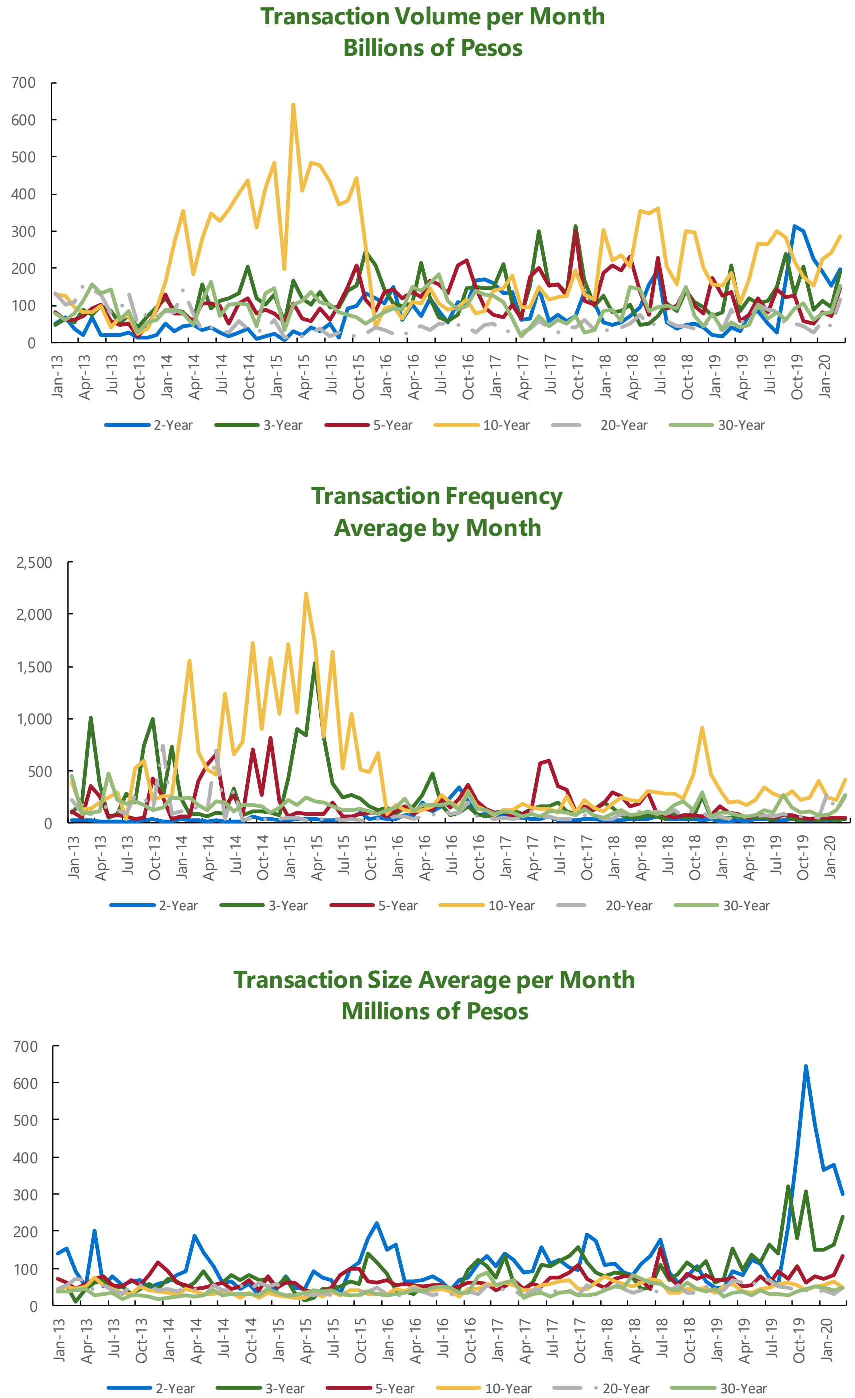
Source: Author's calculations based on transactions data.

Notes: The table shows means and standard deviations (in parentheses) for each indicator for the on-the-run bonds of each maturity. Trade volume is shown in billions of pesos per day, while trade frequency is shown in number of trades per day and (average) trade size is shown in millions of pesos per day.

Figure 6 plots the same indicators over time by month. While the 10-year on-the-run note has been the most widely traded for the most part, other maturities were dominant during specific periods in the sample (e.g. during 2016 and 2017). Interestingly, the 10-year traded particularly heavily during 2014 and 2015, driven by a particularly high frequency of transactions rather than large transaction sizes. During the COVID-19 crisis, in turn, the short end of the curve—2-year and 3-year notes—traded in large volumes.

[8] Mexico does not auction 2-year bonds. Banco de Mexico defines 2-year reference bonds (maturity closest to 2 years) for analysis purposes and to construct indicators.

Figure 6: Trade Volume, Frequency and Size Over Time



Source: Authors' calculations based on data sets discussed in Section 3.

III. A COMPOSITE LIQUIDITY INDEX FOR THE MEXICAN BOND MARKET

Market liquidity can be defined as the ability to rapidly buy or sell a *sizable volume* of securities at a *low cost* with a *limited price impact* (IMF, 2015). Our aim is to provide a relatively complete picture of market liquidity that broadly mirrors this definition. We construct individual liquidity indicators that capture the various features of market liquidity and combine them into a composite measure. Following Adrian, Fleming and Vogt's (2017) work on the U.S. treasury market liquidity index, we construct the different measures based on data for on-the-run fixed rate securities.

The first measure we calculate is the bid-ask spread, which directly measures the *cost* aspect of market liquidity. More specifically, it assesses the average cost of executing a trade at a given point in time by measuring how much a trader would have to pay if buying, and then immediately selling, a given security. For each on-the-run bond, we use the start- and expiration times of each quote, as well as the quoted rates and the quantity of quotes, to reconstruct the limit order book. We then calculate the bid-ask spread as the spread between the best bid and the best ask at each point in time when either a new quote arrives, or an existing quote expires. In calculating the daily average of the bid-ask spread for each on-the-run bond, we give each tick equal weight despite potentially different tick size.

The second measure we calculate is order book depth. While the bid-ask spread directly measures the cost of executing a trade, it does not measure it for all trades, and it does not necessarily measure it for very large trades. Order book depth, in turn, measures the depth of the order book by documenting the quantity of securities for which dealers are willing to supply liquidity services at a given price. Similar to the bid-ask spread, we first reconstruct the limit order book for each on-the-run bond at every moment when either a new quote arrives, or an existing quote expires. At each tick, we sum up the quantities sought at the best three bid prices and the quantities offered at the best three ask prices as the order book depth. We calculate daily averages of order book depth by giving each tick equal weight.[9]

The third measure we calculate is the maximum percentage price change resulting from a transaction of a unit size for each security within each day. We employ the Amihud ratio (Amihud, 2002) for this purpose which is calculated as for a given security at each transaction, the absolute value of price percentage change divided by the transaction volume $\frac{p_t - p_{t-1}}{p_t \times q_t}$, where p_t is the current transaction price, p_{t-1} is the previous transaction price and q_t is the current transaction volume). We then take the daily maximum value as its daily indicator.

