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December 2022

TECHNICAL NOTE ON SYSTEMIC RISK ANALYSIS AND STRESS TESTING

This Technical Note on Systemic Risk Analysis and Stress Testing for the Mexico FSAP was prepared by a staff team of the International Monetary Fund as background documentation for the periodic consultation with the member country. It is based on the information available at the time it was completed in July 2022.

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TECHNICAL NOTE

SYSTEMIC RISK ANALYSIS AND STRESS TESTING

Prepared by
Monetary and Capital Markets Department

This Technical Note was prepared by IMF staff in the context of the of a joint IMF-World Bank Financial Sector Assessment Program (FSAP) mission in Mexico during June 2022, led by Vikram Haksar (IMF), IMF and Ilias Skamnelos (WB), World Bank, and overseen by the Monetary and Capital Markets Department, International Monetary Fund, and the Finance and Markets Global Practice, World Bank. It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations. Further information on the FSAP can be found at http://www.imf.org/external/np/fsap/fssa.aspx

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Glossary

ABM	*Asociación de Bancos de México* (Mexican Banking Association)
AT1	Additional Tier 1
Banxico	*Banco de México* (Central Bank)
CAR	Capital Adequacy Ratio
CB	Central Bank
CBDC	Central Bank Digital Currency
CEB	*Comité de Estabilidad Bancaria* (Banking Stability Committee)
CET1	Core Equity Tier 1
CNBV	*Comisión Nacional Bancaria y de Valores* (National Banking and Securities Commission)
COVID	Coronavirus Disease
CVaR	Conditional Value at Risk
DBs	Development Banks
D-SIBs	Domestic Systemically Important Banks
ELA	Emergency Liquidity Assistance
EM	Emerging Market
FMI	Financial Market Infrastructure
FSAP	Financial Sector Assessment Program
FSB	Financial Stability Board
FSI	Financial Soundness Indicator
FX	Foreign Exchange
GaR	Growth-at-Risk
GDP	Gross Domestic Product
GFSR	Global Financial Stability Report
G-SIB	Global Systemically Important Bank
HQLA	High Quality Liquid Assets
IFRS	International Financial Reporting Standard
IMF	International Monetary Fund
IPAB	*Instituto para la Protección al Ahorro Bancario* (Bank Deposit Insurance and Resolution Agency)
IRB	Internal Ratings-Based Regulatory Approach
LCR	Liquidity Coverage Ratio
LTV	Loan-to-Value
MCM	Monetary and Capital Markets Department, IMF
MXP	Mexican Peso
NBFI	Nonbank Financial Institution
NFC	Nonfinancial Corporations
NGFS	Network for Greening the Financial System
NPL	Non-performing Loans
NSFR	Nest Stable Funding Ratio

PD	Probability of Default
PiT	Point-in-Time
RAM	Risk Assessment Matrix
RoA	Return on Assets
RoE	Return on Equity
RWA	Risk Weighted Asset
SHCP	*Secretaría de Hacienda y Crédito Público* (Ministry of Finance and Public Credit)
SIB	Systemically Important Bank
SME	Small and Medium-Sized Enterprise
ST	Stress Test
STA	Standardized Regulatory Approach
STeM	Stress Test Matrix
TD	Top-down
TLAC	Total Loss Absorbing Capacity
TTC	Through-the-Cycle
WB	World Bank
WEO	World Economic Outlook

EXECUTIVE SUMMARY[1]

Mexico has a resilient financial system but a low level of financial inclusion. The financial system is smaller than in peer countries and is dominated by commercial banks that have had large capital and liquidity buffers for years. Despite these buffers and the high profitability in the banking sector, credit growth has been low due to both supply and demand factors, with banks targeting mainly the prime segments of the economy. The COVID-19 pandemic has had a limited impact on the financial system, reflecting a mix of resumption in mobility and support from global and domestic policies.

The key risk confronting Mexico is the first sustained and ongoing tightening of global liquidity conditions since the Global Financial Crisis, combined with risks of lower growth coupled with higher inflation. The economic recovery has been sluggish and inflation has reached a record high. In this context, the possibility of a disorderly tightening in global and domestic financial conditions could further weaken activity, erode banks' net interest margins via higher corporate defaults, trigger exchange rate volatility and drive system-wide liquidity stress in Mexico. These risks, combined with the possible reemergence of pandemic waves which could worsen the inflation outlook via supply chain channels, underpin the stress test adverse scenario narrative.

Banks are resilient to severe macrofinancial shocks. Capital and liquidity ratios for most banks in the sample would still be above minimum requirements in an adverse scenario, with limited shortfalls for some banks. Solid internal capital generation capacity due to robust interest margins and ample capital buffers ensure that the system can withstand severe shocks. The liquidity of the banking system is guaranteed by high starting liquidity ratios, particularly for systemic banks.

But solvency and liquidity stress tests identified some areas for close monitoring. The large contingent credit lines extended by banks to corporates are identified as a key weakness in both the solvency and the liquidity stress tests, although the majority of them are revocable credit lines, which attenuates the risk. Exposures to these contingent credit lines are unevenly distributed among banks and, under certain conditions, could be triggered quickly and simultaneously during crises thus reducing the system's buffers. It is important to ensure that the related risks are captured in terms of capital and liquidity requirements. Risks stemming from large exposures and other concentration risks as well as bank-specific business model linked risks also merit close monitoring and supervisory attention. Finally, the authorities should monitor the part of retail deposits from high net-worth individuals in search of higher yields that could behave like wholesale deposits and be prone to outflows.

[1] This Technical Note has been prepared by Dimitrios Laliotis (lead), Priscilla Toffano (liquidity and system-wide liquidity) and Xiaodan Ding (solvency and system-wide liquidity), Kevin Wiseman (corporate risk analysis), Padamja Khandelwal and Lu Zhang (interconnectedness analysis) and Sujan Lamichhane (solvency) under the guidance of Vikram Haksar and Heedon Kang (all IMF). The team is grateful to Banxico and CNBV for their excellent collaboration in this exercise, particularly in the challenging remote circumstances under which the mission was conducted at its early stage due to the COVID pandemic.

A novel system-wide liquidity framework was used to identify potential liquidity stress in the system beyond commercial banks. The development of this framework, which complements standard liquidity and interconnectedness analyses, stemmed from the understanding that it is not sufficient to ensure the resilience of an individual sector or institution to protect the stability of the entire system. The system-wide liquidity analysis allowed to trace the liquidity linkages among various agents in the economy and understand the transmission channels and amplification mechanisms of liquidity shocks. It also allowed to evaluate the liquidity capacity of the system and conduct some policy counterfactual experiments.

Results show that the commercial banks ensure the liquidity of the financial system by backstopping liquidity needs of all other agents. Commercial banks act as a shock absorber by providing liquidity to other agents through repo transactions. They show only marginal liquidity shortfalls even under the most severe narratives.

Development banks, on the other hand, appear more vulnerable during periods of stress with binding liquidity constraints (e.g., mandatory LCRs for commercial banks or minimum liquidity buffers for investment funds) being considered. Under the binding constraints, larger liquidity shortfalls could materialize in the system for some agents, given the fact that agents with liquidity surplus might be less willing to roll-over existing funding transactions, and, therefore, amplify stress conditions on development banks' liability side. In a similar vein, policy analysis also suggests that promoting the participation of investment funds to the repo market could reinforce system-wide resiliency and liquidity conditions.

Corporate defaults would rise under the adverse scenario, consistent with the bank solvency stress test. Machine learning tools were used to model corporate default risk since they outperformed linear regressions in the ability to capture non-linearities and interaction effects between variables linked to corporate risk. The outcome of such models points to stronger corporate default paths in the adverse stress scenario and calls for additional caution about the potential effects of a stress scenario with greater financial tightening.

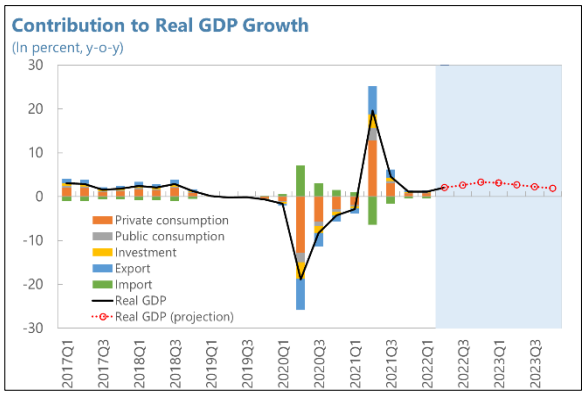
Table 1. Mexico: Recommendations on Systemic Risk Analysis and Stress Testing

Recommendations and Responsible Authorities	Timing*	Priority**
1. Address bank idiosyncratic risk profiles by applying appropriately calibrated capital add-ons through Pillar II requirements; enhance prudential oversight over concentration risks and business models; (CNBV).	NT	H
2. Monitor the dynamics of contingent credit lines closely and assess relevant risks (Banxico, CNBV).	NT	H
3. Incorporate the liquidity analysis in the Supervisory Review Process (SRP) to inform Pillar 2 capital requirements for banks (Banxico, CNBV).	MT	M
4. Continue the work on bridging data gaps (focusing on IFRS 9 and full IRB model application) and further enhance data reporting and modelling capacity (CNBV, Banxico).	MT	M
5. Improve robustness checks in the liquidity stress test framework to address that part of retail deposits (of high net-worth individuals) that could behave as wholesale deposits (Banxico).	NT	M
6. Utilize granular collected data to set up a regular maturity ladder template and use cash flow to further complement the current stress test framework (Banxico).	NT	M
7. Consider incorporating and adjusting the system-wide liquidity analysis, ideally at the entity level, to monitor the relative contribution of different agents to liquidity stress and identify and assess policies that could strengthen the resiliency of the system to liquidity shocks (Banxico).	MT	M

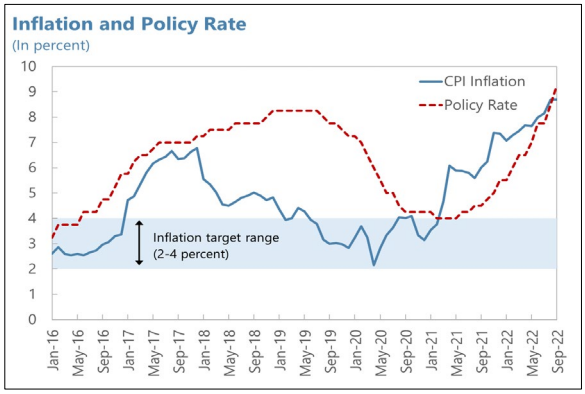
* C: continuous; I: immediate (<1 year); NT: short term (1–2 years); MT: medium term (3–5 years).
** H: high; M: medium; L: low.

INTRODUCTION

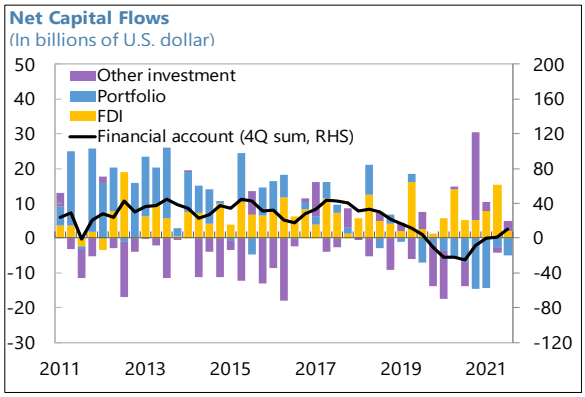
A. Macrofinancial Context



1. The Mexican economy is gradually recovering from its deepest recession in decades. Growth in 2020 contracted by 8.1 percent and was among the lowest in the G20. Thanks to a recovery in mobility and external demand, and a nimble domestic policy response, it rebounded to 4.8 percent in 2021. It is currently forecast at 2.4 percent in 2022—weaker than in other major emerging markets (EMs) (Text Chart). The unemployment rate is declining after a sharp spike at the onset of the pandemic and was at 3.3 percent in May 2022.

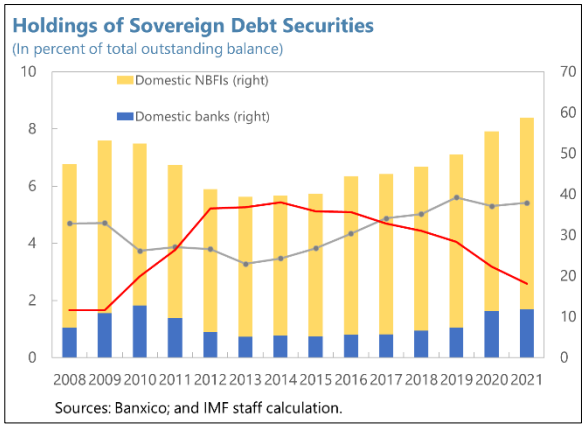


2. Inflation remains above the central bank's target of 3 percent, prompting the central bank to raise rates. Demand reactivation after the pandemic together with pressures on raw food and gas prices, rising wage inflation, and supply chain constraints, particularly in manufacturing, have pushed inflation to 8.7 percent in August (the highest reading since 2001). The domestic yield curve has shifted sharply up in the face of inflation concerns. To anchor medium-term inflation expectations and guard against second-round effects, the central bank has raised the policy rate by a cumulative 525 bps since June 2021, including a 75 bps to 9.25 percent in September 2022 (Text Chart). The Governing Board of Banco de México signaled that it intends to continue raising the reference rate if conditions so require.



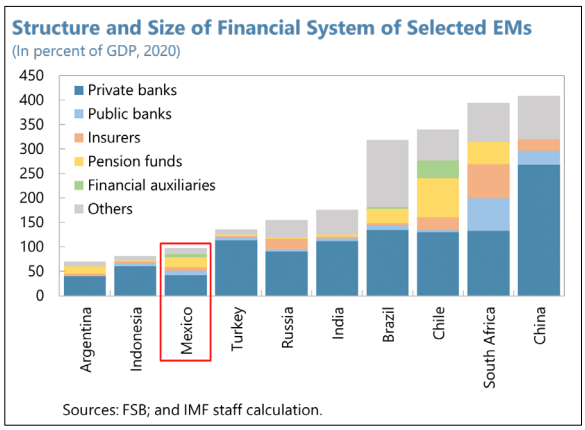
3. The structural current account balance remains in deficit, and portfolio flows are vulnerable to shocks. In 2020, strong U.S. demand, remittance inflows, and weak domestic demand led to a current account surplus of 2.5 percent of GDP. The current account returned to a deficit in 2021 and is expected to remain a deficit over the medium term. Portfolio flows have been volatile (Text Chart) as in other EMs.

4. Mexico is highly integrated with global financial markets and exposed to external liquidity shocks. The public debt and foreign exchange (FX) markets are well developed with high non-resident interest. Foreign investors hold about a sixth of the outstanding local currency government bonds, although the share has fallen sharply since 2017, with domestic banks picking up the slack (Text Chart). The sovereign has also issued 7.2 percent of GDP in external debt as of end-2021, while Mexican non-financial corporates (NFCs) have sizable debt issuance offshore (13 percent of GDP), mainly long-term bonds. The Mexican peso (MXN) is widely used as a proxy for EM currencies. This reflects its high liquidity, given a large global market for exchange traded MXN derivatives. Trading volumes of MXN on major exchanges are significantly higher than most other EM currencies and are comparable to those of major currencies. This proxy trade feature gives MXN a high correlation (or beta) with global risk shocks. As a result, MXN volatility tends to increase the most among peers in periods of global risk aversion.



B. Financial Sector Structure

5. Mexico's financial system is relatively small. The system, with total assets of about 100 percent of GDP, is smaller than in EM peers (Text Chart). The banking sector (commercial and development banks) accounts for more than half of the financial system, while pension funds and insurers account for about 20 percent and 8 percent of total financial sector assets (Figure 1 and Table 2). The financial system is structured around financial groups with banks playing a leading role. As in other EMs, Mexico's domestic debt markets are focused on sovereign securities and stock market capitalization is small relative to peers (Figure 2).

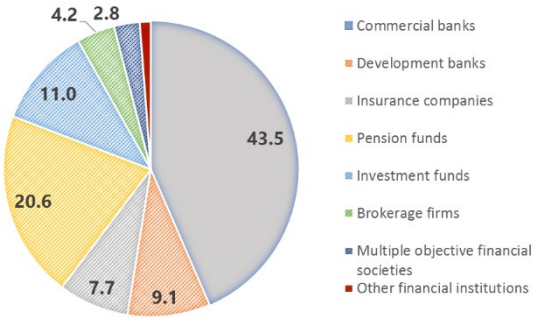


6. The largest commercial banks dominate the financial system. Mexico has 50 commercial banks with total assets at approximately 11 trillion pesos (43 percent of the financial sector's assets). Of these, the six domestic systemically important banks (D-SIBs) comprise almost ¾ of total banking sector assets and play a leading role within their respective financial conglomerate. Five D-SIBs are foreign subsidiaries that generate a large share of the parent groups' profits.

Figure 1. Mexico: Financial and Banking Sector Assets

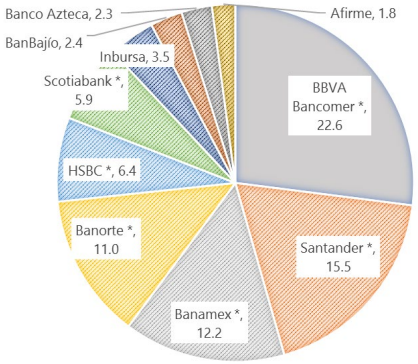
The banking sector dominates the financial system…

Share of Financial Sector Assets
(In percent of total financial sector assets)



… and is dominated by D-SIBs.

Share of Banking Sector Assets
(In percent of top 10 commercial bank assets)

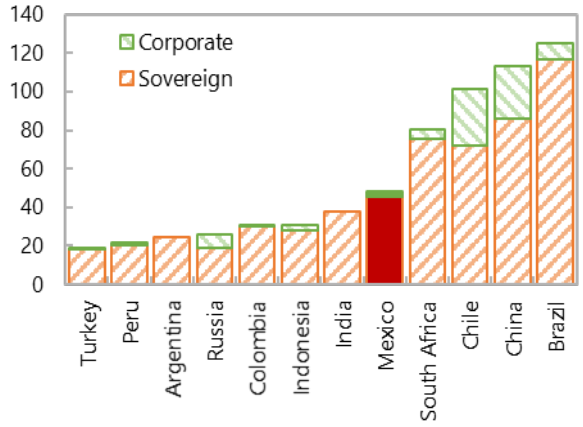


Sources: Banxico; CNBV; and IMF staff calculation.
Note: "*" in the right chart indicates the six D-SIBs in Mexico.

Figure 2. Selected Countries: Size of Financial Markets[1/]

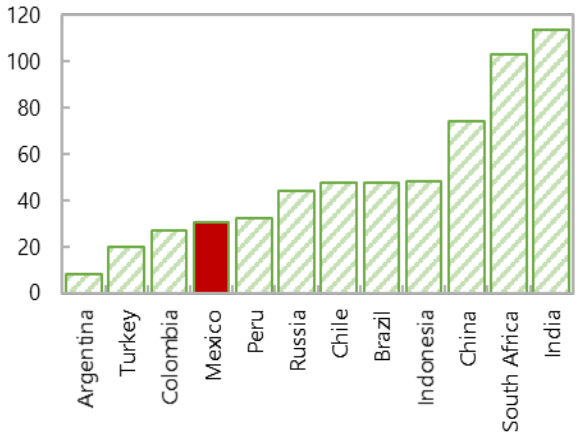
Mexico's domestic debt markets are focused on sovereign securities as in many other EMs but …

Outstanding Domestic Debt Securities
(In percent of GDP, 2021Q3)



Stock market capitalization stood only at 31 percent of GDP, small relative to its peers.

Size of Equity Markets
(In percent of end-GDP, 2021)



Sources: IMF Financial Development Index Database; BIS Debt Securities Statistics; Bloomberg; and IMF Financial Access Survey.
1/ EM peers include Argentina, Brazil, Chile, China, Colombia, India, Indonesia, Peru, South Africa, Russia, and Turkey.

Table 2. Mexico: Structure of Financial System

	2016				2021			
		Total Assets				Total Assets		
	Number	In billions of Mexican pesos	In percent of finacial sector assets	In percent of GDP	Number	In billions of Mexican pesos	In percent of finacial sector assets	In percent of GDP
Commercial banks	47	8,668	48.1	43.1	50	11,078	43.8	42.2
Domestic banks	32	2,803	15.5	13.9	30	3,643	14.4	13.9
Foreign subsidiaries	15	5,865	32.5	29.1	20	7,435	29.4	28.3
D-SIBs	7	6,879	38.1	34.2	6	8,099	32.0	30.8
Domestic D-SIB	2	1,440	8.0	7.2	1	1,236	4.9	4.7
Five foreign D-SIBs	5	5,439	30.2	27.0	5	6,863	27.2	26.1
Development banks	6	1,796	10.0	8.9	6	2,279	9.0	8.7
Pension funds (Siefores)	73	2,754	15.3	13.7	117	5,236	20.7	19.9
Investment funds (Fondos de inversión)	578	2,047	11.4	10.2	613	2,795	11.1	10.6
Insurance and Surety (Seguros y fianzas)	115	1,358	7.5	6.7	113	2,005	7.9	7.6
Brokerage firms (Casas de bolsa)	36	486	2.7	2.4	36	862	3.4	3.3
Multiple objective finance companies (Sofomes)	1704	721	4.0	3.6	1129	709	2.8	2.7
Regulated sofomes	52	389	2.2	1.9	43	257	1.0	1.0
Unregulated sofomes	1652	332	1.8	1.6	1086	452	1.8	1.7
Cooperatives (Socaps)	151	118	0.7	0.6	153	212	0.8	0.8
Microfinance savings and loan entities (Sofipos)	43	31	0.2	0.2	37	35.6	0.1	0.1
Credit unions	85	55	0.3	0.3	77	59	0.2	0.2
Total	2,845	18,034	100.0	89.6	2,337	25,271	100.0	96.2
Memo:								
Financial holding companies (FHCs)	10	6,546	36.3	32.5	15	8,798	34.8	33.5
Largest four FHCs	4	5,434	30.1	27.0	4	6,707	26.5	25.5
Development agencies	4	1,418	7.9	7.0	4	2,199	8.7	8.4
FND[1/]	1	58	0.3	0.3	1	51	0.2	0.2
Infonavit[2/]	1	1,182	6.6	5.9	1	1,882	7.4	7.2
Fovissste[3/]	1	159	0.9	0.8	1	233	0.9	0.9
Infonacot[4/]	1	19	0.1	0.1	1	33	0.1	0.1
Development trusts	3	170	0.9	0.8	3	227	0.9	0.9
FOVI[5/]	1	21	0.1	0.1	1	17	0.1	0.1
FIRA[6/]	1	144	0.8	0.7	1	204	0.8	0.8
FIFOMI[7/]	1	5	0.0	0.0	1	6	0.0	0.0

Sources: Mexican authorities; and IMF staff calculation.

1/ FND: Financiera Nacional de Desarrollo Agropecuario, Rural, Forestal y Pesquero.

2/ Infonavit: Instituto del Fondo Nacional de la Vivienda para los Trabajadores. The total assets are in the constant term for 2016.

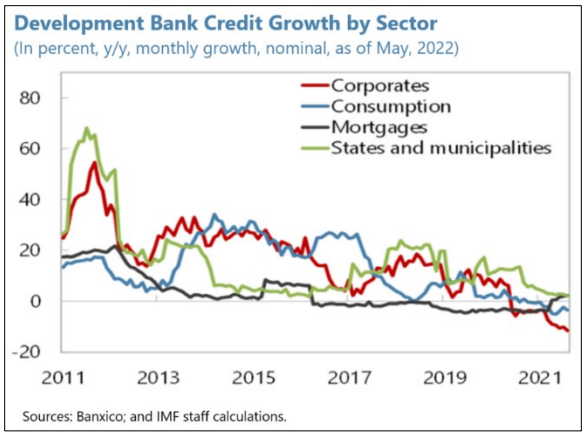
3/ Fovissste: Fondo de la Vivienda del Instituto de la Seguridad y Servicios Sociales de los Trabajadores del Estado.

4/ Infonacot: Instituto del Fondo Nacional para el Consumo de los Trabajadores.

5/ FOVI: Fondo de Operación y Financiamiento Bancario de la Vivienda.

6/ FIRA: Fideicomisos Instituidos en Relación con la Agricultura.

7/ FIFOMI: Fideicomiso de Fomento Minero.

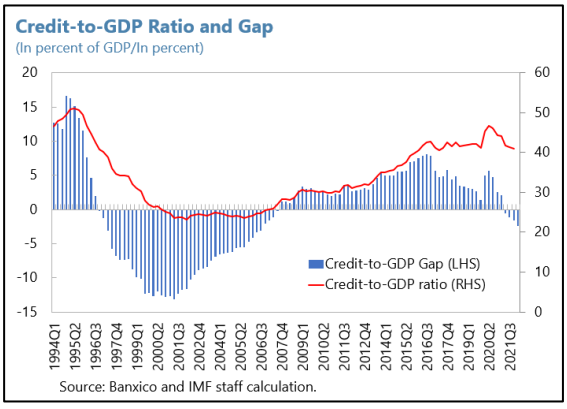


7. Development banks fill some market gaps in the provision of finance. The six development banks (9 percent of financial sector assets) have development objectives and provide finance to long-term projects (e.g., infrastructures), small and medium-sized enterprises (SMEs), exporters, housing, and low-income populations. They provide credit to the private sector both directly in first-tier loans and through other intermediaries (second-tier loans). They also provide guarantees for the credit extended by the banking system. Credit growth extended by development banks continues a long decline (Text Chart). The sovereign backstops their capital and fully guarantees their liabilities.

8. Investment and pension funds are growing. From January 2020 to May 2022, the number of investment funds' contracts has increased by almost 60 percent with assets under management currently at 2.8 trillion pesos (10 percent of GDP). Assets are mainly concentrated in liquid investments (e.g., government securities and repo agreements), equity investment represents only a small fraction (10 percent) of their portfolio, and their investment appetite for more complex and sophisticated products is rather limited. Pension funds have increased their assets from 2.7 trillion pesos (15 percent of GDP) in 2016 to 5.2 trillion pesos (20 percent of GDP) in 2021 (Table 2).

9. Other nonbank financial institutions (NBFIs) are not systemic. Credit unions, sofomes, socaps (cooperatives), sofipos (microfinance savings and loan entities) and other financial companies carry out credit intermediation or credit operations that complement the activity of banks by providing financing to various targeted and smaller sectors. Overall, these entities account for 10 percent of the system's assets. Depending on their ties with banks and issuance of securities, sofomes can be regulated or unregulated; socaps are supervised and regulated if passing a basic asset size threshold as part of a regularization/formalization process. The regulated NFBIs represent around 2 percent of financial sector's assets. While some NBFIs have a large number of members, they do not pose a risk for financial stability because they are small and non-deposit taking or have little interconnection with the banking system.

C. Banking Sector Recent Performance

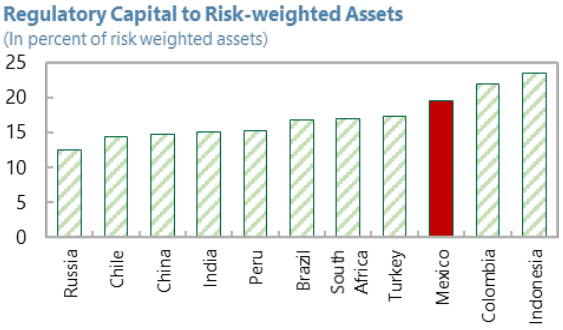


10. The Mexican banking sector's performance compares well relative to peers, but financial inclusion is low. Aggregate capital and liquidity ratios are high with respect to other EM peers, credit risk is moderate, and profitability is high (Figure 3). Despite these features, credit growth is subdued; the credit-to-GDP ratio is low at about 40 percent and has yet to reach the level it had before the 1994 crisis and the credit-to-GDP gap is negative (Text

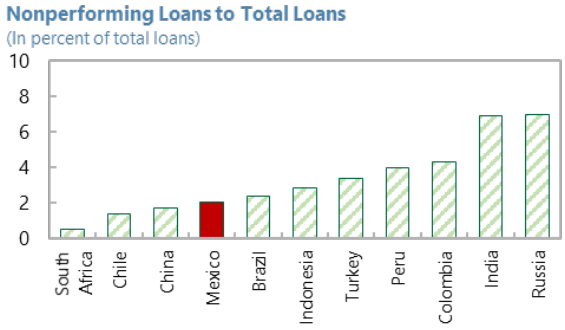
Chart). This is in part explained by the high level of informality in Mexico and the preference of commercial banks to focus on the prime corporate sector segments and high net-worth individuals.

Figure 3. Selected Countries: Financial Soundness Indicators[1]

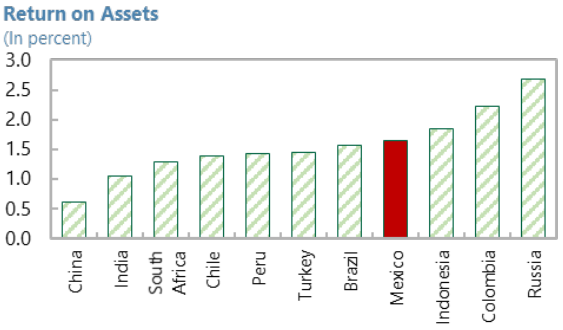
Mexican banks' capital ratios compare well with EM peers.



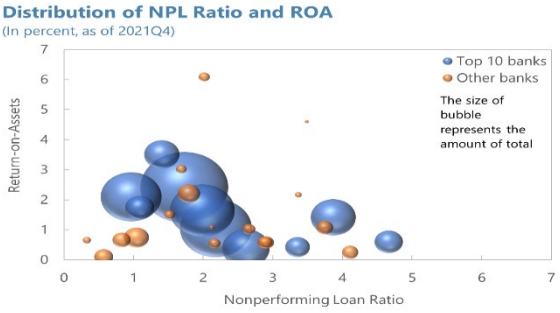
Credit risk remains moderate and …



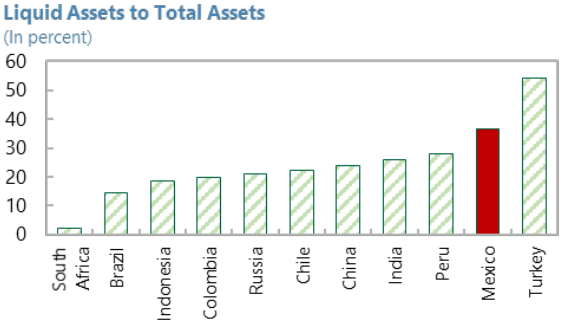
… banks enjoy high profitability,



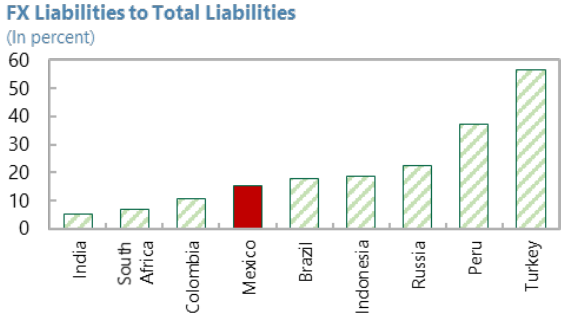
… despite some heterogeneity among banks in Mexico.



Liquid assets account for a large part of total assets but …



… banks have some FX liabilities, but the net open position is small.



1/ Date for the indicators is 2022Q1 unless otherwise specified.

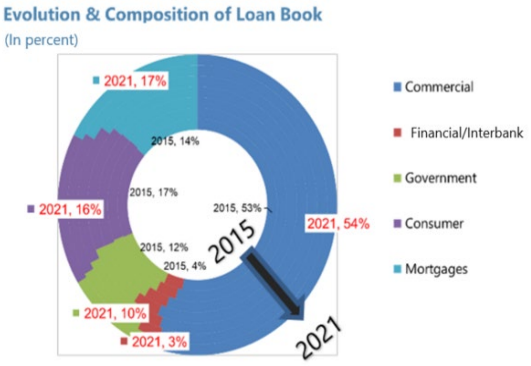
Sources: Mexican financial authorities; Fitch Analytics; and IMF Financial Soundness Indicator Database.

11. The banking sector is mainly exposed to corporates and enjoys very robust net interest margins (Figure 4). The evolution of credit exposures from 2012 to 2021 reveals that the aggregate credit portfolio is concentrated on corporate loans (half of total exposure), followed by mortgages and consumption loans. Interest income from the credit portfolio and investments in securities make up almost 80 percent of banks' revenue. The net interest margin, net of loan-loss provisions, was

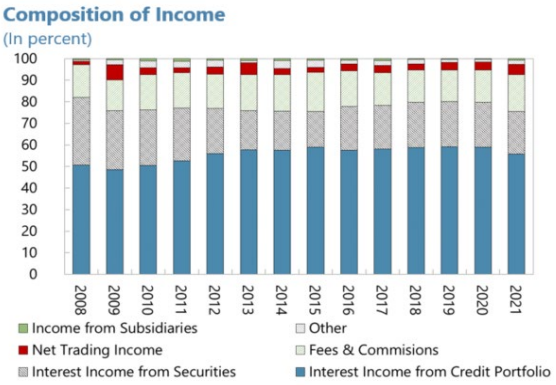
around 5 percent of interest-bearing assets and profitability indices such as ROA and ROE were also high at around 2 percent and 18 percent in 2021, respectively.

Figure 4. Mexico: A System View of the Banking Sector Performance

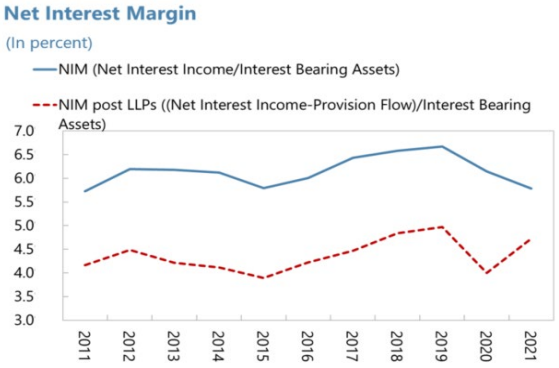
Commercial loans represent more than 50 percent of the loan book…



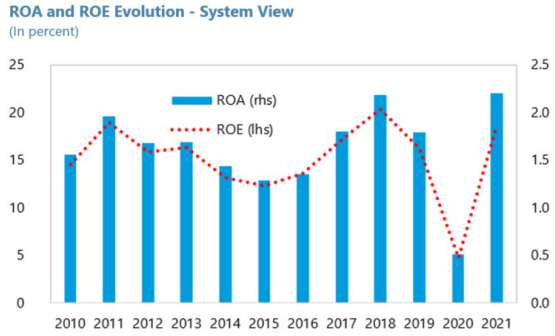
…while interest income is the major driver behind their solid profitability and capital generation capacity.



Net interest margins have been consistently robust …



.. and ROA and ROW rebounded immediately after the 2020, that was hit because of precautionary provisions.



Sources: Banxico; and IMF staff calculations.

12. The financial system impact of the pandemic has been contained. Mexico experienced capital outflows and a sharp exchange rate depreciation during the pandemic. But sovereign and corporate spreads have remained low (Figure 5), and market functioning has been orderly, reflecting in part the authorities' effective policy responses. The central bank (Banxico) cut interest rates by 300 basis points after the outbreak and established facilities to support market functioning and credit provision (Table 3). The banking regulator (CNBV) issued regulatory support measures, encouraging loan payment deferral and loan restructuring, and restricting dividend payouts. Several macroprudential measures were relaxed (e.g., capital conservation buffers and LCR requirement). The authorities implemented a modest fiscal stimulus, but Mexico benefited from sizable fiscal policy spillovers from extensive support in the United States.

Table 3. Mexico: Monetary and Financial Sector Responses During the COVID-19 Crisis

Monetary Policy Decisions

Decisions	Details
• Policy rate cut	Seven times from March 2020 through May 2021, 300 basis points in total.
• Policy rate hike	Ten times since June 2021, 525 basis points so far.

Central Bank Facilities during the COVID-19 Crisis

(In billions of Mexican peso)

Type of Support	Envelope (A)	Disbursed (B)	Percent (B/A)	Expiration date
Liquidity support				
• Government securities term repurchase window	150	465	310	Sep. 2021
• Reduction of the Monetary Regulatory Deposit	50	50	100	Nov 2020
• Temporary securities swap window	50	63	126	Sep. 2021
• Swap of government securities	100	15	15	Feb. 2021
• Corporate Securities Repurchase Facility	100	45	45	Sep. 2021
Credit support				
• Provision of resources to banking institutions to channel credit to MSMEs and individuals affected by the COVID-19 pandemic	250	14	6	Sep. 2021
• Collateralized financing facility for commercial banks with corporate loans to finance MSMEs	100	40	40	Sep. 2021
Total	800	692	86	
Total (percent of GDP)	3.1	2.7		

Other Financial Sector Measures

Policy Description

Liquidity support

- FX swap line with the U.S. Fed by December 2021 and the FCL arrangement with the IMF in November 2021.
- FX Hedging auction program (USD NDF auctions).
- Temporary flexibilities on liquidity requirements for banks. In general terms the flexibilities i) allowed banking institutions to consider as liquid assets, those eligible as such as of February 28 2020, before the markets reflected the COVID-19 outbreak impact; ii) excluded from the calculations of the Look Back Approach the information of margin calls or valuation changes occurred during March 2020; iii) temporary halt to the application of certain corrective measures displayed when the institutions report a LCR below the minimum regulatory requirement; iv) an extraordinary classification for LCR scenarios based upon a combination of average and minimum LCRs that allow for the use of the liquidity buffer; and v) LCRs below the minimum regulatory requirement were not considered a breach of the liquidity framework, thus economic sanctions were not applicable. The liquidity flexibilities were gradually undrawn by February 2022.

Credit and capital support

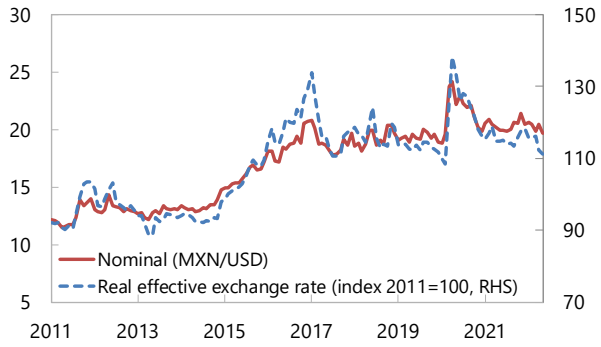
- Special Account Criteria (SAC) to help creditors provide temporary deferral of payments of principal and/or interest to performing loans in March 2020 for up to four months with the possibility of extending it for two additional months, six months in the case of micro-credits, or up to eighteen months in the case of credits directed to the agricultural and rural sectors by July 2020.
- Credit restructuring measure after the expiration of SAC to help creditors restructure deferred loans and increase the probability of payment.
- Use of bank's capital conservation buffer up to 50 percent of the buffer, without impairing the minimum regulatory requirement by December 2021.
- Restriction on paying dividends, carrying out share buy-backs, or conducting any other mechanism aimed at remunerating shareholders, which was relaxed in April 2021 to allow the remuneration up to 25 percent of the results in 2019, 2020 and 2021 with banks' regulatory capital being above 13 percent after the remuneration.
- Relief on the minimum credit card payment by January 2021.