Table 2 shows the correlations between both our transaction and liquidity indicators for the on-the-run bonds at different maturities. The table shows that better liquidity in one maturity is associated with better liquidity in all other maturities for all indicators and all maturity pairs (with only one exception, namely the correlation between the 3-year and 10-year

[9] One drawback of the depth measures is that market participants often do not reveal the full quantities they are willing to transact at a given price such that measured depth will underestimate true depth. Conversely, since orders can be rapidly withdrawn from the market, measured depth can also overestimate true depth.

maturities in the case of the price impact indicator). For our three liquidity indicators, the average correlations tend to be higher for the 10-year, 5-year and 30-year maturities which are also the more widely traded (Table 1). Liquidity conditions for the less widely traded 2-year and 20-year notes seem to be less related to the rest of the market. Across liquidity indicators, correlations are highest for the bid-ask spread and lowest for the price impact indicator. In general, correlations between different indicators are lower than those Adrian et al (2017) finds for the more liquid U.S. treasury market.

Table 2: Correlations Within Liquidity Indicators Across Tenors (Jan 2013-Jul 2019)

Bid-Ask Spread

	2-Year	3-Year	5-Year	10-Year	20-Year	30-Year
2-Year		0.5	0.4	0.3	0.3	0.4
3-Year	0.5		0.6	0.5	0.5	0.6
5-Year	0.4	0.6		0.5	0.5	0.5
10-Year	0.3	0.5	0.5		0.4	0.5
20-Year	0.3	0.5	0.5	0.4		0.6
30-Year	0.4	0.6	0.5	0.5	0.6	
Avg.	0.37	0.53	0.49	0.44	0.47	0.53

Price Impact

	2-Year	3-Year	5-Year	10-Year	20-Year	30-Year
2-Year		0.01	0.04	0.00	0.09	0.02
3-Year	0.01		0.01	-0.01	0.01	0.01
5-Year	0.04	0.01		0.02	0.10	0.13
10-Year	0.00	-0.01	0.02		0.01	0.03
20-Year	0.09	0.01	0.10	0.01		0.18
30-Year	0.02	0.01	0.13	0.03	0.18	
Avg.	0.03	0.01	0.06	0.01	0.08	0.08

Depth

	2-Year	3-Year	5-Year	10-Year	20-Year	30-Year
2-Year		0.1	0.1	0.1	0.1	0.1
3-Year	0.1		0.2	0.2	0.1	0.2
5-Year	0.1	0.2		0.2	0.2	0.3
10-Year	0.1	0.2	0.2		0.2	0.4
20-Year	0.1	0.1	0.2	0.2		0.4
30-Year	0.1	0.2	0.3	0.4	0.4	
Avg.	0.10	0.13	0.20	0.23	0.17	0.27

Trade Volume

	2-Year	3-Year	5-Year	10-Year	20-Year	30-Year
2-Year	1.0	0.2	0.1	0.0	0.0	0.1
3-Year	0.2		0.1	0.1	0.0	0.0
5-Year	0.1	0.1		0.1	0.0	0.1
10-Year	0.0	0.1	0.1		0.0	0.2
20-Year	0.0	0.0	0.0	0.0		0.3
30-Year	0.1	0.0	0.1	0.2	0.3	
Avg.	0.23	0.09	0.08	0.06	0.04	0.14

Trade Size

	2-Year	3-Year	5-Year	10-Year	20-Year	30-Year
2-Year		0.4	0.1	0.1	0.0	0.1
3-Year	0.4		0.2	0.1	0.1	0.0
5-Year	0.1	0.2		0.1	0.0	0.1
10-Year	0.1	0.1	0.1		0.1	0.2
20-Year	0.0	0.1	0.0	0.1		0.1
30-Year	0.1	0.0	0.1	0.2	0.1	
Avg.	0.13	0.16	0.10	0.11	0.05	0.08

Trade Frequency

	2-Year	3-Year	5-Year	10-Year	20-Year	30-Year
2-Year		0.0	0.1	0.0	0.0	0.1
3-Year	0.0		0.0	0.2	0.1	0.1
5-Year	0.1	0.0		0.1	0.0	0.0
10-Year	0.0	0.2	0.1		0.0	0.1
20-Year	0.0	0.1	0.0	0.0		0.1
30-Year	0.1	0.1	0.0	0.1	0.1	
Avg.	0.05	0.08	0.06	0.06	0.05	0.09

Notes: The tables report correlation coefficients of the levels of liquidity indicators across securities for the on-the-run bonds of each maturity.

Table 3 shows summary statistics for each of our liquidity indicators across different maturities. As expected, the bid ask spread is on average over the sample period narrowest for the most widely traded, 10-year, security and widest for the least traded 2-year and 20-year securities. Similarly, order book depth is highest for the 10-year while it is lowest for the 2-year, 20-year and 30-year maturities. The price impact, on the other hand, appears less in line with relative transaction volumes, with the 2-year showing the lowest price impact, compared to the highest price impact on the 30-year tenor.

Table 3: Liquidity Summary Statistics (Jan 2013-Mar 2020)

	2-Year	3-Year	5-Year	10-Year	20-Year	30-Year
Bid-ask spread	2.6	1.8	1.8	1.4	2.2	1.7
	(1.6)	(1.4)	(1.0)	(0.7)	(1.1)	(1.1)
Depth	106.2	138.8	121.6	167.3	85.8	104.0
	(93.3)	(86.8)	(65.4)	(96.1)	(33.7)	(33.7)
Price impact	1.6	4.0	2.5	3.9	4.7	5.9
	(20.5)	(37.3)	(13.3)	(17.4)	(23.3)	(19.1)

Source: Author's calculations based on transactions and order flow data.
Notes: The table shows means and standard deviations (in parentheses) for each liquidity indicator for the on-the-run bonds of each maturity. The bid-ask spread is shown in basis points, depth is shown in million pesos per day; price impact is per one million peso of trading.

We calculate a composite liquidity measure based on our three indicators. The idea behind a composite index of market liquidity is that the three indicators measure complementary aspects, while no indicator would provide a complete picture of market liquidity on its own: while the bid-ask spread measures the cost of a single transaction, order book depth calculates the quantities that can be transacted close to the market price, and the price impact measures the degree to which the market can digest transactions of a given size in the absence of large price movements.

We construct a composite liquidity index both for each market segment and for the overall bond market. We first calculate liquidity indicators for the entire bond market by averaging the individual liquidity indicators (bid-ask spreads, depth and the price impact) across maturities. Following Adrian, Fleming and Vogt (2017), we then standardize each of our three indicators to have mean zero and variance one and construct the composite liquidity index for each market segment as the simple average of the bid-ask spread, the inverse of order book depth and the price impact. We calculate the overall liquidity index as the simple average across the different market segments.

Figure 7: Liquidity Indicators and Overall Liquidity Index

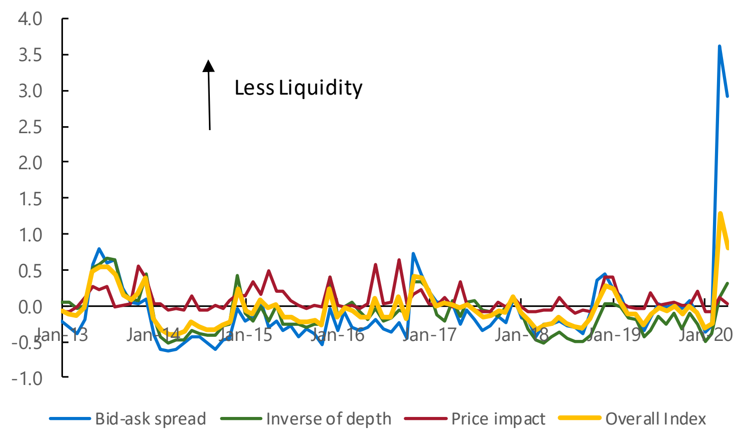


Figure 7 shows the evolution of our liquidity indicators as well as the overall liquidity index over time, with higher values suggesting lower levels of liquidity. The chart illustrates that liquidity has remained broadly stable over the sample period despite increasing foreign ownership and regulatory changes over the period.[10] Liquidity squeezes were strictly temporary (e.g. in spring/summer 2013, end-2015, end-2016 and end-2018). The COVID-19 episode in March 2020 appears to be by far the largest and most persistent shock to market liquidity in our sample when looking at monthly average: all the three indicators increased during this period, although the tremendous jump was mainly caused by the bid-ask spread.

Table 4 shows pairwise correlations both between our transactions and liquidity indicators and the overall index. As one would expect, better liquidity in one measure is generally associated with better liquidity on another. While the correlations of the price impact indicator with the two other liquidity indicators are quite low, a look at Figure 7 suggests that the low correlation may be driven by the fact that the price impact indicator generally hovers around zero and only relatively infrequently shows large reactions.

Table 4: Correlations Across Liquidity Indicators (Jan 2013-Mar 2020)

	Overall Index	Bid-Ask	Depth	Price Impact	Trade Volume	Trade Freq.	Trade Size
Overall Index		0.77	0.75	0.49	0.11	0.18	0.07
Bid-Ask	0.77		0.42	0.06	0.03	0.15	0.00
Depth	0.75	0.42		0.06	0.18	0.32	0.11
Price Impact	0.49	0.06	0.06		0.03	-0.06	0.04
Trade Volume	0.11	0.03	0.18	0.03		0.40	0.87
Trade Freq.	0.18	0.15	0.32	-0.06	0.40		0.13
Trade Size	0.07	0.00	0.11	0.04	0.87	0.13	

Notes: The table reports the correlation coefficients between liquidity indicators. The overall index is composed of the bid-ask spread the inverse of depth and the price impact, all of which are normalized to mean zero and variance one. Each indicator is calculated as the average across the same indicators across maturities. Higher values both on the individual indicators and on the overall index suggest lower liquidity.

IV. Liquidity Resilience

This section examines the drivers of daily liquidity in the Mexican bond market. Highly resilient market liquidity is critical to financial stability because a market with solid liquidity is less prone to sharp and disorderly price movements in response to large macrofinancial shocks. When liquidity drops sharply, prices become less informative and less aligned with fundamentals. It can also lead investors to overreact for fear of illiquidity, leading to increased price volatility and potentially systemic repercussions. While limited market liquidity generally tends to be fragile, even seemingly ample market liquidity can be subject to sudden drops (IMF, 2015).

The focus of this section is on understanding what drives liquidity shortages. An important focus is on the role of diversified investor base and the behavior of different types of investors. We ask two main questions: first, what are domestic and external shock variables

[10] The Mexican banks' regulators (CNBV and Banco de Mexico SHCP) introduced the LCR requirement in December 2014. Capital requirements were amended in 2015 to incorporate, among others, CVA requirements for OTC derivatives and implemented the D-SIB capital requirement was implemented in April 2016. Rules on leverage ratios were published in October 2018. The rules strengthened bank resilience but also increased the regulatory cost for banks in trading government debt and, as such, may have reduced balance sheet space to act as market makers for government debt.

that correlate with large liquidity movements? Second, can we identify specific investor types that tend to drive large liquidity declines and others that would help prevent selling pressure from translating into broader price volatility?

A. Cyclical Drivers of Liquidity Shifts

To assess what types of developments correlate with liquidity movements in the Mexican bond market, we run simple regressions with our overall liquidity index as the dependent variable.[11] We include four sets of explanatory variables in the regressions that represent potential drivers of bond market liquidity in Mexico. These include (i) measures of volatility in other Mexican financial market segments, (ii) measures of funding liquidity, (iii) macroeconomic news shocks, and (iv) variables measuring bond market stress in the U.S. We do not make an effort to deal with potential endogeneity issues as our focus is largely on establishing correlations. Appendix Table 1 presents the definitions and sources of each of the variables we use as well as a set of basic summary statistics.

The regression results suggest an important relationship between financial market volatility and bond market liquidity. In our baseline regression in Table 5 (Regression 1), all measures of financial market volatility in Mexico are highly significant with the expected positive coefficients, signaling that an increase in volatility in bond, equity and FX markets reduces bond market liquidity. While a one-standard-deviation increase in bond market volatility has a somewhat larger impact on bond market liquidity than a one-standard deviation increase in equity and foreign exchange market volatility (based on the t-statistics shown in parentheses in the table), the latter two variables do appear to matter independently (and their impact is not much changed when we exclude bond market volatility as an explanatory variable in Regression 2). This would signal that stress in Mexican financial markets more generally, rather than volatility in bond markets only, matters for bond market liquidity.

There is also strong evidence supporting the possibility of spill-overs from U.S. to Mexican bond markets. In addition to exchange rate volatility, which would be driven at least in part, by external factors, the baseline regression includes an indicator of U.S. bond market volatility (MOVE), which is highly significant in all regressions with a positive coefficient, suggesting that U.S. bond market volatility may contribute to periods of illiquidity in the Mexican bond market (or it is driven by common factors). Regressions 3 and 5 show that the U.S. TED spread and the U.S. High Yield spread—alternative indicators of stress in U.S. bond markets—are also highly significant individually in explaining bond market liquidity and carry the expected positive coefficient. However, both variables become insignificant when included alongside the MOVE index (Regressions 4 and 6), suggesting that all three variables proxy for a similar spill-over channel.

There is some evidence in favor of a role for macroeconomic news announcements in driving bond market liquidity. The Citi Economic Surprise Index for Latin America is significant with the expected negative sign (positive surprises increase bond market liquidity). However,

[11] We do not run the regressions in differences as the dependent variable does not display an obvious trend.

we do not find evidence of spill-overs from economic news in the U.S. on bond market liquidity in Mexico as the U.S. Citi Economic Surprise index is insignificant in Regression 7.

We do not find evidence of an important link between funding liquidity and market liquidity. Both the Mexican swap spread and the Mexican TED spread—indicators of funding liquidity in Mexico—are neither significant individually (not shown here) nor jointly with the other explanatory variables (Regressions 8 and 9). We also cannot confirm for the case of Mexico the finding of Adrian et al (2017) for the U.S. treasury market, namely that a strong link between funding liquidity and market liquidity does not exist in normal times but does exist during episodes of elevated bond market liquidity (results not shown in the table).[12] A possible explanation may be that there is little use of unsecured interbank lending in Mexico.

Finally, as a robustness check, we replace our dependent variable, the overall liquidity index, with an alternative based on a Markov regime-switching framework. We apply a dynamic Markov switching specification to our liquidity index, allowing for three different states (high, mid and low liquidity) that can differ both in mean and variance. Broadly following IMF (2015), we then use the probability to be in the low liquidity state as an alternative dependent variable in our regressions in Table 5. This approach has two advantages: first, Figure 7 shows that liquidity tends to abruptly switch between different levels (see also Flood, Liechty and Piontek, 2015; IMF, 2015), implying that a regime-switching model may fit the data generating process particularly well; second, using the probability to be in the low liquidity state as a dependent variable allows us to directly focus on the determinants of extreme liquidity shortages. Running the same regressions 1-9 again with the alternative dependent variable delivers strikingly similar results. To save space, we only present the joint regression with the new dependent variable as Regression 10 in Table 5. As can be seen, the same variables are significant as in Regression 1, with the same coefficient signs. The main difference is a notably higher R-squared of 0.27, compared to 0.18 in Regression 1, suggesting that our explanatory variables may explain periods of liquidity shortages particularly well.