Sources: Mexican authorities; and IMF staff.

Figure 5. Mexico: Financial Market Developments

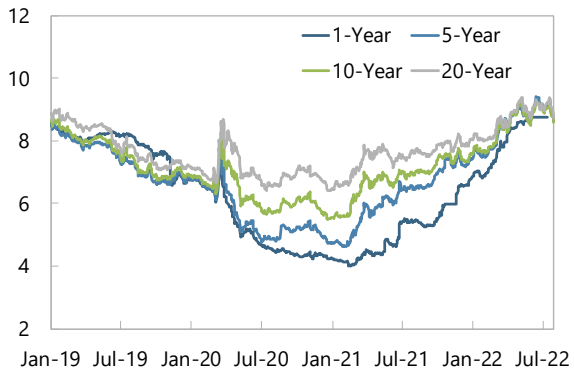
The peso depreciated sharply in April 2020 but has since returned to its pre-pandemic range.

Exchange Rate
(As of July, 2022)



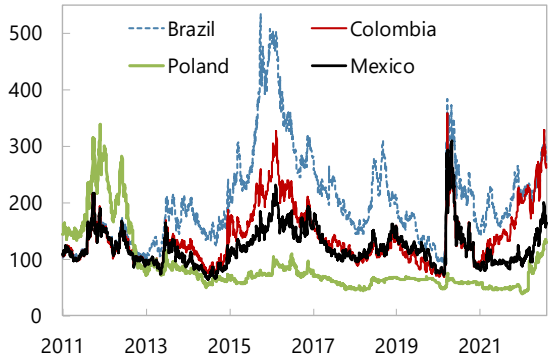
The yield curve has shifted up in the face of inflation concerns, albeit tending to flatten.

Local Government Bonds Yields
(In percent; as of August, 2022)



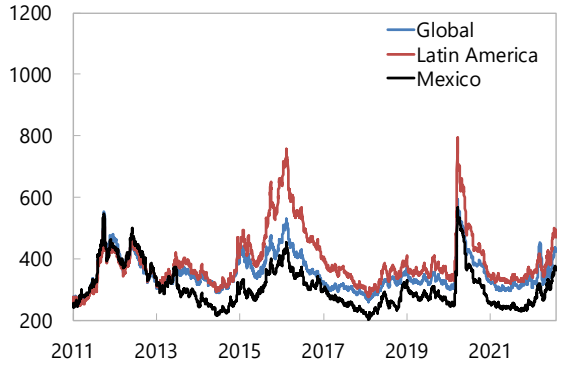
Sovereign credit spreads remain low compared to peers. They have ticked up recently …

Sovereign Risk Spreads
(5Y CDS spread, in basis points; as of August 02, 2022)



…with a similar pattern for corporate debt.

Corporate Risk Spread
(CEMBI spread, in basis points; as of August 02, 2022)



Sources: Bloomberg; Haver Analytics; and National Authorities.

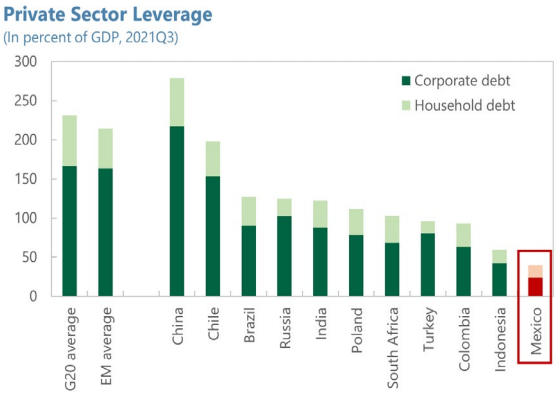
13. Credit growth is resuming but private leverage did not increase much after the pandemic. Credit extended by commercial banks contracted during the pandemic, in particular for corporates and consumer loans, but it is gradually resuming to pre-pandemic levels (Text Chart). Differently from other EMs, private sector leverage and debt service burden remained low after the pandemic (Figure 6).

Commercial Bank Credit Growth by Sector
(In percent, y/y, monthly growth, nominal, as of May, 2022)

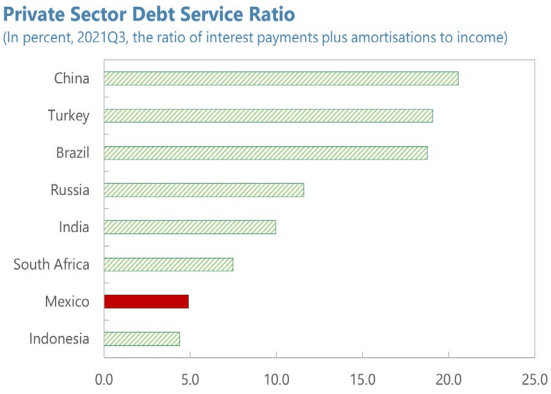
Sources: Banxico; and IMF staff calculations.

Figure 6. Mexico and Selected Countries: Private Sector Leverage and Debt Service

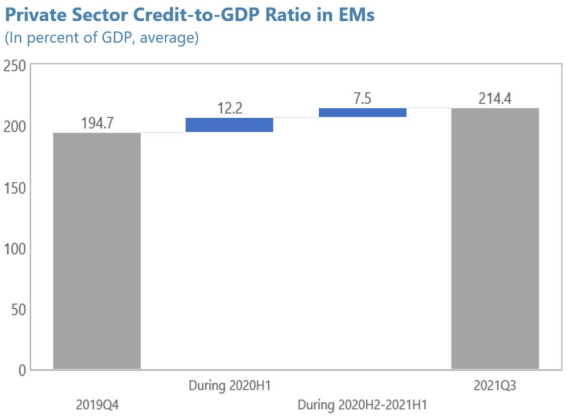
Private sector leverage is low, compared to EM peers.



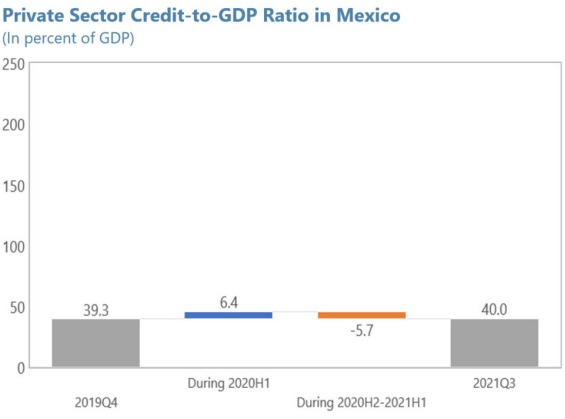
Debt service costs are also low by international standards.



During the COVID crisis, private sector leverage in emerging market economies has considerably increased …



… but leverage has not risen in Mexico.



Sources: BIS; and IMF staff calculation.

14. Buffers have risen after the pandemic and profitability remains high. The aggregate capital adequacy ratio increased to 19.5 percent at end-2021 (Table 4). The higher capital level reflects high profitability, preparation for TLAC implementation by D-SIBs, and the buffers built because of pandemic-linked dividend payout restrictions. The banking sector maintains ample liquidity buffers with the aggregate Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR) above 200 and 120 percent at end-2021.

Table 4. Mexico: Financial Soundness Indicators
(In percent)

	2016	2017	2018	2019	2020	2021	2022 Q2
Capital Adequacy							
Regulatory capital to risk-weighted assets	14.9	15.6	15.9	16.0	17.7	19.5	18.7
Regulatory Tier 1 capital to risk-weighted assets	13.2	14.2	14.2	14.4	16.1	18.1	17.3
Capital to assets	9.9	10.4	10.7	11.0	10.7	11.8	10.8
Asset Quality							
Nonperforming loans to total gross loans	2.1	2.1	2.1	2.1	2.4	2.0	2.3
Provisions to Nonperforming loans	157.1	154.9	152.4	146.2	160.1	160.5	143.4
Earnings and Profitability							
Return on assets	1.7	2.0	2.2	2.2	1.2	2.1	1.9
Return on equity	16.3	19.6	20.9	20.5	11.7	18.6	17.4
Interest margin to gross income	73.8	73.3	74.5	74.3	76.0	72.7	76.0
Trading income to total income	4.4	5.0	4.5	5.8	5.5	6.7	9.4
Liquidity							
Liquid assets to total assets	31.4	32.0	31.6	31.1	35.7	36.3	38.5
Liquid assets to short-term liabilities	42.4	42.2	42.3	40.8	48.0	47.0	49.8
Customer deposits to total loans, excluding interbank loans	88.9	91.4	89.3	90.7	100.2	105.2	99.5
Net open position in foreign exchange to capital	0.8	1.1	1.2	2.9	1.8	0.1	2.2

Sources: Mexican authorities; and IMF Financial Soundness Indicator.

15. But some banks may be more vulnerable. While data on banks' point-in-time probability of defaults (PIT PDs) suggests that COVID scarring has been contained so far (Text Chart), restructurings allowed during the pandemic, may be still masking some underlying strains. Deferred loans accounted for 13 percent of total outstanding loans at end-2021 and have been already phased-out. Banks have restructured about 17 percent of these, which are currently mostly performing (Table 5).

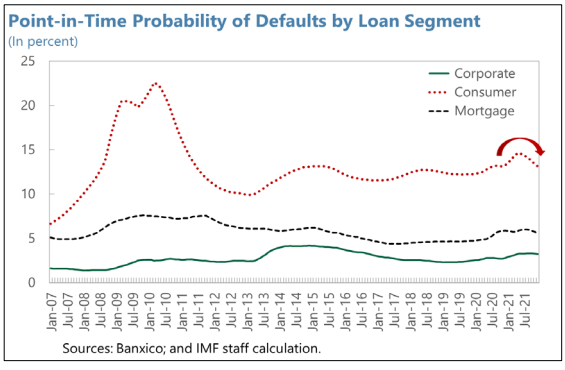


Table 5. Mexico: Commercial Bank Loans and Loans Under Deferred Loan Category

Amount of Total Commercial Bank Loans and Loans under Deferred Loan Category

(In millions of Mexican pesos, at the end of 2021)

	Total	Commercial	Consumer	Mortgage
Total bank loans 1/	5,459,257	2,560,732	837,478	1,118,610
Bank loans benefitted from loan deferral program	1,067,334	499,978	243,083	324,273
Amount of loans voluntarily reduced by banks	358,674	272,226	26,421	60,027
Amount of loans under deferred loan category	708,660	227,752	216,662	264,246
- Performing	553,424	166,428	156,518	232,478
- Restructured	121,024	51,895	48,048	21,081
- Nonperforming	34,212	9,429	12,096	12,687

Share of Loans under Deferred Loan Category

(In percent of total commercial bank loans, at the end of 2021)

	Total	Commercial	Consumer	Mortgage
Bank loans benefitted from loan deferral program	19.6	19.5	29.0	29.0
Amount of loans voluntarily reduced by banks	6.6	10.6	3.2	5.4
Amount of loans under deferred loan category	13.0	8.9	25.9	23.6
- Performing	10.1	6.5	18.7	20.8
- Restructured	2.2	2.0	5.7	1.9
- Nonperforming	0.6	0.4	1.4	1.1

Performance of Loans under Deferred Loan Category

(In percent of total loans under deferred loan category, at the end of 2021)

	Total	Commercial	Consumer	Mortgage
Amount of loans under deferred loan category	100.0	100.0	100.0	100.0
- Performing	78.1	73.1	72.2	88.0
- Restructured	17.1	22.8	22.2	8.0
- Nonperforming	4.8	4.1	5.6	4.8

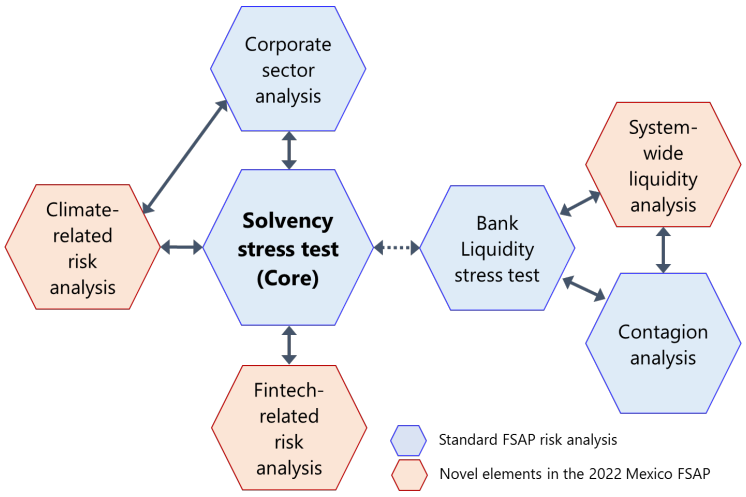
Sources: Banxico; CNBV; and IMF staff calculation.
1/ The official name of the deferred loan category is Special Accounting Criteria. CNBV issued accounting flexibilities for credit institutions that helped to provide payment facilities to clients who had taken commercial, consumer, and housing loans. In general terms, the payment facilities consisted of the partial or total deferral of principal and interest payments for up to 4 months, with a possibility of extending it for two additional months. Credits were eligible for this support program provided they were fully performing as of March 31, 2020.

MACROFINANCIAL RISKS: SCOPE AND SCENARIOS

A. Scope of the FSAP Analysis

16. The FSAP conducted a multitude of quantitative stress tests and contagion analyses (Figure 7). Quantitative approaches included: (i) bank solvency tests to assess resilience to credit, interest rate, and market risks; (ii) bank liquidity stress tests; (iii) a novel system-wide liquidity analysis that focused on liquidity interlinkages between the different agents in the system; (iv) interconnectedness and contagion risk analysis to evaluate the degree of interlinkages and risks from cross-exposures between domestic institutions; and (v) machine learning techniques to assess corporate vulnerabilities and project corporate default rates as an alternative to more conventional econometric techniques.

Figure 7. Mexico: Components of Systemic Risk Analysis



Source: IMF staff.
Note: Arrow show linkages across components of the systemic risk analysis.

17. Bank solvency stress tests were also used for sensitivity analyses. First, the team tried to assess and quantify how the presence of material contingent credit lines of banks towards corporate clients might have an impact on capital projections under a scenario where the economic downturn is also accompanied with triggering of these lines due to global tightening conditions.[2] Second, given the current uncertainty on the global inflation outlook and future interest rate paths, the team investigated the potential impact of an even sharper rise in interest rates on bank balance sheets and key metrics.[3]

[2] This scenario is similar in nature to what experienced in Mexico during the pandemic, when corporates used their available credit lines in a precautionary manner (see paragraphs 82-83 for a discussion of the March-May 2020 stress episode).

[3] The team simulated an additional shift by 150 bps in domestic interest rates on top of the adverse scenario.

18. Climate risks were considered in the banking stress tests. An estimate of the impact of climate-related physical risks based on available country-specific historical data series was established, focusing on increased risks of hydrometeorological hazards. The estimated economic impact was used to anchor an additional layer of shocks in the stress scenario and the revised (for physical risks) scenario was used to assess the materiality of the impact for the banking system. Transition risks across corporate bank exposures were also considered as part of the climate risk analysis using the solvency stress testing machinery.[4]

19. The team performed a novel system-wide quantitative liquidity analysis that used sectoral balance sheet data to simulate the impact of liquidity shocks. The analysis uses aggregated balance sheet data and cross-linkages information between different interacting economic agents in the financial system (e.g., commercial and development banks, investment and pension funds, NFCs, and households) under a large number of simulated liquidity and asset revaluation narratives. These multi-layered shocks capture the transmission of sovereign securities revaluation and liquidity outflow shocks between different agents in the system and tries to identify the relative contribution of each type of agent to the system-wide liquidity stress conditions. In the future, similar analysis can also be used to gauge the impact of policy reactions and how specific policies may attenuate (or amplify) liquidity stress conditions owing to the interlinkages between agents.

20. Counterparty and funding risks through domestic and cross-border contagion channels were also examined. The analysis uses data on exposures among banks and NBFIs, and BIS International Banking Statistics. It applies a range of methodologies to simulate the failure of one or several entities on the domestic intercompany and cross-border banking network through cascade effects.

21. The FSAP has explored the potential impact of a macrofinancial downturn on NFCs' vulnerabilities. The team uses firm-level data to evaluate the share of firms that could be financially distressed under the FSAP scenarios. The analysis has focused on listed firms due to availability of high-quality data but has applied the analysis to a larger set of companies using machine learning estimation techniques that provide a stronger basis to extrapolate across firm types. A relationship between firm-level vulnerability indicators (e.g., liquidity, solvency, and earnings metrics) and firm-specific EDFs was estimated. The analysis provides a window to view stresses in these more difficult to observe firms. Applying these estimates to the FSAP scenarios has yielded implied PD paths that complement those from the risk analysis. The outcome of such models points to stronger corporate default paths for listed companies and these paths are even more severe when looking at the extrapolated sample.

22. The potential impacts of penetration of new forms of digital payments in the financial system was also assessed as a layer of the bank solvency STs. The FSAP team has conducted a hypothetical sensitivity analysis in which banks experience an erosion of net interest income (as they

[4] Climate risk analyses are described in a the separate Mexico FSAP TN on Climate Risk Analysis.

compete for retail sight deposits and pay higher rates) and income related to payments services (proxied by fees received from the use of credit cards) in the face of increased competition from new forms of digital payments (i.e., CBDC or other forms of digital money).

B. Macrofinancial Scenarios

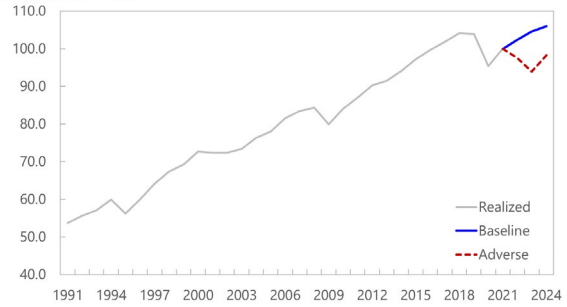
23. The team has assessed the outlook for solvency and liquidity of banks, NBFIs, and NFCs under the adverse scenario (Appendix II. Stress Test Matrix). Starting with data as of end-2021, the scenario horizon spans 2022–2024. The baseline scenario is aligned with the latest available IMF projections as of June 15, 2022.

24. The adverse scenario entails low growth and high inflation in the global economy and significant stress in global financial markets. It considers a combination of the first three external risks in the Risk Assessment Matrix (RAM, Appendix I). Shocks that drive inflation up, such as supply chain disruptions and commodity prices surge triggered by COVID variants and the war in Ukraine, lead to a de-anchoring of inflation expectations in the United States, and advanced economies' policy rate hikes at a faster clip than in the baseline. Investors' reassessment of market fundamentals would lead to a widespread risk-off event in the global financial markets. These risks would be amplified by pockets of domestic vulnerabilities, causing currency depreciation and a rise in sovereign and corporate spreads in the financial market, and system-wide liquidity stress and negative macrofinancial feedbacks in the financial system. In the adverse scenario, the level of real GDP falls about 11 percent below baseline by 2023, equivalent to 2¼ standard deviation cumulative 2-year growth rate shock relative to the historical mean of this measure (Figure 8 and Table 6). A pick-up in external demand, supported by accommodative policy in Mexico and a decline in the risk premia drives the rebound of economic activity in 2024.