[12] We interacted the funding liquidity measures with the bond market volatility measures but the interaction term was not significant. We also ran quantile regressions to determine whether a link between funding and market liquidity may exist at low levels of market liquidity but, again, did not find any evidence in favor of this hypothesis.

Table 5: Regression Analysis

Dependent Variable: Liquidity Index	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
MEX Bond Market Volatility	1.845***			1.487***		1.901***	1.845***	1.826***	1.887***	0.014***
	(8.145)			(6.512)		(8.231)	(8.140)	(7.992)	(8.554)	(12.466)
MEX Equity Market Volatility	0.490**	0.655***		0.545***		0.464**	0.490**	0.437**	0.382*	0.002**
	(2.397)	(3.162)		(2.741)		(2.261)	(2.396)	(2.133)	(1.904)	(1.997)
MEX FX Market Volatility	2.610***	3.066***		3.137***		2.492***	2.612***	2.428***	2.631***	0.010***
	(7.047)	(8.197)		(6.411)		(6.520)	(6.952)	(5.454)	(6.894)	(5.147)
U.S. Bond Market Volatility	0.243***	0.306***		0.232***		0.208***	0.243***	0.282***	0.238***	0.002***
	(3.839)	(4.770)		(3.744)		(2.988)	(3.783)	(3.238)	(3.755)	(6.282)
Latam Citi Surprise Index	-0.092***	-0.137***		-0.091***		-0.097***	-0.092***	-0.096***	-0.099***	-0.001***
	(-3.830)	(-5.694)		(-3.828)		(-3.974)	(-3.819)	(-3.986)	(-4.173)	(-6.950)
U.S. TED spread			26.191***	-10.426						
			(3.711)	(-1.133)						
U.S. High Yield Spread					3.916***	1.055				
					(4.701)	(1.239)				
US Citi Surprise Index							-0.001			
							(-0.046)			
MEX TED Spread								0.518		
								(0.744)		
MEX Swap Spread									-0.045	
									(-0.652)	
Constant	-68.979***	-72.222***	-14.692***	-71.213***	20.529***	-69.419***	-68.992***	-71.822***	-66.139***	-0.216***
	(-13.828)	(-14.221)	(-6.337)	(-14.505)	(-6.010)	(-13.884)	(-13.804)	(-10.486)	(-9.735)	(-8.618)
Observations	1,582	1,583	1,550	1,549	1,599	1,582	1,582	1,575	1,573	1,582
R-squared	0.175	0.140	0.009	0.174	0.014	0.176	0.175	0.174	0.186	0.270

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Notes: The dependent variable in Regressions 1-9 is the overall liquidity index. In Regression 10, the dependent variable is the probability of the same liquidity index being in the high volatility state based on a dynamic Markov Regime-Switching regression model with three states that differ in both intercept and variance.

B. Who Drains Bond Market Liquidity?

To better understand the behavior of individual investor types, we examine episodes of large liquidity squeezes in the Mexican government bond market. A complicating factor in identifying large liquidity declines is that liquidity developments are subject to calendar effects. For example, most index funds tend to trade at the end of the month to rebalance their holdings. Our approach is thus to identify the largest 5-day declines in market liquidity by comparing the behavior of our composite liquidity index to a counterfactual that projects the index ahead based on calendar effects.

More specifically, we take the following steps: first, we calculate the cumulative 5-day ahead change in our composite liquidity index for each day in our sample; second, we construct a counterfactual that, for each day in our sample (t=0), projects the index 5 days ahead based on a simple ARMA(2,1) regression on the entire sample period in which the liquidity measure is regressed on its own lag, a moving average terms, as well as calendar effects;[13]

[13] The ARMA(2,1) model is the one with the lowest BIC score. The calendar effects include day-of-the-week dummies, month dummies, dummies for the last/first 5 working days of the month, dummies for the working day before/after a holiday and dummies for auction days (even though we exclude the auctioned bonds on auction days from our analysis) as a counterfactual.

third, we choose the 10 days with the largest cumulative difference between the actual 5-day ahead change in the liquidity index and the counterfactual 5-day ahead change.

Table 6 describes these episodes and makes an attempt to tentatively group them into external and domestic shocks based on our reading of the political and economic events that coincided with them. We add one additional episode (Episode 0) to the list, namely the Lehman bankruptcy in September 2008. While we do not have the necessary electronic quotes data to calculate the composite liquidity index for this episode, we do have the transactions data to calculate the responses of different investor types. Overall, we end up with four externally driven episodes, four domestically driven episodes and three episodes with mixed or unclear drivers. A look at Table 6 shows that most of the events we identify are associated with well-known political or economic shock events. We leave one episode out of the analysis for the time being, namely the COVID-19 pandemic, since its long-lasting impact makes it difficult to identify a specific 5-day window. We will come back to it later in this section.

Table 6: List of Episodes of Large Liquidity Declines

	t = 0	Type	Events
Episode 0	September 15, 2008	External	Lehman Brothers files for bancruptcy on September 15 (t=0).
Episode 1	May 21, 2013	External	Fed Chairman Ben Bernanke testifies to Congress on May 22, 2013 (t=1), that the Fed would likely start slowing—that is, tapering—the pace of its bond purchases later in the year.
Episode 2	December 9, 2015	External	On December 13 (weekend before t=3), a new Monmouth University poll suggests that Donald Trump expanded his lead to nearly triple the support of his nearest rival for the GOP presidential nomination.
Episode 3	September 8, 2018	Unclear	Mexican Finance Secretary Luis Videgaray, resigns on September 7 (t=-1). On September 11 (weekend before t=2), Hillary Clinton leaves the 9/11 memorial service with pneumonia while a number of polls see Trump closing in on her.
Episode 4	November 8, 2016	External	Trump wins U.S. presidential election held on November 8 (t=0).
Episode 5	December 16, 2020	Domestic	Concerns over the expected jump in fuel prices lead to panic purchases and gasoline shortages in some states on December 26 (t=4).
Episode 6	December 30, 2016	Domestic	Gasoline prices in Mexico jump by some 20 percent on January 2 (t=1).
Episode 7	October 26, 2018	Domestic	On October 29 (t=1), President-elect Andrés Manuel López Obrador announced he would cancel the construction of the new Mexico City airport in Texcoco.
Episode 8	December 19, 2018	Unclear	On December 20 (t=1), the Remain in Mexico policy is announced under which non-Mexican migrants will remain in Mexico while their asylum claims in the U.S. are assessed. At the same time, the U.S. Move index increased during the episode, suggesting possible spillovers.
Episode 9	January 17, 2019	Domestic	A pipeline explosion on January 18 (t=1) kills 137 people, raising concerns over President Lopez Obrador's policy of combating fuel theft.
Episode 10	n.a.	Unclear	COVID-19 Shock

Having identified our episodes of interest, we calculate the role different types of investors played in each of the episodes. We compute these, for each episode and investor type, as the difference between the actual cumulative net purchases of government bonds (over the 5-day period) and a counterfactual computed based on a simple AR(10) regression that is akin to the one used for the liquidity index in identifying our episodes of interest.[14]

Figure 8a illustrates the episodes of large liquidity declines we classify as externally driven, Figure 8b illustrates the episodes we classify as domestically driven, and Figure 8c illustrates the remaining episodes. We exclude Episode 10 (the COVID-19 shock) for the time being.

[14] We regress each investor type's purchases (sales) of government securities on its first lag and the same calendar effects as in the case of the liquidity indicator. We then construct the counterfactual as the cumulative 5-day ahead purchases (sales) predicted by the estimated regression.

The blue line in the left charts in each figure captures the difference between the actual behavior of our composite liquidity indicator and the counterfactual, with the blue shaded area illustrating the 90 percent confidence interval. The chart also includes three of the important correlates of our liquidity indicator identified in the previous section, namely the equity and implied exchange rate volatility measures and the U.S. MOVE index, all normalized to 100 at t=0. The right chart shows the difference between each investor type's net cumulative purchases of government securities and its counterfactual. The blue columns show net purchases of benchmark fixed rate securities, while the orange columns show net purchases of all securities (all fixed, floating and inflation linked bonds as well as T-bills).[15]

Figures 8a, 8b and 8c suggest that increases in our liquidity indicator during the episodes of interest (suggesting liquidity depletion) were large. Across Episodes 1-9, the liquidity index increases at peak level on average by 1.9, which is equal to about 4.4 standard deviations. The maximum increase is 3.2 (7.4 standard deviations) in the case of Episode 2, while the minimum increase is 1.0 (2.4 standard deviations) in the case of Episode 6. The three externally driven shocks appear to be among those with the largest peak liquidity declines. Moreover, episodes of large liquidity declines tend to come with volatility in different segments of the Mexican financial markets and/or appear to be driven by distress in U.S. bond markets. FX volatility seems to be elevated mostly around externally driven episodes while it remained mostly flat during domestically driven ones.

Taking a closer look at the components of our liquidity indicator during the episodes of interest (Appendix Figure 2), it is noteworthy that the episodes differ markedly in terms of the components driving the respective liquidity squeezes. For example, while the bid-ask spread is an important driver in Episodes 4, 7 and 8, it contributes little or nothing to the liquidity squeezes in Episodes 2, 3 and 9. Similarly, the price impact indicator matters little for the squeezes in Episodes 5, 6 and 8, while it is crucial for Episodes 2, 3 and 9. This finding underlines the importance of considering the various aspects of market liquidity when tracking market liquidity or aiming to identify episodes of severe liquidity squeezes.

A striking regularity we observe across external, domestic and other episodes in Figures 8a, 8b and 8c is that foreign investors as a group contributed significantly to the liquidity depletion in the fixed income market as a whole in almost all episodes (the orange column is almost always negative for foreign investors).[16] Interestingly, however, the blue column—showing net purchases of benchmark fixed rate securities relative to the counterfactual—is positive in at least half of the cases. In other words, it appears that foreign investors consistently contributed to selling pressure in the fixed income market as a whole, but they

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[15] Note that the responses of different investors do not necessarily sum to zero since not all investor types are included in the chart to save space (e.g. the authorities, brokerage firms and other domestic investors) and since we show the difference relative to the counterfactual rather than net purchases themselves.

[16] Foreign investors hold 56 percent of Mbonos outstanding as of September 2019. Their holdings are more concentrated in the belly of the yield curve (5-10Y sector). Most foreign investors are passive index investors and follow global asset allocation strategies. A global risk aversion event can thus cause non-residents to exit in a similar fashion.

also, in about half of the cases, shifted out of less liquid securities and into more liquid benchmark fixed rate bonds.[17] This finding appears to rationalize the conclusions of Christensen and Fischer (2019), among others, namely that foreign investor presence tends to drive up liquidity premia.

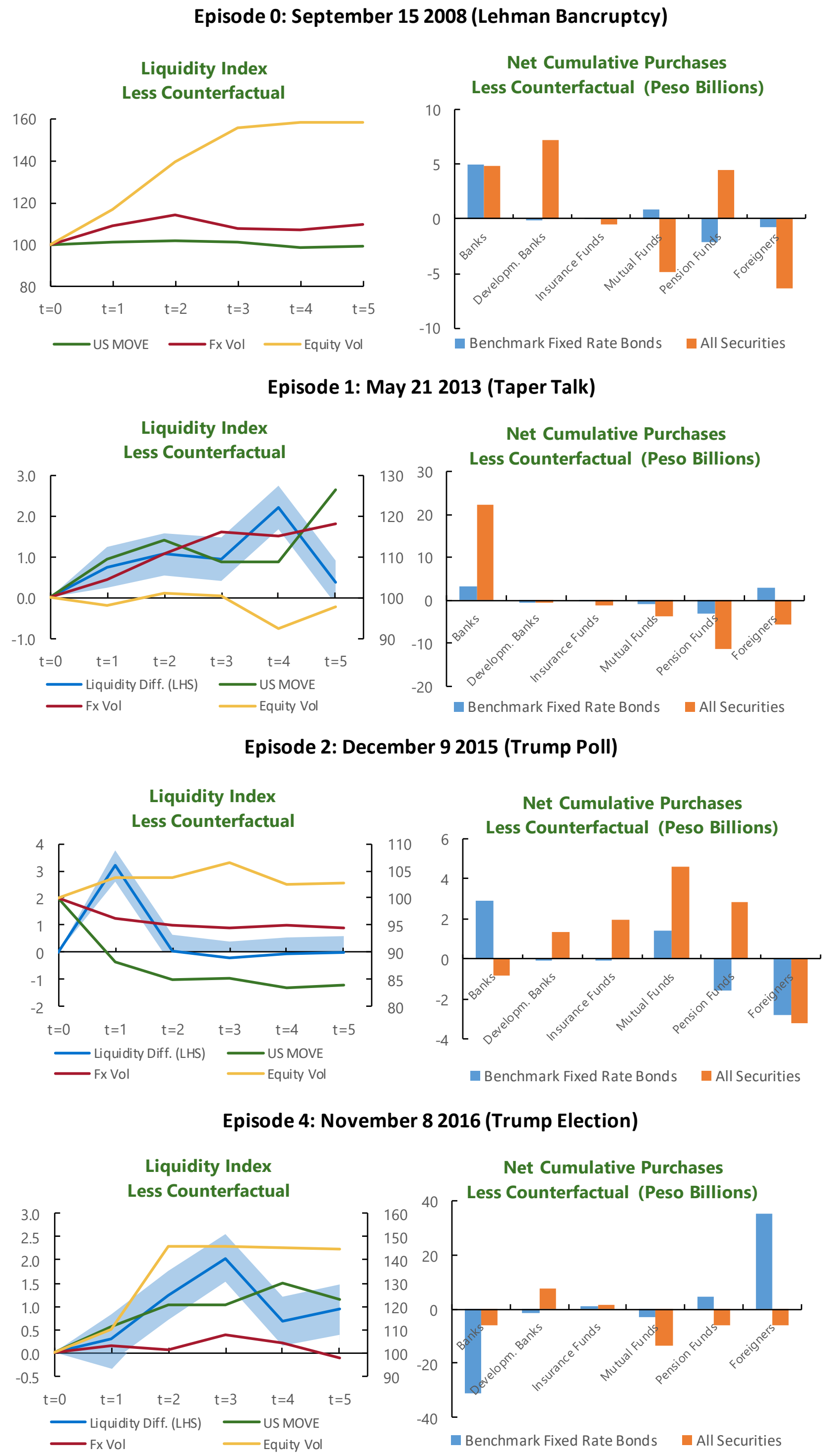
Domestic banks, on the other hand, appear to be more likely to increase their holdings of Mexican government securities, especially benchmark fixed rate securities, during shock events, representing by far the largest buyers relative to the counterfactual in several of the episodes. This behavior could, at least in part, be motivated by their obligation as primary dealers to provide liquidity to facilitate an orderly exit for investors.