Figure 8. Mexico: FSAP Stress Test Scenarios

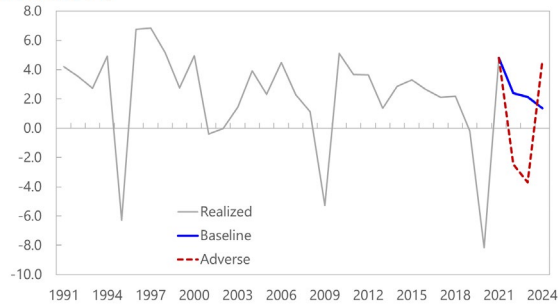
Shocks to global financial condition would drive a sharp output contraction in Mexico, …

Real GDP Path
(Level in 2021 = 100)



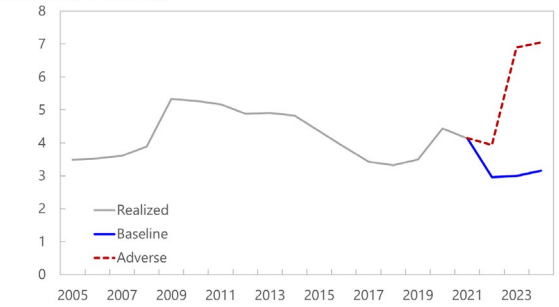
… causing a severe recession in line with a 2¼ standard deviation shock to output growth, …

Real GDP Growth Rate
(In percent, y-o-y)



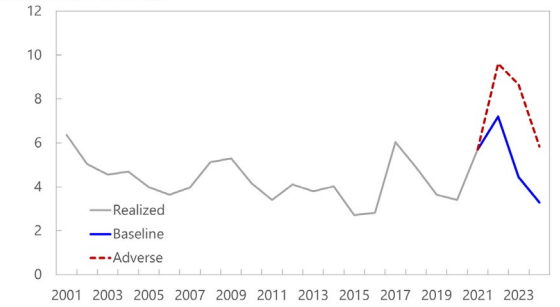
… a sharp rise in unemployment, …

Unemployment Rate
(In percent, y-o-y, average)



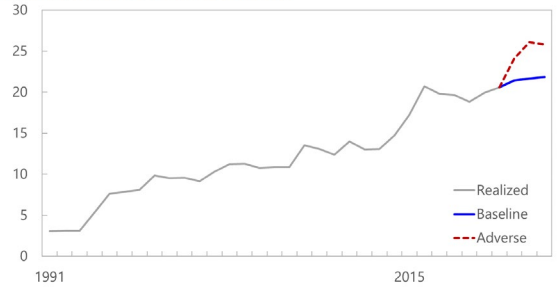
… a high inflation that Mexico has not experienced since the 1994 financial crisis, and …

CPI Inflation Rate
(In percent, y-o-y, average)



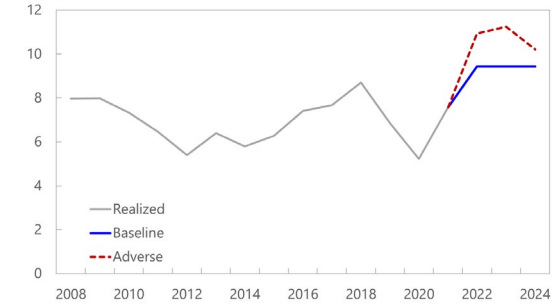
… a sharp currency depreciation.

Foreign Exchange Rate
(Mexican peso per U.S. dollar, end-of-period)



Long term yields would be sustained at 11 percent on average during 2022-23

10-Year Sovereign Yield
(In percent, end-of-period)



Source: IMF staff.

Table 6. Mexico: FSAP Stress Test Scenarios

	2021	2022	2023	2024
Real GDP (2021=100)				
Baseline	100.0	102.4	104.6	106.0
Adverse	100.0	97.5	93.9	98.3
Real GDP Growth Rate (In percent, y-o-y)				
Baseline	4.8	2.4	2.2	1.4
Adverse	4.8	-2.5	-3.7	4.6
CPI Inflation Rate (In percent, y-o-y)				
Baseline	5.7	7.2	4.4	3.3
Adverse	5.7	9.6	8.7	5.8
Exchange Rate (Mexican peso per U.S. dollar, end of period)				
Baseline	20.6	21.4	21.6	21.9
Adverse	20.6	24.1	26.1	25.8
Policy Rate (In percent, year averages except 2021)				
Baseline	5.5	7.9	9.1	8.1
Adverse	5.5	9.4	10.1	6.9
10-year Sovereign Bond Yield (In percent, year averages except 2021)				
Baseline	8.0	9.4	9.4	9.4
Adverse	8.0	10.9	11.2	10.2
Equity prices (2021=100)				
Baseline	100.0	106.7	113.3	119.7
Adverse	100.0	90.3	78.1	76.0
Housing prices (2021=100)				
Baseline	100.0	106.7	113.3	119.7
Adverse	100.0	82.6	82.6	105.1
Price of Commodities (energy/oil, 2016 = 100)				
Baseline	184.4	346.5	262.4	224.1
Adverse	184.4	443.9	258.8	191.9

Source: IMF staff calculation.

SOLVENCY STRESS TESTS

A. Overview

25. The FSAP top-down solvency stress test accounted for a comprehensive set of risks. The FSAP team used IMF's internally developed solvency stress testing models to capture credit risk (covering both credit impairments and scenario impact on risk-weighted assets, funding, and interest rate risk), market risk (covering repricing and spread risks for interest rate sensitive assets, as well as equity, FX, and commodity risks), net interest income and non-interest income risks.[5]

[5] Operational risk capital requirements were not stressed in the analysis but were kept at the levels of the cut-off year following a standard practice in FSAP stress tests and a common approach in most macroprudential stress tests.

26. The bank sample for the solvency stress test was selected based on systemic relevance. The ten largest commercial banks, in terms of size of asset holdings, were included in the sample capturing more than 80 percent of total assets of the commercial banking system in Mexico. The sample included all six D-SIBs. The exercise was conducted at the highest level of consolidation, with a three-year projection horizon used for both scenarios (baseline and adverse). End-2021 was used as the exercise cut-off point and Dec 2021 data from the regulatory reports was used to infer the exercise starting points for all segments of risk analysis.

27. A separate partial analysis exercise was conducted by CNBV on development banks and the largest non-deposit taking credit providers. CNBV staff provided outputs on scenario-based simulations, on a partial analysis exercise covering credit and market risk impact for the development banks (DB) and the largest non-deposit taking credit providers (hereafter called NBFIs) to gauge the impact of the scenarios on their balance sheet. For this exercise, internal models developed by CNBV were used in a methodological approach very similar to the regular bottom-up exercise conducted by CNBV; thus, the two exercises are very different in scope and approach and the results are not directly comparable. The output of this exercise can be found in Appendix III.

28. The exercise was performed within a solvency ST technical infrastructure, developed by the FSAP team, tailored to the data available. The infrastructure included a core balance sheet and capital engine that was responsible for the forward-looking projection of P&L and balance sheet items under specific macroeconomic scenarios and a multitude of satellite models for the projection of scenario dependent paths for banks' parameters.

B. IMF Top-Down Stress Tests: Methodology

Balance Sheet, Income Projections, and Hurdle Rates

29. The exercise was performed under a static balance sheet assumption. This assumption was driven by the need to maintain neutrality with respect to the different business models within the bank sample (new origination might be favoring banks with material concentration on high margin segments). The assumption would therefore allow the direct comparison between the two scenarios. The allocation of assets and the composition of funding sources remained constant during the stress test horizon, as of end-2021 cut-off date. In particular, total credit exposures (the sum of performing and nonperforming) were kept constant following overall exposure levels at the cut-off date. For the purpose of calculating net interest income the asset and liability compositions remained static throughout the horizon of the scenario and no increases in capital or other managerial actions were assumed.

30. Current minimum capital requirements were used as the hurdle rates for the FSAP exercise. Hurdles rates were set to 4.5, 6, and 8 percent respectively for CET1, T1 and total capital requirements under both scenarios. In the baseline an additional 2.5 percent Capital Conservation Buffer (CCB) was included in the minimum requirement. For both scenarios the bank specific D-SIB

capital surcharge (as of 2023) was also included as part of the hurdle rate applied.[6] The FSAP team used Banxico's staff projections on eligible capital instruments (for each type of eligible capital CET1, AT1, T2) for each year of the stress test horizon.

31. Projection of RWAs accounted for the deterioration of the portfolios' credit quality. End-2021 starting point Basel III RWAs (accounting for credit, market, and operational risks RWAs) were used to anchor RWA changes through the horizon; market and operational RWAs were kept constant and only credit risk RWAs were allowed to change reflecting the change in the credit quality of the portfolio for both Internal Ratings-Based (IRB) and Standardized (STA) regulatory approaches. TTC PDs were adjusted in the Basel RWA formula for the IRB approach and RWA densities for performing and non-performing exposure were kept constant (at the level of the cut-off date) for portfolios under STA.[7]

32. The exercise assumed that accounting impairments match the regulatory mandated expected losses and provisioning level. IFRS9 were introduced in Mexico in January 2022 and historical data on stage transition rates were not available at the time the exercise was conducted; therefore, the current (regulatory mandated) provisioning scheme was used as the working assumption for the solvency ST analysis. In that context, a regulatory expected loss approach was used and, where applicable and feasible, projected provisions were anchored to the current provisioning framework.

33. Income (profit or loss) and regulatory capital were projected based on the overall impact of all risk factors considered in the stress test. Specifically, total net income reflected projections for net interest income, non-interest income and expenses, market risk revaluation of securities, credit loss provisions, and tax charges. Changes to regulatory capital also accounted for dividend distribution payout ratios, income from subsidiaries and minority interest payments.

34. The effective tax rates during the cut-off year were used as a proxy for future applicable tax rates. A dividend payout ratio of 40 percent for year 1 and 50 percent for years 2 and 3 was assumed;[8] a zero-dividend payout ratio was assumed for loss-making years. The core balance sheet and capital engine were used to project full income statements and calculate capital positions for all scenarios, scenario years, and banks. The same infrastructure was used to produce capital paths for a series of analyses, including for the sensitivity analyses described later in this section, the digital money solvency overlay, and the physical risk scenario analysis presented in another FSAP TN.

[6] D-SIB capital surcharge is not a buffer in Mexico and should be always met (as opposed to a capital buffer that banks can step into during downturns).

[7] A smoothing multiplier on the PiT PDs delta was used to account for the TTC nature of the impact.

[8] The increased payout ratio for years 2 and 3 was used to reflect the intention of banks to increase dividends as COVID19-linked dividend distribution restrictions are gradually lifted and given the current material capital buffers of the system.

Credit Risk Analysis and Estimation

35. While the overall size of credit exposures is relatively small (only 50 percent of the total assets) credit risk is one of the most important risk factors for the banking system. In terms of geographical dispersion, there is a strong domestic concentration of portfolios with only a very small portion of exposures abroad. Given the low materiality of the non-domestic exposures, a single modelling geography was selected. Portfolios are split between two different regulatory approaches (IRB and STA) and, therefore, a separate modeling was assumed, driven by the regulatory approach.

36. A variety of approaches for modelling credit parameters was used under the baseline and adverse scenarios. Exposures were initially allocated to asset types based on an exposure segmentation scheme that included commercial exposures, exposures to government and to financial institutions, retail mortgages and retail consumer exposures. This segmentation was mandated by the requirement to map segments to available time series of credit parameters. Table 7 illustrates the segmentation scheme, with the five asset exposure classes for a single geography (domestic) and two regulatory approaches (IRB and STA).

37. For the projections of PDs, the stress test approach made use of satellite models to project scenario-dependent forward paths. For the three most material credit exposure segments of Table 7 (i.e., commercial, retail mortgages, and consumer), the models used historical point-in-time (PiT) default rates on a monthly basis going back to 2008. A Bayesian Model Averaging (BMA) technique was employed for modelling and projecting PDs at the individual bank and portfolio segment levels. The approach adopts panel fixed effect regressions and operates on a pool of equations per dependent variable, to which weights are assigned that reflect their relative predictive performance, which then results in a "posterior model" equation. Further details of the econometric modelling approach and the model calibration can be found in Appendix IV.

Table 7. Mexico: Credit Risk Exposure Segmentation

Exposure segments	Description of segment	Modeling of PD Paths	Regulatory Approach	Geography
Commercial	Corporates- individually assessed	BMA Panel FE	IRB and STA	single domestic
Government	Exposures to SOEs or guaranteed by the government	Proxied using the commercial segment	IRB and STA	single domestic
Financial Institutions	Exposures to financial institutions	Proxied using the commercial segment	IRB and STA	single domestic
Retail/Mortgages	Retail exposures secured by residential property	BMA Panel FE	IRB and STA	single domestic
Retail/Consumer Credit	Retail consumer credit	BMA Panel FE	IRB and STA	single domestic

Source: IMF staff.

38. Based on the estimated models, a PD path for each scenario and asset segment was generated. For the segments where PD paths were proxied, the team used a distance-to-default transformation to obtain the relevant paths based on the bank PD paths for the corporate segment. This was selected as the best solution, given the lack of historical time series data, which also reflected the nature of the exposure and given the small materiality for such segments. The scenario dependent PD PiT paths were used to generate default flows based on the initial segment exposures (EADs at the cut-off date) under the additional assumption that the non-performing state is absorbing/terminal, i.e., cure rates are already captured in the PD PiT model. The resulting PD paths (illustrated in Figure 48 of Appendix IV) were used to drive NPL ratios by bank and portfolio segment.

39. Scenario dependent LGD PiT paths were also estimated at the bank and portfolio level using the Frye-Jacobs approximation. Using an initial anchoring at the level implied by the starting point, implied default rates LGD PiTs were projected for each bank, portfolio segment and regulatory approach. The resulting LGD PiT paths were used to model the evolution of LGD paths over the 3-year horizon.[9] Given that loan loss provisions (LLPs) are mandated by the banking regulation using a regulatory imposed standard model as the floor for loss rates, the team also explored with Banxico the possibility of running a simulation on portfolio LGDs on the basis of repriced/stressed collateral valuations at the granular/exposure level. Data constraints on realigning starting points based on updated exposure level collateral valuations and the lack of sufficient and updated information (mainly on collateral for commercial exposures) mandated the use of the former Frye-Jacobs approximation. In this context there is some room for expert-judgment on how LGD paths can be properly anchored to specific stress scenarios, driven by the structural characteristics of each exposure segment in Mexico versus current coverage ratios in peer jurisdictions.

Market Risk Analysis

40. The analysis for market risk captured the valuation risks of the securities due to changes in risk-free interest rates and credit spreads for interest sensitive instruments, as well as equity, commodity, and exposure to mutual fund risks. Based on regulatory reports at the cut-off date each bank's sovereign and corporate debt (issued by financial and non-financial entities), equity, mutual fund and commodity portfolios by maturity bucket and credit quality class of issuer (where applicable and available) were collected and used to estimate the impact on P&L and Other Comprehensive Income (OCI) under both scenarios.

41. Market valuation losses from interest rate risks in the debt portfolios were derived using a modified duration approach. First, the analysis captured the re-pricing losses in the

[9] In this context, the LGD path analysis corresponds to the projection of regulatory prescribed accounting LGDs (which also considers several other factors, including the delinquency period of each loan, the types of loans involved, the account duration, and the amount outstanding) and is not necessarily directly following real recovery rates which may be more closely linked with the relative value of collateral vs the outstanding loan exposure (current LTV approach).

securities portfolios due to shocks to sovereign yield curves. Second, it also accounted for the valuation impact due to shocks to spreads of corporate debt securities. Spread projections on corporate, bank and financials bonds were proxied based on average yield per maturity tenor of the relevant type of security from Bloomberg and were anchored to reflect the macrofinancial conditions in the two scenarios. The GFC period and the history of corporate credit spreads for Mexico were used to estimate a corporate spread path peaking at 650 bps in 2024 in the adverse scenario, while in the baseline the corporate spread path was kept between 300 and 350 bps on average.

42. The analysis covered the impact of interest rate risks and spread risks on sovereign and corporate debt securities in all accounting portfolios. For conservatism, existing (and future) hedges were assumed to be ineffective during the scenario horizon. Data limitations made it impossible to include counterparty credit risk and credit valuation adjustment (CVA) risk in the scope of the market risk analysis.

43. Equity and commodity price risks were also accounted for, using shocks provided in the scenarios. Given the lack of data on the country breakdown of equity exposures, all equity positions were assumed to pertain to the domestic equity market. For commodities the applied shocks were aligned with the oil shock in the scenario, however, the banking sector's exposure to these types of risks is relatively limited when compared to interest rate and credit spread risks. Finally, FX net open position and inflation risks for all banks were ignored in the analysis because of their low materiality for Mexican banks.

Net Interest Income Analysis

44. An earnings-based measure approach was used to project the Net Interest Income (NII) under the two scenarios. In the absence of historical data for effective interest rates on new business (repricing flow) and repricing ladder, the FSAP team deployed an econometric approach to calculate effective interest rates for the stock of each asset and liability segment and consequently stress NII during all horizon years. The projection captures the impact of projected interest rate paths (policy rate and yield curve slope) as well as interbank shocks assumed by the adverse scenario and also ensure that the model maximizes the use of available historical regulatory data on effective interest rates by segment. Details of the econometric modelling is presented in the second part of Appendix IV.

45. Simplified asset and liability segmentations were used, matched to the ones that could be mapped to the regulatory reporting sources. Under this segmentation scheme the breakdown for assets contains cash equivalent positions and interbank loans, investments in securities, commercial, mortgage and consumer loans, derivative assets, other assets, and non-interest-bearing assets as the segments on the asset side. On the liability side, the segments covered were sight and term retail deposits, wholesale deposits, issuance that includes variable and fixed rate bonds, derivative liabilities, and other interest rating liabilities.

46. Regulatory reports were used to establish the outstanding volumes by asset/liability segment at the cut-off date. The output of the econometric modeling for each segment was

applied to the outstanding projected volume by segment/asset-liability class to project NII deltas from the cut-off date. Given the large interbank shock under the adverse scenario and in order to enhance the conservatism of the approach, a further floor constraint on the pass-through rate for the retail segments was used: under the adverse scenario the delta in sight and term retail deposit rates was floored at 35 and 70 percent of the delta in wholesale funding rates (a minimum pass-through of 35 and 70 percent percent) respectively.

47. A partial recognition of income from non-performing exposures was also assumed. Under the baseline scenario, 50 percent of the income is recognized for all banks; this percentage was set to 25 percent under the adverse scenario. This assumption was driven by the need to strike some balance between largely dispersed business models and to ensure that uniform application of assumptions does not over penalize specific models or business concentrations. This is particularly important for Mexico, given that there is a material distance between effective interest rate spreads (and price of risk) for the credit segment considered. For example, commercial loans might have an aggregate PiT PD of 3 percent, while consumer loans may be in the range of 20 to 30 percent. Therefore, assuming zero income from non-performing loans under a static balance sheet assumption would materially overstate losses for banks concentrating on consumer products, that mainly depend on new origination for income and internal capital generation.

Non-Interest Income Analysis

48. Non-interest income has a modest contribution to Mexican banks' overall profitability. In relative terms total non-interest income during 2021 stood at about 21 percent of total income for the set of banks in the stress test sample (Figure 4, second panel). Non-interest income was stressed only under the adverse scenario, based on a constrained approach.[10] In the baseline, non-interest income and expenses were assumed constant at the income level reported during the cut-off year.

49. The constrained approach produces conservative projections for each individual non-interest income revenue source. Initially, the historical mean and standard deviation of the income for each different revenue stream is calculated. Historical data on source income are normalized using the bank's total assets as a normalization basis and for each year of the scenario a revenue stream projection is produced as a multiple of standard deviation away of the stream's historical mean.[11] In this manner, streams with high variability get penalized since they end up with more conservative projection estimates. Additional constraints may be further imposed for each stream as floors and caps ensure the scenario narrative is appropriately translated into the model. For example, on overall non-interest income not exceeding the level realized during the cut-off year (2021), or that a specific source projection may not exceed the cut-off year income for the source,

[10] The approach follows the basic principles of the 2018 EBA methodology for non-interest income but deviates in terms of the applied haircuts by income source and the fact that the impacts on P&L are phased-in during each scenario year rather than fully applied in the first year.

[11] A multiple of 1 standard deviation from the mean was used for year 1, 0.25 for year 2 and 0 for year 3 of the adverse scenario was used in the core solvency ST result; 0 deviations were used for all years under the baseline scenario.

reduced by a certain factor.[12] It is also assumed that that non-interest expenses are kept constant for every year in both scenarios.

50. Net Trading Income (NTI) due to intermediation was not modelled and kept constant through all years for both scenarios. This reflects the fact that most of such income originates from agency business, and it does not appear to be material for Mexican commercial banks. FV adjustments for the FVTPL portfolio (due to the market risk approach above) were only reported to the NTI result. Administrative and other operating expenses were also kept constant at their respective 2021 levels for all banks in the sample.

C. IMF Top-Down Stress Tests: Results

Main Results

51. The banking system remains broadly resilient in terms of capitalization under the adverse scenario, with most banks experiencing ample capital buffers relative to hurdles. Aggregate capital shortfalls are relatively small (less than 0.4 percent of GDP) under the adverse scenario and may be partially attributed to the specific business models of banks. The aggregate capital adequacy ratio declines by 4.7 percentage points to 14.5 percent by 2022, comfortably above the minimum hurdle rates for the adverse scenario, despite some dispersion among banks in the exercise due to the diversity of business models (Figure 9).

52. Two key drivers underpinning the capital depletion are the material market losses due to the pronounced rise in interest rates and credit spreads and the increase in loan loss provisions due to the deterioration of credit conditions. The impact of NII is moderate, confirming the solid net interest margins of Mexican banks under a higher interest rate environment. The static balance sheet assumption has also an impact on internal capital generation since new loan origination is constrained, and, hence, profitability affected (reduced) and securities exposures are assumed to remain constant (in the absence of any active hedging assumption).

53. In the baseline, the aggregate capital ratio (CAR) would be on an upward trajectory after the first year due to banks' revenue-generating capacity and the mild impact of the scenario on net interest income and credit impairments. The system's aggregate capital ratio would increase by 2.8 percentage points to 22 percent by 2024 (Figure 9, panel 1). Solid core profitability and internal capital generation capacity help banks counterbalance losses from market risk that appear to be significant during the first two years. Contained loan loss provisions due to credit risk also contributes positively to this upward direction in capital ratios in the baseline.

54. In the adverse scenario, the aggregate capital ratio would decline by 4.1 percentage points to 15.1 percent in 2023. The decline is larger (almost 5.3 percentage points) when compared with the baseline path in 2023 (Figure 9, panel 3) but still comfortably above the minimum capital ratios at the aggregate level. Increased loan loss provisions and reduced net interest income are the key factors underpinning the larger system-wide capital depletion in the

[12] Such additional constraints were not introduced for the Mexico FSAP exercise given the relatively small materiality of non-interest income sources when compared with the strong net interest income contribution to profits.

adverse scenario. Cumulative credit losses up to year 2 stand at 6.1 percentage points of capital under the adverse scenario compared to a 2.8 percentage point decline in the baseline scenario. The net interest income in the adverse scenario is also lower on average by 1.3 percentage points of capital for the first two years of the horizon (Figure 9, panel 4).

55. Market risk losses also have material negative contributions to capital results under both scenarios. Cumulative NTI and OCI losses are 2.2 percentage points under the baseline and 3.6 percentage points of capital under the adverse scenario; they are the main drivers of the negative slope of the capital path during 2022. Non-interest income impact does not appear to be material under the adverse scenario, given the low relative contribution of fees and commissions in the profitability of banks.

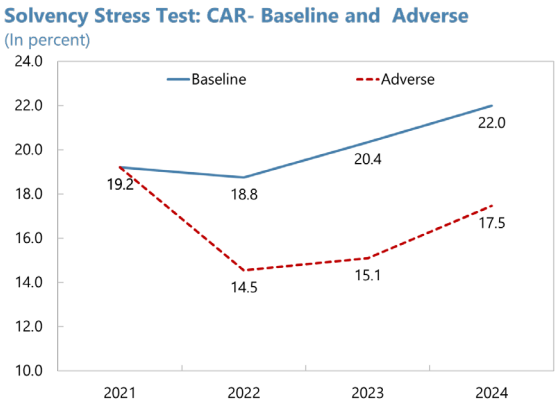
56. The negative capital impact in the adverse scenario is partially mitigated by reduced dividend distributions (since banks during loss making years are assumed not to pay dividends) and the difference in the tax outcomes because of projected losses. The aggregate leverage ratio also remains well above the regulatory minimum under both scenarios given the ample capital buffers that Mexican banks enjoy (Figure 9, panel 5).

57. Individual bank results also suggest substantial heterogeneity in the materiality of drivers of capital depletion. During an economic downturn—as the one captured in the adverse scenario—the drivers negatively affecting the evolution of CET1 capital may be different depending on business model and portfolio concentrations of banks. Banks in the sample with higher concentrations on loan portfolios that are more severely hit by the scenario (for example, banks focusing on consumer segments) may experience larger capital depletion rates relative to peers. Similarly, differences in terms of asset or exposure concentrations (for example, holdings of sovereign debt) or weaker starting point capital positions may play an important role with respect to total capital depletion and potential shortfalls, especially for smaller and less diversified banks.

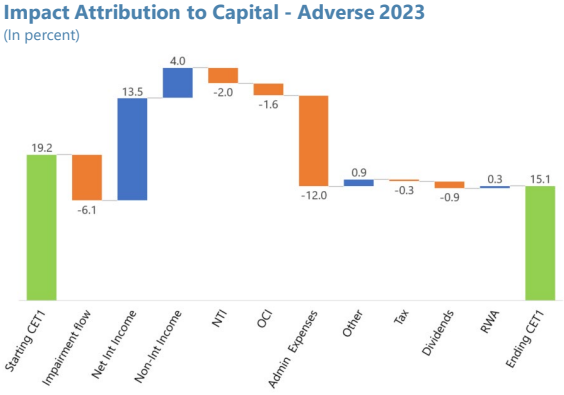
58. The high NPL ratio under the adverse scenario also contributes materially to the lower NIIs. The exercise assumes 25 percent of the effective interest income recognition for non-performing exposures under the adverse scenario and 50 percent under the baseline. Therefore, the net interest income impact has two components: one that is driven by the actual funding and lending rate repricing, and second the forgone interest due to the formation of non-performing exposures that do not contribute to income generation. The relative importance for each component is shown in Figure 10; in the adverse scenario, where net interest income is reduced by approximately 14.2 percent during the first two years relative to the cut-off year. Almost one eighth of that impact is driven by the interest rate shocks (more pronounced during year 1) while the remaining of the decrease can be attributed to the forgone interest impact. This proves that banks may increase their net interest margins, on the basis of benign pass-through rates on stable deposits and it is even more pronounced the larger the participation of these deposits in banks' funding mix.

Figure 9. Mexico: Bank Solvency Stress Test Results

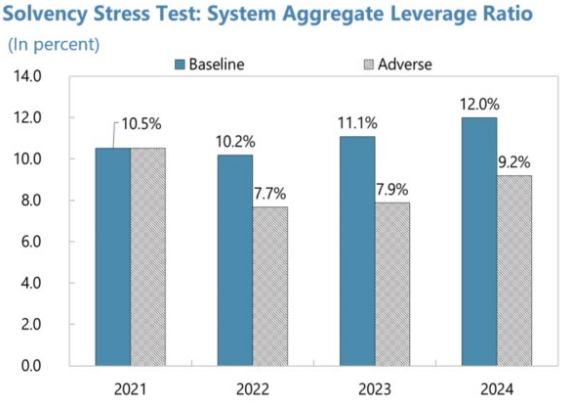
The banking sector has sufficient buffers in both scenarios, despite the sharp revaluation of bond portfolios.



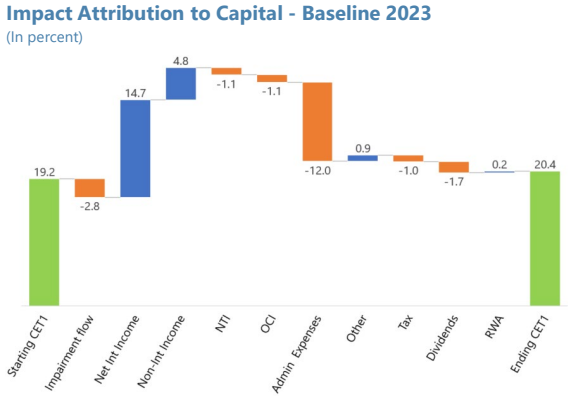
...while loan impairments and Fair Value portfolio losses drive the impact in the adverse scenario.



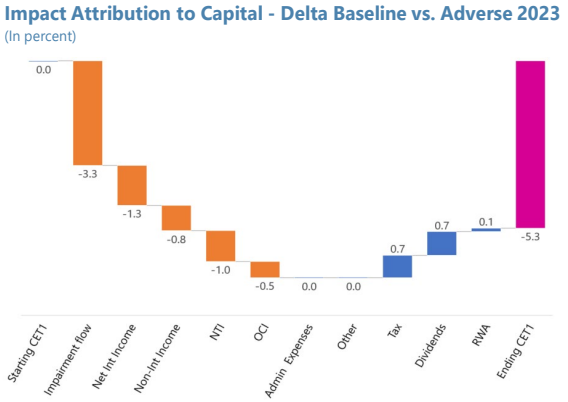
Leverage ratio has also ample space relative to thresholds under the adverse scenario...



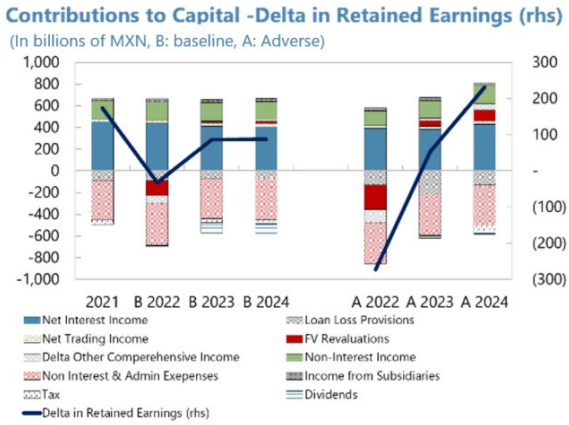
In the baseline, solid core profitability and internal capital generation counterbalances losses from market risk....



Loan impairments and a moderate net interest income impact drive the difference between two scenarios.



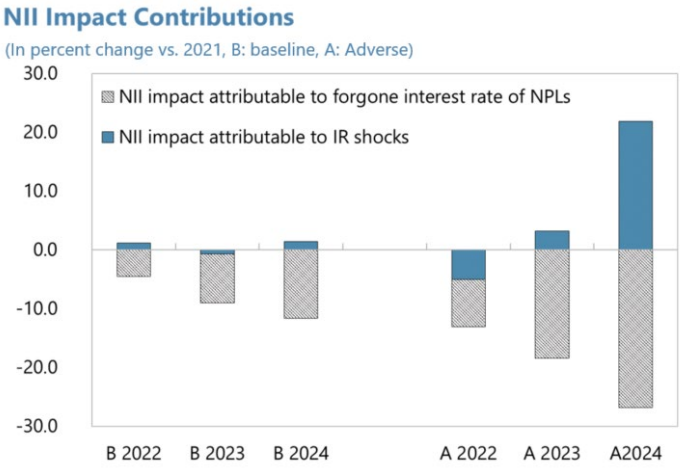
... with market risk impact and loan loss provisions driving the capital depletion vs the baseline.



Source: IMF staff calculations.

Figure 10. Mexico: Solvency Stress Test—NII Impact Contributions

In both scenarios, the impact of forgone interest due to NPL formation is the major driver of the result; positive interest rate shocks eventually tend to favor profitability as the pass-through rates on retail deposits are small compared to the benefits of the positive term spread shock.



Source: IMF staff estimates.

59. The impact of market risk is very material in the overall adverse scenario result. As shown in Figure 11, revaluation of debt securities drives the market risk impact which is 3.6 percent of RWAs during year 1 of the baseline and almost 6 percent under the adverse (Figure 11, left panel). While these losses are mainly concentrated during year 1, the cumulative revaluation (FV and OCI) remains important under both scenarios. This is almost entirely driven by the bond securities portfolios (Figure 11, right panel) and only equities have also a small contribution to the result. As regards the contribution of accounting portfolios to the losses, FVTP portfolio is almost double the size of the impact.[13]

60. Non-interest income contribution to the capital depletion is also very modest. As shown in Figure 12, while the overall applied stress on this source of income is approximately 9.2 percent (as an average across all three years), the contribution to capital depletion is much smaller when compared to market and credit risk impacts: 0.80 percent in terms of starting RWAs versus the baseline scenario respective result during the first two years. Non-interest income does not appear to be a significant contributor overall for the Mexican banks since they mainly rely on the solid interest margins for profitability and internal capital generation.

61. While not directly measured under the stress test exercise, concentration risk might be an important risk for Mexican banks. A stylized analysis on large exposure amounts suggests that a relatively high percentage of banks would face a material capital loss if the largest counterparty defaults.[14] This points to some need to closely monitor such exposure concentration risks and ensure that appropriate prudential measures are in place to mitigate their impact.

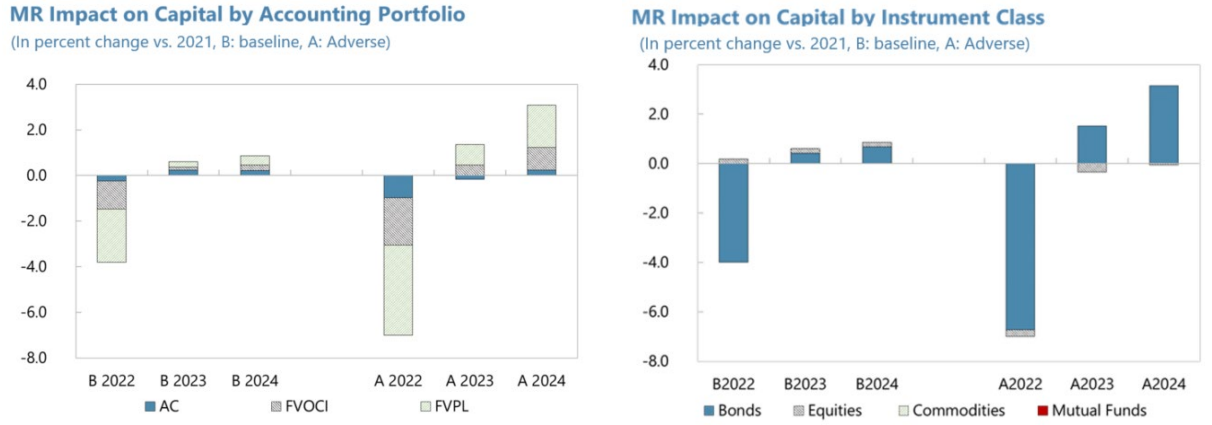
[13] AC portfolios are also shown for illustration and comparison purposes. The exercise did not assume any losses coming from the AC/HtM portfolios, since such losses are accounted for under credit risk. However, the results presented illustrate that the relative impact of these portfolios would be small compared to FVOCI and FVTPL.

[14] Under a very conservative assumption of an LGD of 100 percent for that counterparty and being fully agnostic on the type of such counterparty.

Figure 11. Mexico: Solvency Stress Test—MR Impact by Risk Class

During the outer years, accommodative policy rates and a partial unwinding of spread shocks contribute to the positive revaluation effects.

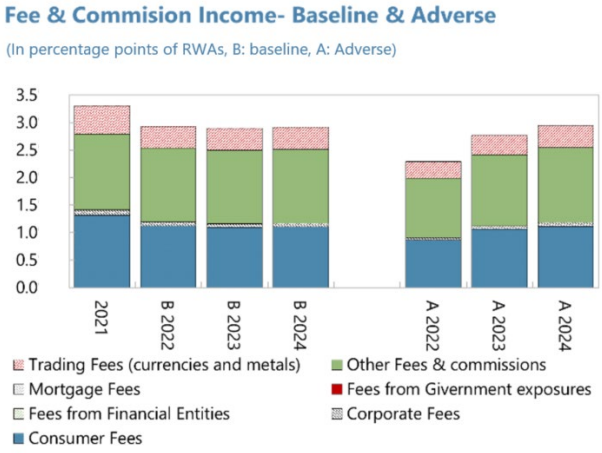
The revaluation of debt instruments is the main driver of market risk shocks. Contributions of other risk classes is not material.



Source: IMF staff estimates.

Figure 12. Mexico: Solvency Stress Test—Non-Interest Income Projections

A modest stress in the adverse scenario reduces Non-Interest Income by 17.8 percent on aggregate across all scenario years. This results in a delta of 47 bps between baseline and adverse in terms of capital depletion.

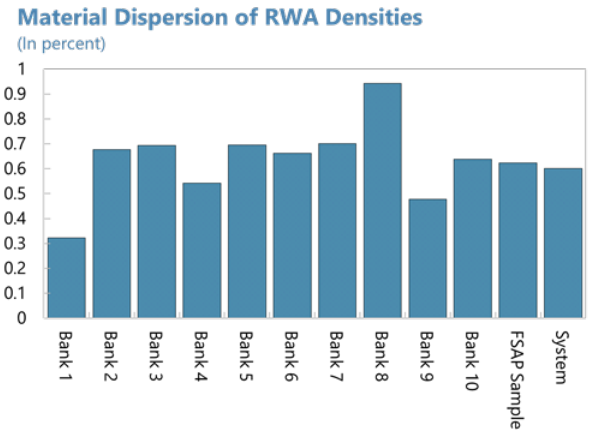


Source: IMF staff estimates.

62. In similar fashion, the high RWA density dispersion across signals the diversity of business models (Figure 13). RWA densities range from 30 to 90 percent in the exercise sample of banks; this probably illustrates how banks might be different in terms of business models, magnitude of exposure to sovereign risk or loan book concentrations and raises the question whether business model risks are appropriately accounted for (under Pillar 2 capital requirements) for a banking ecosystem consisting of 50 commercial entities. This observation could further strengthen the argument favoring bank-specific capital measures, since the uneven features of banks in terms of exposures, strategies and business models was often spotted in the context of the FSAP solvency stress testing exercise.

Figure 13. Mexico: Business Model Risks

The large dispersion of RWA densities is also an illustration of the divergence in business models and strategies.



Source: IMF staff calculations.

Sensitivity Tests

63. Sensitivity analyses suggest that there are material risks stemming from exposure to off-balance sheet credit lines to NFCs and from large holdings of debt securities. Based on the major vulnerabilities identified during the preliminary risk analysis the team has decided to conduct a number of sensitivity analyses focusing on: (i) the substantial level of revocable contingent credit lines to some corporate credit clients for some of the banks in the sample set, and (ii) the potential impact of a higher than anticipated interest rate rise in the adverse scenario, given the diversity of level concentration of sovereign exposures across banks and the uncertainty on how bank profitability could be affected by a materially more pronounced inflationary path.