While one may have expected mutual funds to behave similarly to foreign investors in adding selling pressures during large liquidity declines, this is at best true during externally originated events. In contrast, looking at Episodes 0-9 as a group, mutual funds bought more securities than projected by the counterfactual in about half of the episodes and often appeared to shift out of the more liquid benchmark securities rather than into them. In other words, their price-sensitive investment behavior may have contributed to stabilizing the market, perhaps suggesting differentiated views on risks and strategies to deviate from the market once the price adjustment is considered attractive.

Pensions and life insurance companies as well as development banks, in turn, are long term investors that tend to be more driven by asset liability management and can look through the short-term market volatility. Their behavior during the ten episodes appears to be largely opportunistic and could include adding positions when pricing is attractive, perhaps reflecting longer term strategies more so than short term positioning.

[17] The only exception to the rule is Episode 7, the announcement on the part of newly elected President Lopez Obrador to cancel the construction of the partially built new Mexico City airport. This exception to the rule may suggest that domestic investors were more concerned about the event than foreigners.

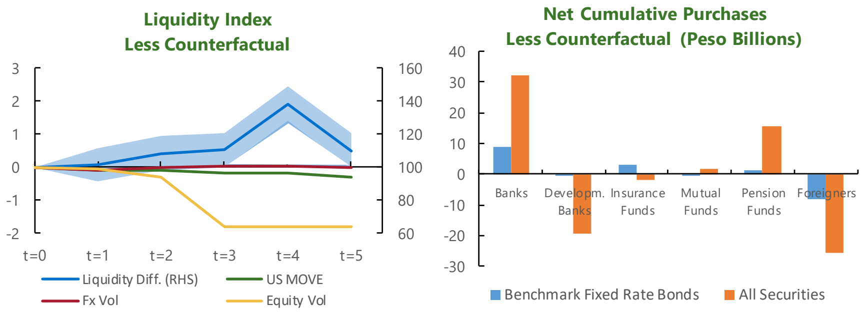
Figure 8a: Liquidity Stress Associated with External Shocks



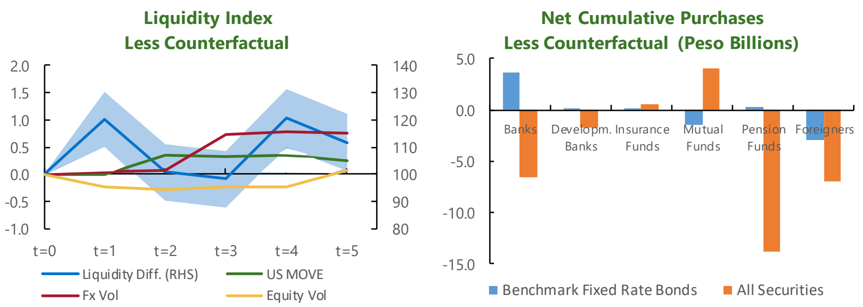
Notes: The blue line in the left charts shows the difference between the actual values of our liquidity indicator and the counterfactual based on calendar effects; the blue shaded area captures the 90 percent confidence interval around it; the yellow, red and green lines show equity volatility, FX volatility and the U.S. MOVE index, normalized to 100 at t=0. The blue columns in the right chart show the difference between net purchases of benchmark fixed rate securities and the counterfactual for each investor type, while the orange bars show the difference between net purchases of all securities and the counterfactual. The columns do not sum up to zero for two reasons: first, we do not include all investor types to save space (we exclude, e.g. brokerage firms, the authorities and other domestic investors); second, we are showing net purchases relative to a stochastic counterfactual rather than net purchases themselves.

Figure 8b: Liquidity Stress Associated with Domestic Shocks

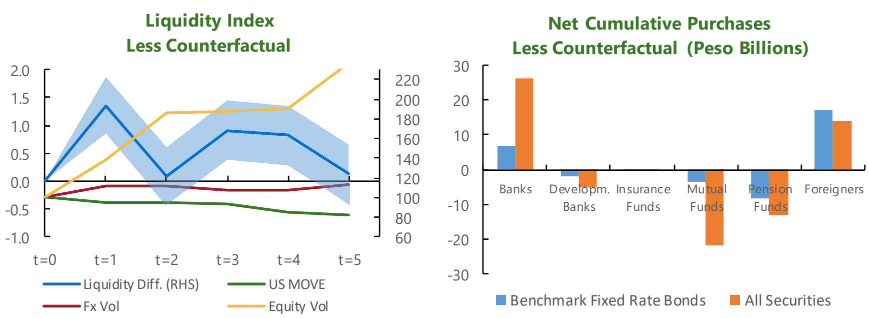
Episode 5: December 20 2016 (Fuel Price Concerns)



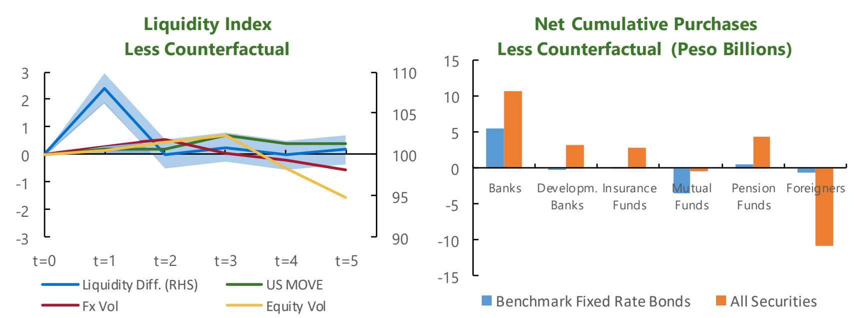
Episode 6: December 30 2016 (Fuel Price Increases)



Episode 7: October 26 2018 (Airport Cancelation)