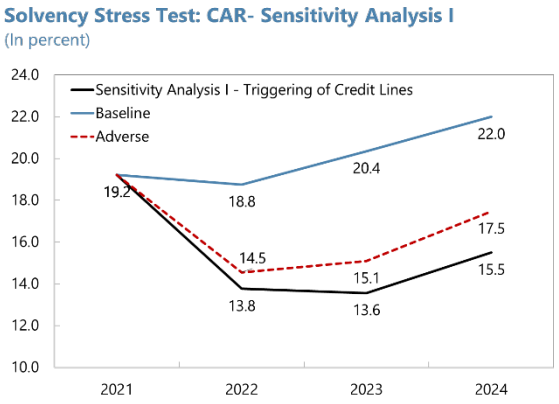
64. Contingent credit lines to corporate clients are substantial. At the end of 2021 they accounted for 1.6 trillion pesos for NFCs and financial entities which is almost 15 percent of total banking sector's assets or 31 percent of the total loan book.[15] More importantly, they are unevenly distributed among banks, and, therefore, may have a diverse impact if they are to be triggered. However, most credit lines are revocable and can be canceled at any time, which should mitigate this risk. Also, the contemporaneous triggering of credit lines by corporates is a tail event that did not materialize even when the initial COVID shock occurred. A number of sensitivity tests were performed to analyze the sensitivity of each bank and the resiliency of the system under a narrative where such lines are triggered. The central scenario of this analysis assumed that a proportion of such credit lines was triggered during the scenario horizon, while assuming that the expansion of the balance sheet was fully funded by wholesale deposits, in an attempt to explore a conservative funding option.

[15] Because of their revocable nature (which is generally not linked with any conditionality clause on borrowers' deteriorating credit profile), CCFs are set to zero, and, thus, Pillar I capital charges for such off-balance sheet elements are non-existent.

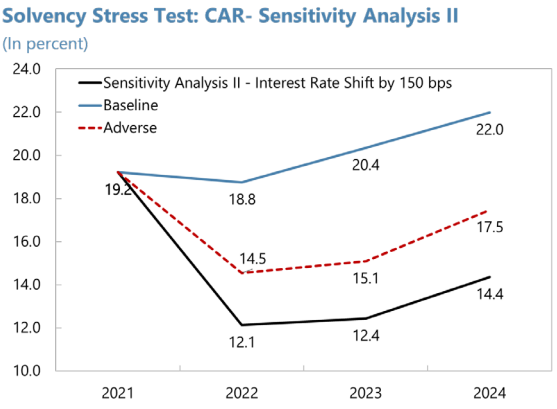
65. The scenario assumed that a proportion of these credit lines is triggered with a specific time profile.[16] Given that only aggregate data were available, the total off-balance sheet exposures were allocated to credit risk segments on a pro-rata basis, and it was assumed that 25 and 30 percent of the outstanding lines would be triggered through the three years of the adverse scenario. The impact on credit losses, net-interest income and RWAs was accounted for each bank within the perimeter of the exercise. Aggregate results for the system are illustrated in Figure 14 (left panel) indicating that under such a narrative, capital depletion would be material and the landing capital ratio by 2024 would be almost 2 percentage points lower than the one observed under the normal adverse scenario.

Figure 14. Mexico: Bank Solvency Stress Test—Sensitivity Analysis Results

Triggering of contingent credit lines can be a challenge for some banks …



… while interest rate shifts could further reduce capital buffers.



Source: IMF staff calculation

66. The dispersion of the capital depletion deviation between banks warrants some further prudential monitoring and action. The analysis shows that such contingent exposures are unevenly concentrated between banks and given their revocable nature, have a minimal contribution on capital charges. Such concentrations might be material and while at the system level capital buffers appear to be sufficient, the relevant authorities are advised to closely monitor banks' appetite for this type of facilities and ensure that all risks (expected and unexpected losses) that derive from such appetite are properly assessed and accounted for. Given the bank-specific nature of such risks, Pillar II requirements are probably the best measure to address them.

67. The second sensitivity analysis involved a higher-than-anticipated rise in interest rate (+150 bps) to gauge for potential impact if an interest rate scenario further into the tail were to materialize. A parallel shift of 150 bps (on top of the adverse scenario's level) was assumed for the Mexican yield curve and a full exercise was conducted (including the production of all satellite outputs under the adjusted adverse scenario). Credit risk, market risk and net-interest income were

[16] This balance sheet expansion was assumed as being materialized during the adverse macroeconomic scenario, i.e., it was assumed to be in addition to economic downturn captured under the adverse scenario.

calculated for the new scenario while non-interest rate income components were kept similar to the ones used in the core adverse.

68. The results suggest that the additional shift would have considerable effects, leading the sample banks' capitalization to decline by 2.4 percentage points by 2022 or 3.1 percentage points by the end of the horizon (Figure 14, right panel). The result is mainly driven by the larger impact on the FV and OCI portfolios of banks, which due to their materiality would suffer substantial losses in the absence of hedging in such an adverse scenario. While credit losses would also increase, this impact can be almost fully mitigated by the increase in the NII since the higher rates tend to suggest higher interest income due to the low pass-through rates on retail deposits which form the core of the funding side.

69. As above, the issue for concern is the dispersion of capital impact between banks. This suggests that an exposure level issue to sovereign risks is also present here (a concentration issue if seen from another angle) and the prudential authorities should seriously consider a way to account for such business model or concentration risk issues in their capital frameworks (Pillars I and II).

70. The potential impacts of penetration of new forms of digital payments to the financial system is assessed as a layer of the bank solvency STs. The FSAP team has conducted a hypothetical sensitivity analysis in which banks experience an erosion of net interest income (as they compete for retailed sight deposits and pay higher rates) and income related to payments services (proxied by fees received from the use of credit cards) in the face of increased competition from new forms of digital payments (i.e., CBDC or other forms of digital money).

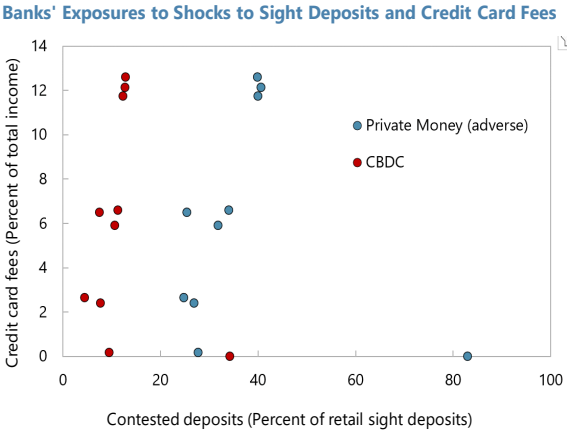
71. The sensitivity analysis suggests that the impact of new forms of digital money would, under current assumptions, be limited, but some banks' business models could be affected. In the most adverse scenario where competition arises from "private money", the banking system's total capital depletion would amount to 34 basis points by 2024, relative to the baseline solvency stress test results (Figure 15).[17] Banks that rely more on retail sight deposit funding and/or credit card fee income could see their capital ratios decline up to 75 basis points by 2024. When CBDC is the source of increased competition for banks, putting a cap on the size of CBDC accounts could mitigate the impact on banks with the capital adequacy ratio dropping by 25 basis points.[18]

[17] In this scenario, the cost of funding for all sight deposits below 1 million of Mexican pesos increases by 50 bps. This shock is calibrated using the model by Chang et al (2022). Income from credit card fees falls by 20 percent at the end of the projection. The dynamic of the shock assumes a 30 percent impact in the first year and a 70 percent in the second year.

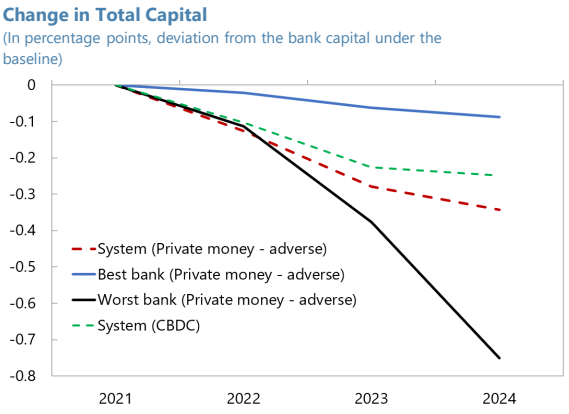
[18] In this scenario, CBDC has a cap of UDI 3000 (approximately 21,000 Mexican pesos). The cost of funding for this amount per sight deposit account also increases by 50 bps.

Figure 15. Mexico: Results from Fintech-related Risk Analysis

Reliance on retail sight deposits and credit card fees differ across banks



Potential impact of digital money penetration would vary considerably across banks.



Sources: Banxico; and IMF staff calculation.

D. Policy Recommendations

72. The results of the solvency exercise demonstrate the resilience of the banking system at the aggregate level, but weak pockets exist. Such weaknesses are mainly associated either to the specific business models of some banks that are not well diversified for each potential economic scenario or to the weaker capital buffers of some banks that deviate substantially from the system average. Authorities should continue ensuring that currently vulnerable banks with low capital levels or with elevated business model risks should implement capital raising plans without any delays and ensure that minimum capital levels reflect such idiosyncratic risks.

73. Material exposure concentration warrants some additional prudential oversight. The FSAP analysis suggests that concentration levels are important in the Mexican banking system. Concentration risks has multiple forms. Firstly, it can be seen as concentration on large credit exposures which may be partially attributed to the structural features of the domestic corporate ecosystem (a major part of which consists of a few large and dominant firms), or as a business model concentration where some of the banks are expanding their operations in a less diversified way, focusing primarily on few market segments and, hence, facing risks when their business strategy is significantly challenged by macroeconomic developments. In both cases, bank-specific capital add-ons should be in place to ensure that such risks are adequately captured by prudential supervisors. An efficient Supervisory Review Process and an appropriate calibration of Pillar 2 requirements may properly address such concerns.

74. Contingent credit lines are also a source of concern. While most of such lines is contractually revocable, it is uncertain how banks will behave in the tail event where they face contemporaneous requests for such lines to be drawn. In this context, authorities should ensure that such exposures are appropriately monitored, the associated risks identified and mitigated, and the prudential oversight is tightly secured against potential blind spots that provide wrong incentives to

some of the market participants. Dispersion of the use of such facilities among banks is an additional reason of concern, since the stress impact in the case that such lines were to be utilized would also be uneven between banks, causing additional stability concerns and market frictions.

75. The granularity and sophistication of the current regulatory reporting and available data repositories at Banxico and CNBV is impressive, but some further adaptation may be required. Dynamically linking exposures at the granular level with their current/updated LTVs and eliminating identified weaknesses in assessing the value of collateral in line with housing price fluctuations should be a priority in this context. Enhancing the granularity of prudential credit exposure metrics, with increased focus on IFRS9 and IRB metrics, should be another priority.

76. The footprint of existing data and stress testing infrastructure is impressive and provides evidence of the respective teams' technical competence, efficiency, and dedication to develop and maintain it. Stress tests are resource-intensive, requiring specialized staff, systems, and IT infrastructure. Authorities should continue to ensure that resources and the organizational structure remain adequate given the high complexity of the tasks.

LIQUIDITY STRESS TESTS

A. Overview

77. Monitoring bank liquidity conditions and testing their resilience under stressed market conditions is important to maintain stability in the banking system. Liquidity imbalances can stem, for example, from an expansion of banks' assets, a run-off on banks' liabilities or the triggering of off-balance sheet contingencies. Banks can rebalance their liquidity positions in various ways, including by swapping high quality liquid assets (HQLA) for liquidity in the repo market. This may prove expensive though, if counterparties have doubts about banks' liquidity (or solvency), or if the value of collateral is eroded because asset prices are falling. These liquidity imbalances can then have an impact on the propagation of asset quality and liquidity shocks throughout the financial system.

78. In Mexico, CNBV and Banxico share the mandate to monitor liquidity in the banking sector and to issue liquidity regulation. The regulatory requirements include a mandatory liquidity coverage ratio (LCR) and net stable funding ratio (NSFR) of 100 percent for all commercial banks. Development banks are not subject to these mandatory requirements, given the sovereign guarantee of their liabilities, but report to Banxico and CNBV LCRs on a monthly basis, for monitoring purposes but these are not published. Regulated and supervised nonbank institutions are monitored via a basic liquidity indicator.[19]

[19] The indicator is calculated as the ratio between liquid assets and short-term liabilities. Liquid assets include cash and equivalents, investment in government and banking securities, and reverse repo investments. Short-term liabilities include deposits (if any), short-term bank loans and securities issued.

79. The FSAP team assessed liquidity in the banking system with an LCR-based stress test, the NSFR, and a cash flow analysis. The FSAP team conducted a Basel III LCR test over a period of 30 days (by aggregate currency position and by significant currency) and a cash flow-based liquidity stress test over a three-month period. For all tests, the team considered a set of scenarios reflecting potential liquidity stress episodes. After the application of each scenario, the team in collaboration with the authorities simulated liquidity conditions for all banks and calculated the relevant liquidity metrics. The recent dynamics of the NSFR were also analyzed.

80. The analyses revealed that aggregate liquidity conditions were robust, but with some vulnerabilities. By December 2021, Mexican commercial banks had an aggregate LCR equal to 225 percent and no bank in the system had a ratio lower than the regulatory minimum. Large banks, representing almost 80 percent of the commercial banking sector's assets, were strong in terms of available liquidity. The system aggregate NSFR stood at 145 percent. LCR-based stress tests showed that some medium- and small-sized banks breached the LCR's 100 percent threshold in some scenarios. These results were confirmed by the cash flow analysis over a three-month time horizon. The major weaknesses that the FSAP team identified were (i) the material contingent credit lines extended by banks to corporates, that could be withdrawn quickly or simultaneously during crises, thus, reducing the system's liquidity buffers; and (ii) part of the retail deposits from high net-worth individuals, in search of higher yields through synthetic-repo products, could behave like wholesale deposits and be more prone to outflows, diverging from their current classification as stable deposits. The FSAP made some explicit recommendations to mitigate these risks in a subsection below.

B. LCR and NSFR

81. The LCR is designed to ensure that banks hold a sufficient reserve of HQLA to allow them to withstand a period of significant liquidity stress of 30 days. Basel III LCR promotes the short-term resilience of banks' liquidity profile by requiring that in normal times banks hold a stock of cash or unencumbered HQLA (the numerator of the ratio) at least as large as the expected total net cash outflows (the denominator) over a period of significant liquidity stress lasting 30 calendar days. The idea is that by converting HQLA into funding in private markets, banks can absorb shocks and reduce the risk of spillovers into the real economy.

82. In Mexico, the system-wide LCR declined during the pandemic but recovered immediately afterwards. The average LCR for the banking system was 165 percent in January 2020, before the pandemic. Like in other countries, the pandemic caused a temporary reduction of liquidity. Of particular importance was the drop in aggregate LCR linked to the tapping of committed credit and liquidity lines that corporates held with commercial banks in March-May 2020 (Table 8). This drop was partially contained because corporate and retail customers triggered their credit lines for precautionary purposes and placed them as deposits with banks. Following this episode of market uncertainty, banks' holdings of HQLA increased fostered by an increase in deposits from corporates and households, and substantially reduced credit origination activity. By December 2021, Mexican commercial banks had an aggregate LCR equal to 225 percent and no bank in the system had a LCR below the 100 percent regulatory minimum.

83. Credit lines represent a vulnerability for the banking sector's liquidity. Mexican banks grant contingent credit lines to individuals, corporates, government, banks and other entities (Figure 16 shows the evolution of undrawn credit lines in the last two years). In May 2022, revocable credit lines were 2.5 trillion pesos, irrevocable credit lines were 0.25 trillion pesos and liquidity lines were 0.15 trillion pesos. Out of the revocable credit lines, 1.2 trillion pesos were to individuals, 1.2 trillion pesos to corporates and 0.3 trillion pesos to other financial entities. In a tail scenario, the contemporaneous triggering of such lines would involve an expansion of banks' assets that needs to be accommodated by the parallel expansion of the liability side. This accommodation can stretch the liquidity of the entire system, particularly if the triggering is of precautionary nature but replaces external funding due to global tightening conditions. This was not the case during the March-May 2020 stress episode, but it could happen during a crisis, in particular with tighter global liquidity conditions.

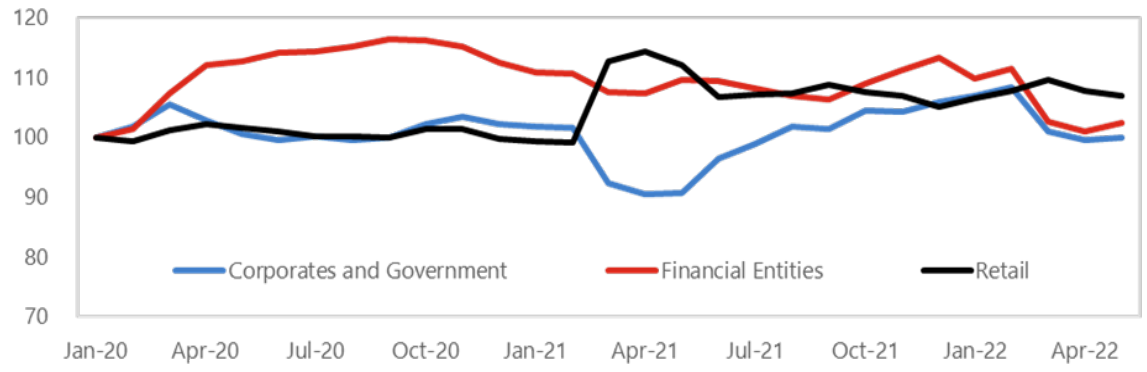
Table 8. Mexico: Evolution of Credit Lines During the Pandemic

Outstanding undrawn commited credit lines (month end) - System level								
(billion pesos or percent, at month end)								
	All sectors		Financial institutions		Non-financial corporates and government		Retail customers	
Sector	Outstanding undrawn amount	outflow ratio	Outstanding undrawn amount	outflow ratio	Outstanding undrawn amount	outflow ratio	Outstanding undrawn amount	outflow ratio
Jan-20	2,658		354		1,221		1,083	
Feb-20	2,732	-2.815%	374	-5.724%	1,265	-3.628%	1,093	-0.949%
Mar-20	2,740	-0.283%	392	-4.679%	1,245	1.563%	1,103	-0.912%
Apr-20	2,711	1.053%	401	-2.257%	1,217	2.270%	1,094	0.855%
May-20	2,680	1.161%	396	1.204%	1,195	1.795%	1,089	0.440%
Jun-20	2,696	-0.601%	417	-5.388%	1,205	-0.811%	1,074	1.368%
Jul-20	2,665	1.137%	398	4.633%	1,197	0.612%	1,070	0.368%

Source: Banxico.
Notes: Outflow ratio = Outstanding undrawn credit line in month (t) - Outstanding undrawn credit line in month (t+1) / Outstanding undrawn credit line in month (t).

Figure 16. Mexico: Undrawn Credit Lines

(January 2020 = 100)



Source: Banxico

84. The FSAP team also noted that some deposits are classified as "retail" but could behave more similarly to "wholesale" and be more prone to outflows than it is currently assessed. Part of retail deposits are from high net-worth individuals that require an interest rate higher than that generally offered by banks to their retail customers. The large difference between repo and reverse repo outstanding volumes at the system level may be an indication of material synthetic positions of banks providing yield pick-up products to high net-worth depositors and warrants some monitoring from the authorities. Thus, classifying high net-worth individual deposits as retail deposits could probably overestimate their stable nature and bias in a positive direction the standard liquidity metrics.

85. The FSAP team conducted a top-down LCR test covering all 50 commercial banks. For stress-testing purposes, the regulatory assumptions and weights underlying the standard LCR were revised to make the liquidity requirements more severe. This was achieved by increasing the haircut applied to banks' counterbalancing capacity (i.e., to the HQLA that banks rely on to obtain liquidity in secondary markets or through standard central bank liquidity facilities) and by increasing the run-off rates applied to the outflows (e.g., rates at which deposits are withdrawn and securities issuances cannot be rolled over). The LCR stress test combined three HQLA haircut scenarios with four increased outflows scenarios for a total of 12 combined scenarios. Haircut scenario 1 corresponds to the regulatory scenario, i.e., it applied the haircuts mandated by the Mexican regulation, which are aligned to the Basel standard. Haircut scenario 2 and 3 assumed increasingly severe haircuts on banks' counterbalancing capacity. Outflow scenario 1 corresponds to the regulatory scenario, i.e., it applied the outflow rates mandated by the Mexican regulation, which is aligned to the Basel standard. Outflow scenarios 2, 3 and 4 included shocks on retail funding, wholesale funding, and combined (see Annex V for full details on the haircuts and run-off rates applied in the range of LCR scenarios considered).

86. In all scenarios, the average LCR for the banking sector remained above 100 percent, though some banks breached the threshold under some of the scenarios (Table 9 and Figure 17). Lower starting LCRs (also connected to banks' specific strategy or business models) and greater exposure to wholesale outflows were the most common reasons for breaching the threshold for smaller banks. Triggering of the contingent credit lines seems to be a liquidity vulnerability particularly for larger banks, however, since they start from a high LCR point (245 percent asset weighted LCR)—D-SIBs only breached the threshold in the most severe scenario.

Table 9. Mexico: Bank Liquidity Stress Test Results

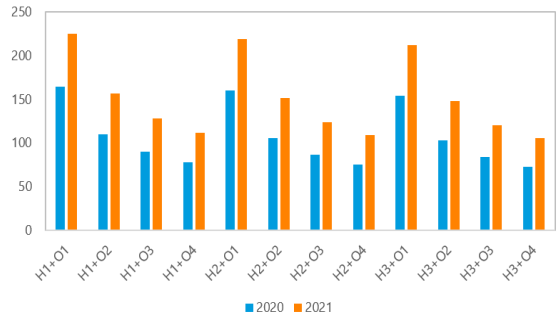
		System-level
Regulatory Scenario[1]	Aggregate LCR (In percent)	225
	No. Banks with LCR<100	0
Retail Shock[2]	Aggregate LCR (In percent)	157
	No. Banks with LCR<100	6
Wholesale Shock[3]	Aggregate LCR (In percent)	128
	No. Banks with LCR<100	13

Sources: Banxico; and IMF staff calculation.
1/ In the regulatory scenario, the LCR is computed by using the regulatory run-off and haircut rates.
2/ In the retail shock scenario, run-off rates on retail deposits are increased above the regulatory rates.
3/ In the wholesale shock scenario, run-off rates on wholesale deposits are increase above the regulatory rates.

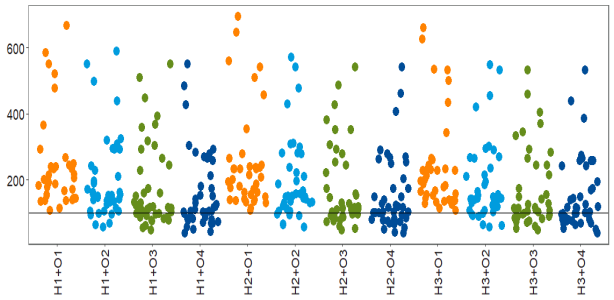
Figure 17. Mexico: LCR Test Results—All Currency

System-Wide LCR: 2020–2021

(All currencies)



System-Wide: Liquidity Coverage Ratio 2021



Sources: Banxico and IMF staff estimates.
Note: LCR calculated for year-end of 2020 and 2021. Dots represent banks. H1 is Haircut scenario 1 corresponding to the regulatory scenario obtained by applying the haircuts mandated by the Mexican regulation, aligned to the Basel standard. H2 and H3 are Haircut scenario 2 and 3 that assume more severe (than Basel) haircuts on banks' counterbalancing capacity. O1 is Outflow scenario 1 corresponding to the regulatory scenario obtained by applying the outflow rates mandated by the Mexican regulation, aligned to the Basel standard. O2, O3 and O4 are outflow scenarios 2, 3 and 4 that assume more severe (than Basel) run-off rates on retail funding (O2), wholesale funding (O3), and both (O4).

87. The FSAP's LCR tests complement Banxico's existing Liquidity-at-Risk analysis. Banxico conducts LCR-based stress tests but there are differences in the estimation of haircuts and run-off rates applied to outflows with respect to the FSAP's methodology. In particular, Banxico estimates haircuts using its solvency stress test scenarios and stressed outflows are constructed for each bank based on the 95 percent Conditional Value at Risk (CVaR) of the distribution of the historic outflows, going back as far as 2006. Results were comparable between Banxico and the FSAP's tests, but the latter identified more banks potentially breaching the 100 percent threshold because run-off rates for outflows, particularly for retail deposits and contingent credit lines, were more severe under the FSAP's scenario assumptions.

88. In line with Basel III, the Mexican authorities do not set regulatory minimum limits for LCR by single currency. For liquidity risk in foreign currency, Mexico introduced, back in the mid-1990s, the regulation for foreign currency liquidity, consisting of three limits:

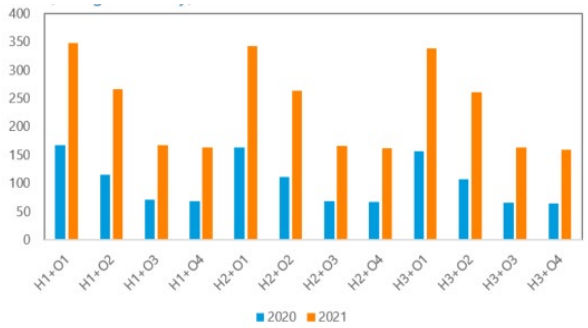
- **Limits to net open position**. To minimize currency mismatch, banks' net open position in foreign currency is limited to 15 percent of Tier-1 capital (including peso denominated products linked to the exchange rate). This minimizes the magnitude of balance sheet losses in the case of material FX rate adjustment.
- **A short-term liquidity requirement**. Banks must hold enough liquid assets to cover the sum of the largest gaps (liabilities minus assets) for up to 60 days, as well as a percentage of all other liabilities up to 60 days that are not covered by assets with the same or shorter maturity. This reduces the risk that banks will incur losses due to fire sales of illiquid assets, and it also prevents the FX market from under undue pressure when banks have to cover short-term liabilities' outflows in foreign currency.
- **A structural liquidity requirement.** At the end of each day, no commercial bank can have an amount of Net Foreign Currency Liabilities[20] greater than 1.83 times its core capital (CET1). Thus, a bank may increase the size of its balance sheet in foreign currency as long as it does not create a large imbalance between the maturities of its assets and liabilities

89. The FSAP team also conducted LCR-based stress tests in domestic currency and USD (Figure 18). As of end-December 2021, Mexican banks registered a 182 percent LCR in national currency and a 348 percent LCR in U.S. dollars. For most banks, complying with the tighter liquidity regulation in foreign currency (see previous paragraph) results to an LCR above 100 percent and indeed this was the case for 33 out of 44 banks with material operations in U.S. dollars. For most of the remaining banks that did not comply with the minimum LCR threshold, the main driver behind non-compliance was that the LCR regulation imposes a limit on the recognition of inflows, and it does not consider deposits held by banks in other financial entities as eligible HQLA to meet the LCR requirement. Relaxing these constraints (LCR cap on inflows) results in U.S. dollar LCRs above the minimum threshold.

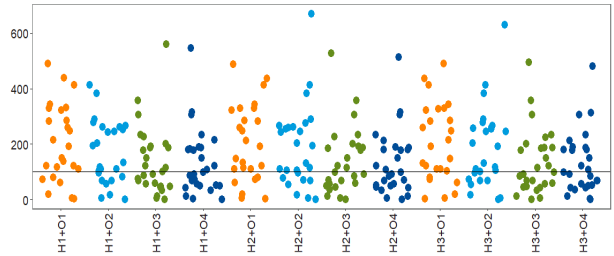
[20] Net Foreign Currency Liabilities are defined as the difference between liabilities weighted by maturity (with 100 percent weight for maturity up to one year and decreasing thereof, with a weight of 0.05 percent for liabilities maturing beyond three years) and assets weighted by maturity and degree of liquidity (with 100 percent weight for liquid assets and 50 percent weight for highly graded loans up to one year).

Figure 18. Mexico: LCR Test Results—FX/USD

System-Wide LCR: 2020-2021
(Foreign Currency)



System-Wide: Liquidity Coverage Ratio: 2021

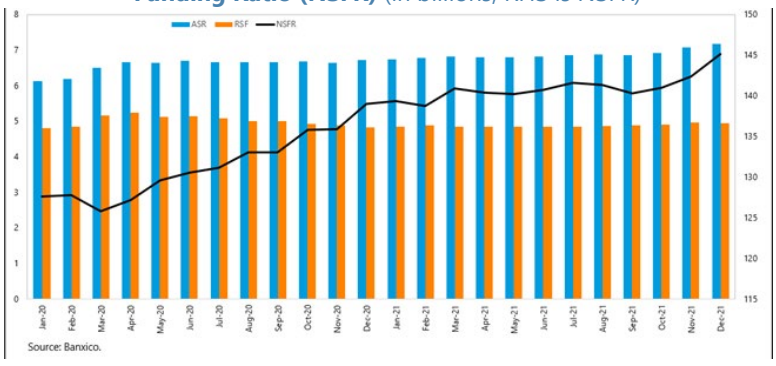


Sources: Banxico and IMF staff estimates.
Note: LCR calculated for year-end 2020 and 2021. Dots represent banks. H1 is Haircut scenario 1 corresponding to the regulatory scenario obtained by applying the haircuts mandated by the Mexican regulation, aligned to the Basel standard. H2 and H3 are Haircut scenario 2 and 3 that assume more severe (than Basel) haircuts on banks' counterbalancing capacity. O1 is Outflow scenario 1 corresponding to the regulatory scenario obtained by applying the outflow rates mandated by the Mexican regulation, aligned to the Basel standard. O2, O3 and O4 are outflow scenarios 2, 3 and 4 that assume more sever (than Basel) run-off rates on retail funding (O2), wholesale funding (O3), and both (O4).

90. The FSAP team did not stress the LCR of development banks. While development banks report their LCR on a monthly basis, they do not have to comply with a mandatory threshold since they legally have an explicit backstop by the government in case of liquidity shortages.

91. Relative to the LCR, the NSFR aims at reducing funding risk over a longer time horizon. To achieve this objective, it requires banks to fund their activities with sufficiently stable sources of funding to mitigate the risk of future funding stress. The implementation of the NSFR was postponed due to the COVID-19 outbreak, however, for monitoring purposes, banks have been reporting NSFR data and calculations since 2017. The NSFR became a binding requirement for Mexican banks from March 2022.

Available (ASR) and Required Stable Funding (RSF) and Net Stable Funding Ratio (NSFR) (in billions, RHS is NSFR)



92. The end-2021 the average NSFR stood at 145 percent and remained above the 100 percent target. It has increased from end-2019 (128 percent) due to a steady increase of Available Stable Funding (ASF) (Text Chart). This increase was driven mainly by the seven largest banks and by an increase in retail deposits and capital. Corporate deposits also showed substantial growth, though partially offset by the decreases in deposits from government and financial institutions, as well as outstanding issuance of securities.

C. Cash Flow Analysis

93. The cash-flow analysis assessed the banks' ability to withstand liquidity outflows using their counterbalancing capacity. The analysis used information aggregated by the authorities in a contractual maturity ladder for assets and liabilities[21] and explored the balance between outflows, inflows, and counterbalancing capacity assuming that stressed liquidity conditions persisted for a period of three months.[22] A four-step approach was applied. First, the FSAP team estimated banks' maturing liabilities by funding segment over the next three months. Second, it applied progressive stress scenarios to these liabilities to establish the part that could not be rolled-over (run-offs) and created a funding need. The sum of funding needs across all liability segments results in an overall funding need for each bank. Third, it quantified the counterbalancing capacity of each bank after applying progressive haircuts to banks' liquid assets to reflect discounts associated with asset sales. Fourth, it compared funding needs (including contingencies) and counterbalancing capacity to estimate liquidity surpluses and shortfalls both at the bank- and at the system- level. Detailed information on the run-off rates and haircuts for liquid assets are presented in Annex VI.

94. This analysis also assumed a full collateral revaluation and triggering of committed credit lines. For each scenario collateral release and additional pledging due to run-off rates applied on repo and reverse repo were accounted for and the resulting collateral change was applied to the counterbalancing capacity. The FSAP team also assumed that contingent credit lines held by corporates with commercial banks were partially triggered, thus further increasing funding shortfalls from liability run-offs. A similar assumption will be exploited in the system-wide liquidity analysis (see the section on System-Wide Liquidity later in this Note).

95. Recognition of inflows from maturing loans was assumed to decrease with the increase of the scenarios' severity. Under this approach (and contrary to what is commonly used in regulatory metrics focusing on bank-specific shocks such as the LCR) roll-over rates of maturing retail and corporate loans are assumed to progressively reach 100 percent, i.e., banks are not allowed to counterbalance outflows by not extending new credit to the real economy during the most severe stress episodes. This assumption increases the severity of banks' liquidity needs and can be thought of as corresponding to the objective of the stress test which is to ensure that banks have enough balance sheet capacity to maintain their lending under stress.

96. Over longer time-horizons cash flow analysis pointed to some gaps in banks' counterbalancing capacity under severely adverse conditions. All banks would be able to handle funding shortfalls with their existing counterbalancing capacity under the mildly adverse scenarios, though 21 banks representing almost 70 percent of total banking sector's assets would encounter

[21] The authorities provided data converted into a template similar to C46 for the contractual maturity ladder.

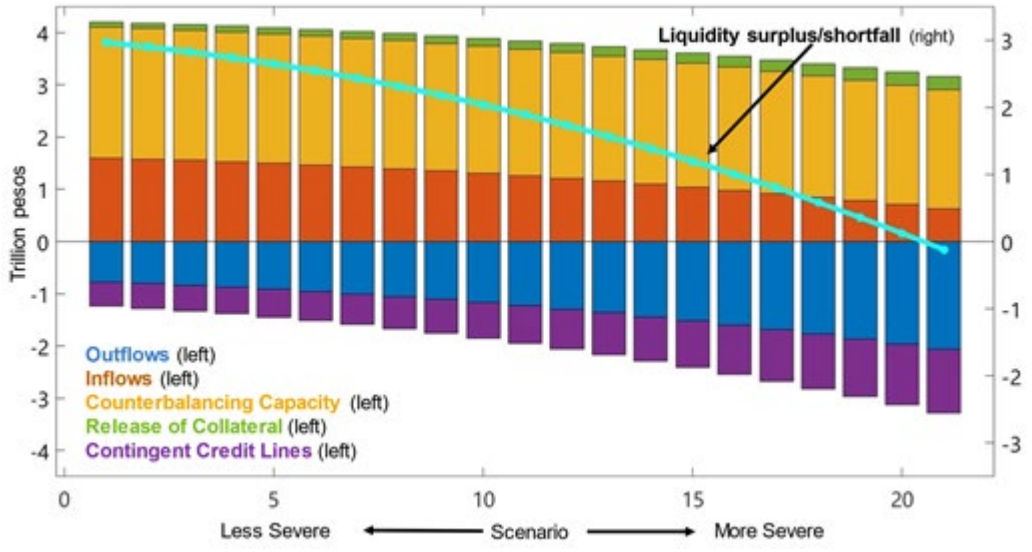
[22] This horizon is considered to be more pragmatic in terms of the time span of a real liquidity stress incident, allowing for a more reasonable assessment of systemic spillovers and their impacts in the markets. Since in the Mexican case most banks' balance sheet items are included in the three-month bucket, the FSAP team did not analyze stressed liquidity conditions persisted for more than three months.

liquidity shortfalls under the most severe adverse scenario.[23] Under this latter scenario, the combined liquidity shortfall was 0.3 trillion pesos (4 percent of total assets), while at the aggregate level (i.e., netting liquidity shortfalls with the surpluses of some banks) the shortfall was around 0.1 trillion pesos (1 percent of total assets). This shortfall seems manageable, given Banxico's ability to support the system during stress events, either through standard facilities or via the instrumentation of extraordinary measures. Figure 19 presents results for the cash flow analysis scenarios at the aggregate level, disaggregating the different flows composing liquidity surpluses or shortfalls.

97. The cash flow analysis complements LCR stress tests and is useful to highlight differences in banks' exposure to stress. Even if the results of the LCR tests and the cash flow analysis have significant differences,[24] some comparison can be done in terms of the severity of the assumed run-off rates, with the LCR fitting between the cash flow's mild and adverse scenarios. A comparison of the results confirms that the banks with liquidity shortfalls in the LCR-based tests and the cash flow analysis are mostly the same. But in relation to different structures of their balance sheet, banks are exposed to different sources of liquidity stress. For example, investment banks are particularly vulnerable to wholesale deposit outflows and the loss of counterbalancing capacity; large and small banks are more vulnerable to the triggering of credit lines.

Figure 19. Mexico: Bank Cash Flow Analysis Results

***Liquidity shortfalls are limited even under a severe* scenario**



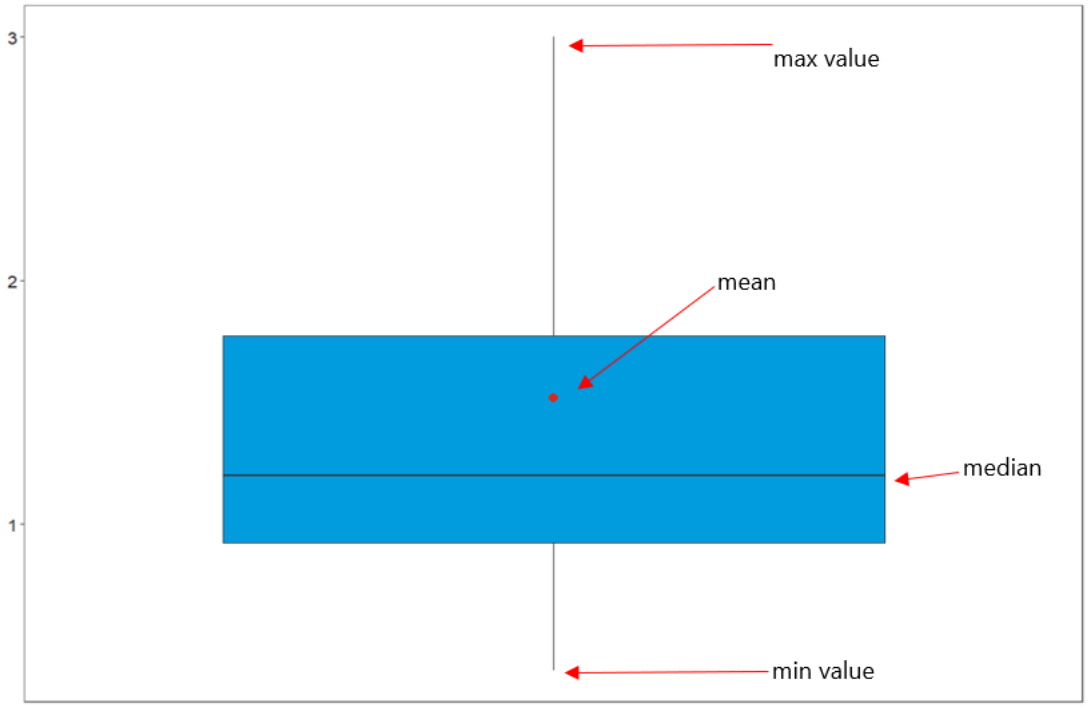
Source: IMF staff calculation.
Note: This chart shows the liquidity surplus/shortfall in the right y-axis for the banking sector with the contribution of the different flows. In the most severe scenario, the banking sector faces liquidity shortfalls equal to 0.1 trillion pesos (1 percent of total assets in the sector).