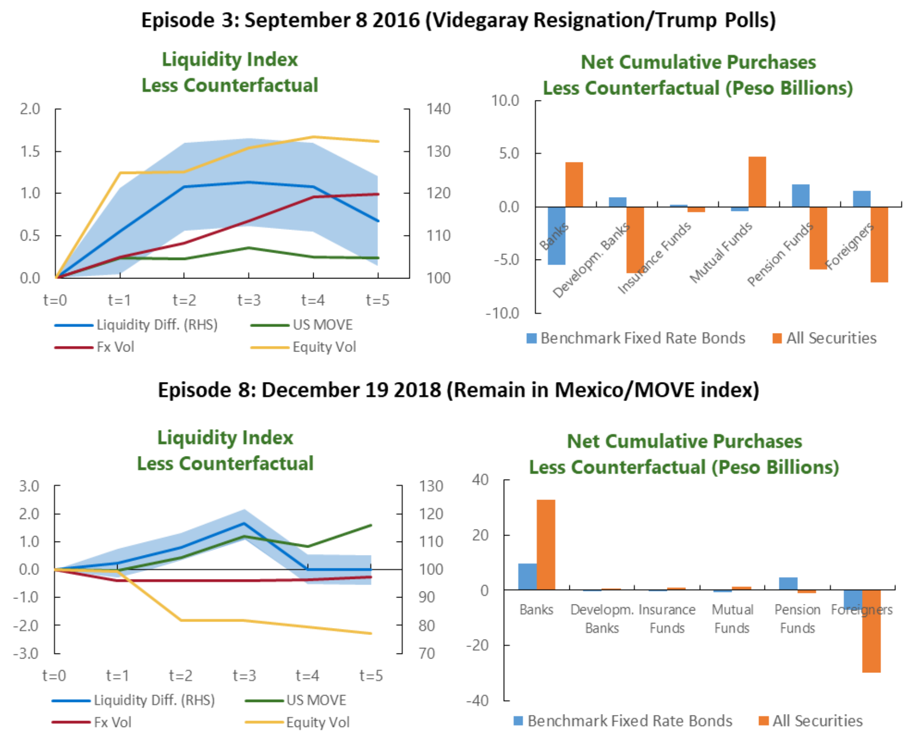


Episode 9: January 17, 2019 (Pipeline Explosion)



Notes: The blue line in the left charts shows the difference between the actual values of our liquidity indicator and the counterfactual based on calendar effects; the blue shaded area captures the 90 percent confidence interval around it; the yellow, red and green lines show equity volatility, FX volatility and the U.S. MOVE index, normalized to 100 at t=0. The blue columns in the right chart show the difference between net purchases of benchmark fixed rate securities and the counterfactual for each investor type, while the orange bars show the difference between net purchases of all securities and the counterfactual. The columns do not sum up to zero for two reasons: first, we do not include all investor types to save space (we exclude, e.g. brokerage firms, the authorities and other domestic investors); second, we are showing net purchases relative to a stochastic counterfactual rather than net purchases themselves.

Figure 8c: Liquidity Stress Associated with Unclear Shocks



Notes: The blue line in the left charts shows the difference between the actual values of our liquidity indicator and the counterfactual based on calendar effects; the blue shaded area captures the 90 percent confidence interval around it; the yellow, red and green lines show equity volatility, FX volatility and the U.S. MOVE index, normalized to 100 at t=0. The blue columns in the right chart show the difference between net purchases of benchmark fixed rate securities and the counterfactual for each investor type, while the orange bars show the difference between net purchases of all securities and the counterfactual. The columns do not sum up to zero for two reasons: first, we do not include all investor types to save space (we exclude, e.g. brokerage firms, the authorities and other domestic investors); second, we are showing net purchases relative to a stochastic counterfactual rather than net purchases themselves.

The COVID-19 Shock

As mentioned previously, we examine the onset of the COVID-19 shock separately from the other episodes in large part because the shock appears not only to be larger but also more persistent than other shocks. We choose March 1 as a start date for the episode to capture the market reaction to increasing fears about the pandemic at the global level during the early days of the month.[18]

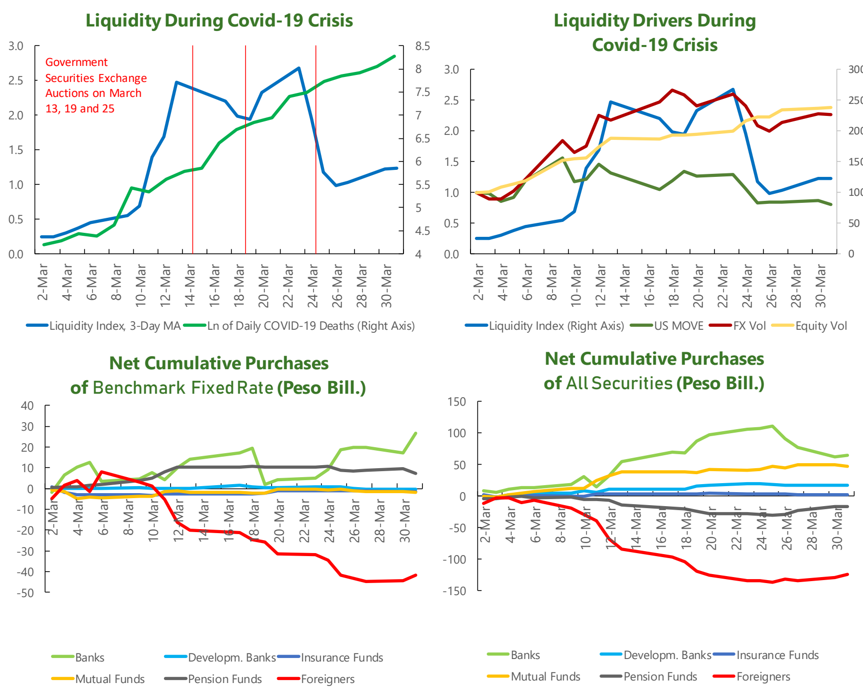
The top left chart of Figure 9 shows that the liquidity index correlates quite noticeably with the evolution of the pandemic at the global level. It peaked at 2.7 on March 23, a level only reached (for one day) in one of the episodes discussed earlier. Strikingly, however, the index remained above a value of 2 for a full 10 days, and thereafter hovered around a level of 1 despite support from securities exchange auctions on the part of the Mexican authorities. The top right chart shows that these liquidity developments correlated closely with volatility in

[18] This analysis only includes data until the end of March. As the lockdown in Mexico started in the third week of March, there may be additional impacts on market liquidity beyond the period covered by the analysis.

other Mexican financial markets, while volatility in U.S, fixed income markets was contained during the entire episode by substantial policy support.

While the shock is thus larger and much more persistent than other liquidity declines the Mexican fixed income market has experienced, the reaction of different investor types has been qualitatively very similar. Foreign investors, in particular, sold off substantial amounts of securities since the beginning of the crisis, both in the case of benchmark fixed rate securities and for the market as a whole (see bottom left and bottom eight charts in Figure 9). Domestic banks, in turn once again appear to have provided the necessary liquidity to facilitate an orderly exit for foreign investors. Similarly, mutual funds contributed liquidity, and primarily so for non-benchmark fixed rate securities. Interestingly pension funds reacted to the crisis by selling off securities in the market as a whole and shifted into the more liquidity benchmark securities.

Figure 9: The COVID-19 Crisis



V. Conclusion

This paper examines the drivers of liquidity shortages in the Mexican bond market, one of the largest and most liquid among emerging markets. It employs unique transactions and quote level data sets with information on end investors participating in each transaction. It builds a composite index of market liquidity in the Mexican government bond market and analyzes its drivers.

The analysis suggests that market liquidity has remained relatively stable in recent years despite rising foreign ownership and regulatory changes. Sharp liquidity declines remained strictly temporary, although the COVID-19 shock accounted for a more dramatic and persistent liquidity squeeze than previously experienced. A closer look at the most severe liquidity squeezes reveals that foreign investors not only consistently accounted for much of the selling pressure but also tended to switch from less liquid market segments to on-the-run securities when liquidity dried up. Domestic banks, on the other hand, were more likely to absorb pressures during liquidity squeezes, perhaps in line with their responsibility as primary dealers to provide for an orderly exit of non-resident investors. Interestingly, domestic mutual funds contributed to market stability during most of the episodes. Other more long-term oriented domestic investors, including pension and insurance funds, appeared to take more opportunistic positions in response to the shocks, supporting market liquidity at times and, at others, contributing to selling pressure

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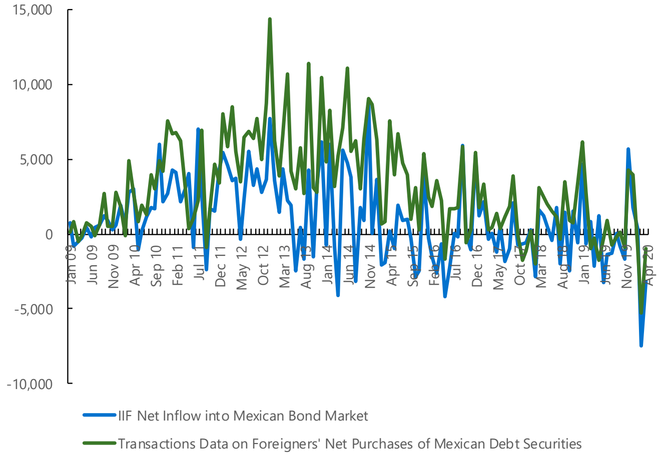
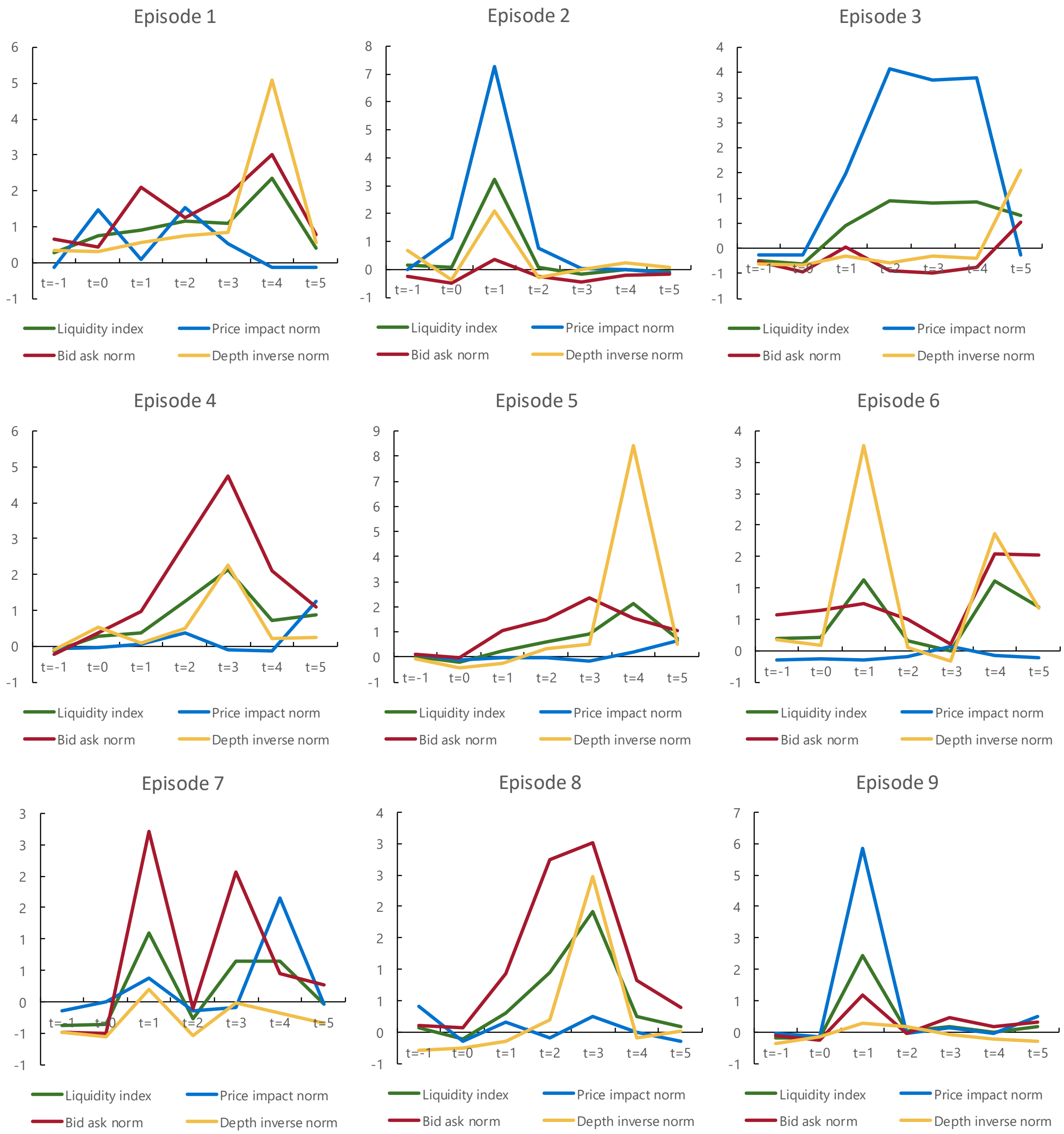
APPENDIX

Appendix Figure 1: Net Securities Purchases of Foreigners vs. IIF Bond Market Flow Data



Appendix Figure 2: Decomposing Liquidity Squeezes



Appendix Table 1: Summary Statistics and Definitions

Dependent Variables

Variable	Obs	Mean	Std Dev	Min	Max	Definition	Source
Market liquidity index	1,600	-5.0	36.2	-69.4	430.3	Index multiplied by 100; higher values imply less liquidity	Authors' calculations
Probabiliy of high vol. state	1,600	0.1	0.2	0.0	0.7	Probability calculated based on Markov regime-switching model on daily data of liquidity index, allowing for three states that differ in mean and variance.	Authors' calculations

Volatility/Stress Variables

Variable	Obs	Mean	Std Dev	Min	Max	Definition	Source
MEX bond market volatility	1,599	4.8	3.7	0.2	48.7	Standard deviation of daily 10-year bond yield between t-1 and t-5	Bloomberg
MEX equity market volatility	1,600	13.1	4.6	5.7	35.3	Bolsa Mexicana de valores 30-day volatility	Bloomberg
MEX FX market volatility	1,600	11.9	2.4	6.0	19.8	Volatility implied by 3-month on-the-money peso-dollar option	Bloomberg
US bond market volatility	1,590	65.2	13.5	42.5	117.9	MOVE index	Bloomberg
US TED spread	1,470	30.8	10.9	14.5	68.9	3-month libor minus 3-month T-bill rate	
US High Yield Spread	1,599	4.0	1.1	2.2	8.4	10-year U.S. corporate high yield rate minus 10-year U.S. Treasury rate	

Funding Liquidity Variables

Variable	Obs	Mean	Std Dev	Min	Max	Definition	Source
MEX swap spread	1,587	5.8	1.7	3.7	8.9	26-month swap spread (28 day TIIE)	Bloomberg
MEX TED spread	1,591	39.1	12.3	-25.0	91.5	28-day TIIE interbank rate minus 28-day Cetes yield	Bloomberg

Macroeconomic Shock Variables

Variable	Obs	Mean	Std Dev	Min	Max	Definition	Source
Latam Citi surprise index	1,592	-10.9	36.4	-152.6	59.6	Citi index of economic surprises in Latam	Bloomberg
US Citi surprise index	1,592	-3.0	32.6	-78.6	84.5	Citi index of economic surprises in the U.S.	Bloomberg