[23] The severely adverse scenario was anchored to correspond to a system-wide outflow of approximately 20 percent of total assets.

[24] The cash flow analysis assumes a three-month stress horizon compared to the one-month horizon of the LCR. Moreover, contrary to the LCR, no stable inflows are assumed.

98. The distance to liquidity stress indicator (DLSI) measures the degree of resiliency to liquidity stress conditions.[25] The DLSI measures the required stress factor that would make the bank reach the point where it suffers from liquidity shortfalls. Since in the FSAP specification the mild scenario corresponds to a stress factor of 0.25 and the severely adverse scenario to a stress factor of 1, any value of DLSI below 1 suggests that the bank would face a liquidity shortfall at a stress level below the one corresponding to the severely adverse scenario. However, a DLSI value above 1 would suggest that the bank has the counterbalancing capacity to withstand the stress that corresponds to the severely adverse scenario, and even higher levels of stress would, therefore, be required in order to bring that bank to a liquidity shortfall. In Mexico, half of the banking sector (in terms of asset size) has a DLSI value higher than 1, for the other half, even in the most severe adverse scenario (corresponding to 1) liquidity shortfalls are small and manageable. (Figure 20).

Figure 20. Mexico: Reverse Cash Flow Analysis—Distance to Liquidity Stress Indicator



Source: IMF staff calculation.
Notes: The Figure represents the distribution of the DLSI among Mexican banks through a boxplot. The maximum value is capped at 3. Banks positioned at or below 1 in the distribution present a liquidity shortfall in scenarios considered by the FSAP. Banks positioned above 1 in the distribution present a liquidity surplus in scenarios considered by the FSAP and develop a liquid shortfall in more adverse scenarios than those considered by the FSAP.

[25] The DLSI is a reverse stress-testing metric and was introduced in "A Liquidity Shortfall Analysis Framework for the European Banking Sector" by Laliotis and others (2020) published in *Mathematics*.

D. Policy Recommendations

99. The authorities should continue to monitor the dynamics of contingent credit lines and assess with the relevant supervisors how the related risks are managed. While liquidity conditions are robust in Mexico, the FSAP identified that the substantially size of contingent credit lines could be a source of vulnerability. Banks' credit lines to corporates were material at 1.2 trillion pesos on average between January 2020 and May 2022. In March 2020 part of these lines was withdrawn for precautionary reasons and were deposited with banks so that the drop in liquidity for the system was generally contained. Moreover, only irrevocable and liquid credit lines were withdrawn (while revocable credit lines, that represent 90 percent of the total, were not), and global liquidity conditions were accommodative. This episode showed nonetheless that the impact on bank liquidity from withdrawal of credit lines could be sudden and significant, as in other jurisdictions. During a crisis it may generate large reputational costs for banks to stop the provision of credit by revoking such facilities, and spillover effects could be amplified in an environment of tighter liquidity conditions. The FSAP team suggests that the authorities should continue monitoring the dynamics of contingent credit lines and design a framework of incentives (or capital charges) that would lead to a reduction of their outstanding amount.

100. The authorities could also incorporate the liquidity analysis and relevant quantifiable metrics in the Supervisory Review Process (SRP) to inform Pillar 2 capital requirements, including for development banks. The authorities could develop a plan to incorporate the liquidity analysis into the Supervisory Review Process (SRP) for each individual entity and use such analysis to inform the calibration of Pillar 2 capital requirements. In that context liquidity positions of development banks might also be used to assess capital surcharges needed in order to ensure that these banks' capital fully reflects the undertaking of risk or the contribution to systemic risks.

101. The authorities could improve their robustness checks in the current liquidity stress testing framework to address that part of retail deposits (of high net-worth individuals). While Basel rules in the classification of deposits should not be challenged, retail deposits of high net-worth individuals could behave as wholesale deposits in their search for yield. The authorities could thus monitor the evolution of such deposits (including by further analyzing and monitoring of the difference between repo and reverse repo transactions) and conduct sensitivity analyses on the LCR. This could complement the standard LCR by providing a more realistic angle on banks' liquidity positions.

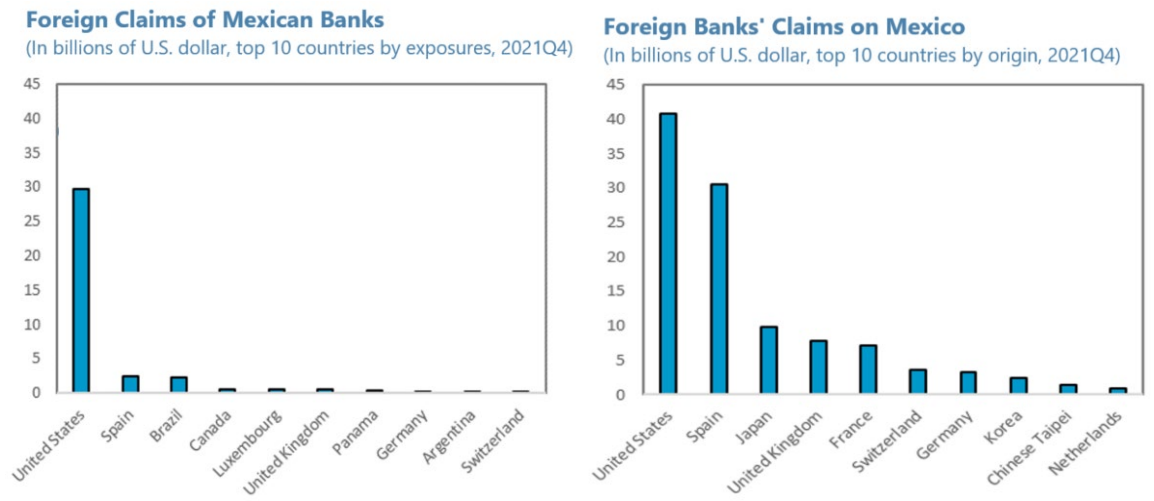
102. Finally, the authorities could use the collected data to set up a regular maturity ladder template and use cash flow analysis to further complement the well-developed current stress testing framework. The authorities started to collect regulatory data which allow setting up a maturity ladder template to produce the cash flow analysis since March 2022. They could consider making the production of the maturity ladder template more systematic so as to be able to complement their liquidity metrics with a full cash flow analysis-based liquidity indicator. As the FSAP showcased, such analysis could efficiently complement LCR-based stress tests and could be useful to highlight differences in banks' exposure to various sources of stress.

INTERCONNECTEDNESS ANALYSIS

A. Network Analysis on Cross-Border Bank Linkages

103. Both Mexican banks' foreign claims and the claims of foreign banks on Mexico are concentrated in the United States and Spain.[26] According to the BIS Locational Banking Statistics, the total foreign claims of Mexican Banks stood at US$37 billion as of 2021Q4, with the United States comprising around 80 percent of total foreign claims. The claims of foreign banks in Mexico were US$130 billion in 2021Q4. The largest claims also came from the United States and Spain, covering 55 percent of total claims (Figure 21).

Figure 21. Mexico: Foreign Claims of Mexican Banks and on Mexico



Source: BIS Locational Banking Statistics

104. A cross-border network analysis was used to assess the extent to which the failure of a banking system in one country could spread across borders and trigger knock-on effects. The analysis used BIS Locational Banking Statistics and covered 13 countries.[27] It included a credit shock and a funding shock following the methodology outlined in Espinosa-Vega and Solé (2010). The first simulation considered the credit shock only, and the second simulation examined the effects of a joint credit plus a funding shock.

105. The network analysis was based on the following assumptions: First, banks in a country were assumed to fail when their loss of capital from shocks exceeds their initial level of total regulatory capital. Second, in a credit shock, the loss given default (LGD) was set to be 0.5, meaning that creditors can only recover half of their cross-border claims on another country that is in default.

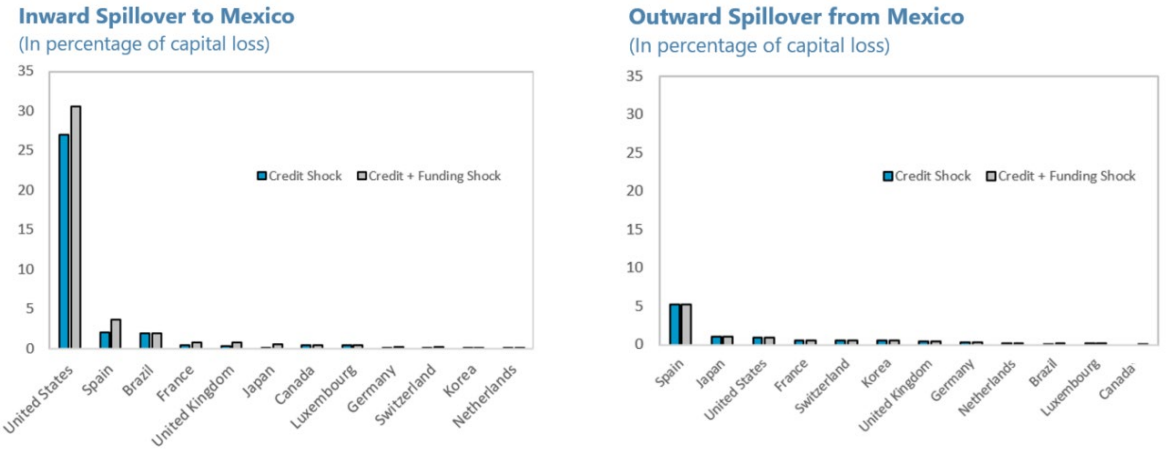
[26] Mexican banks' foreign claims are on all sectors of foreign countries.

[27] The 13 countries include: Brazil, Canada, Switzerland, Germany, Spain, France, the United Kingdom, Japan, Korea, Luxemburg, Mexico, Netherlands, and the United States. The countries are determined mainly based on the volume of cross-border claims and data availability.

Third, in a funding shock, the analysis assumed that borrower banks are unable to replace 10 percent of the funds that were previously granted by the creditor country that is in default, leading to a fire-sale in assets of equivalent value. In this situation, the assumption was that the borrower bank's assets were sold at a 30 percent discount.

106. The simulation result showed that inward and outward spillovers to and from Mexico are relatively modest (Figure 22). A hypothetical financial distress in Mexico would impact banks in Spain the most through both the credit and the funding channels (loss of approximately 5 percent of bank capital). But overall Mexican banks play a limited role as shock originators or transmitters to other countries. Conversely, a hypothetical financial distress in the United States would have the most significant impact on banks in Mexico (loss of 30 percent of bank capital).

Figure 22. Mexico: Cross-Border Bank Contagion[1/, 2/]



Sources: BIS Locational Banking Statistics, IMF Financial Soundness Indicators, and IMF staff calculations.
1/ Results are based on the Espinosa-Vega and Sole (2010) approach. The outward spillover reflects the percentage of capital loss in other countries due the failure of banking system in Mexico. The inward spillover reflects the percentage of capital loss of Mexican banks due to shocks from the banks in corresponding countries.
2/ Canada claims on Mexican bank data not available.

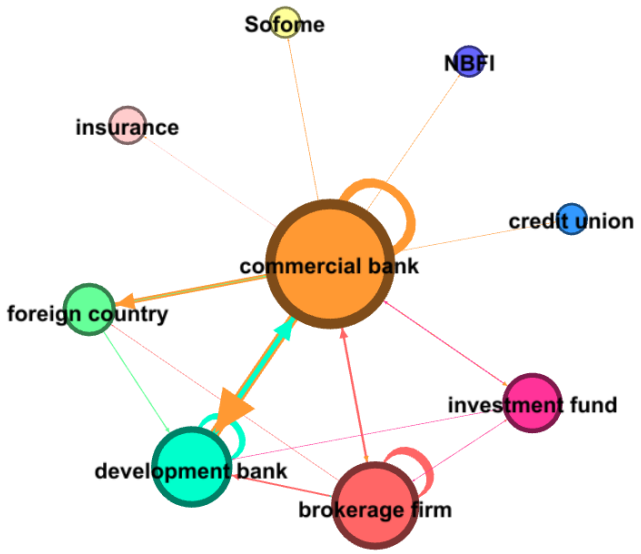
B. Domestic Financial System Interconnectedness

107. For domestic network and contagion analysis, the FSAP team used supervisory data on unsecured and secured bilateral exposures as well as on securities transactions between a large number of entities in the domestic financial sector (Figure 23). The data included bilateral exposures among 42 commercial banks, 6 development banks, 25 brokerage firms, 4 credit unions, 6 insurance companies, 34 investment funds, 6 Sofomes, 1 nonbank financial institution, and 8 foreign countries, totaling 132 entities. A network analysis was applied to the supervisory data to assess the extent to which the failure of one institution could spread across institutions and trigger knock-on effects. Results of a combined credit and funding shock are reported below.[28]

[28] Data are for December 9, 2021. Results of a standalone credit shock are milder and available upon request.

108. The balance sheet exposures by type of entities indicate that development banks are the largest net borrowers from the system. Commercial banks play a key role in providing funds. The major debtors of commercial banks are other commercial banks and development banks. Brokerage firms are among one of the main creditors. Credit unions, Sofomes and other NBFIs are on the borrower side, while investment funds and insurance companies have both bilateral asset and liability exposures. These entities have very limited risk due to small exposures.

Figure 23. Mexico: Financial System Interconnectedness [1/]



Sources: Banxico and IMF staff calculations.
1/ The diagram represents bilateral exposures of the Mexico financial system. The size of nodes reflects the share of the total claim of this type of entity in percent of the system-side total claims. The thickness of the edges represents the share of claims in percent of the system-wide total claims.

109. The domestic network and contagion analysis was based on assumptions that represent a severe shock scenario: First, a financial entity was assumed to fail when its loss of capital from a shock exceeded its initial level of total regulatory capital. As the team was able to collect capital data only for commercial banks, development banks, and brokerage firms, the other entities were not assumed to act as a channel of contagion. Second, during the credit and funding shock, the loss given default (LGD)—that represents the percentage loss on bilateral credit exposure in the event of a default by the borrowing financial entity—was set at 0.7 for unsecured bilateral exposures, 0.2 for secured bilateral exposures, and 0.5 for bilateral exposures through securities' holdings.[29] When a funding shock and a credit shock occurred simultaneously, the assumption was that a bank could only replace 70 percent of the funds that were previously granted by the default creditor, causing the borrower bank's assets to be traded at a 15 percent discount fire-sale.

[29] Since many of the domestic bilateral exposures on securities are due to securities issued by the development banks, a relatively low LGD on these instruments was assumed.

110. According to the simulation results, there is limited interconnectedness and contagion in the Mexican financial system. The main reason is that total domestic bilateral exposures are small relative to the total system capitalization. The total of all bilateral exposures is only half of the size of the total regulatory capital for commercial banks, development banks and brokerage firms. Therefore, the failure of a domestic financial entity barely triggers the failures of other entities in the system, except for a few institutions. Figure 24 reports the distribution of contagion index and vulnerability index for the financial entities in the Mexican financial system.[30] Panel (a) shows that development banks are the most contagious entities, along with a few commercial banks. The default of a development bank (in any case unlikely given their sovereign guarantee) would cause an average loss of 1.8 percent of its counterparties' capital. The default of a commercial bank would cause an average loss of 0.2 percent of its counterparties' capital. Panel (b) demonstrates that a few brokerage firms, commercial banks, and development banks are the most vulnerable to the hypothetical failures of other financial entities. However, the overall vulnerability index remains relatively low, indicating individual entities' capital remain resilience during the shocks trigged by the failure of other entities.

CORPORATE RISK ANALYSIS

A. Overview

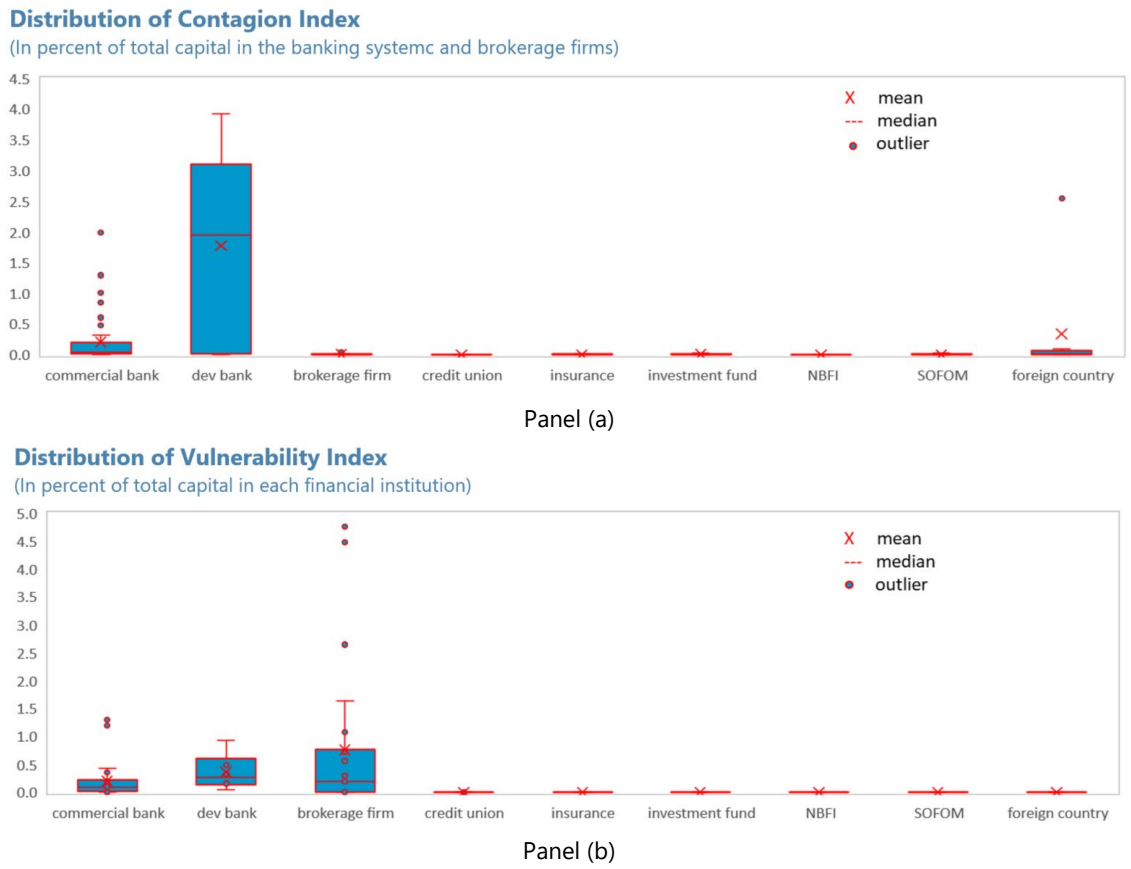
111. Corporate sector health is an important pillar of financial stability. Sound fundamentals and adequate buffers against liquidity and solvency risk insulate the economy and the financial sector against adverse shocks. Deterioration in corporate fundamentals may presage rising NPLs and deteriorating bank asset quality in the baseline or present greater vulnerability to external shocks. A complete picture of corporate sector health is vital for assessing financial sector vulnerability.

112. Large, publicly traded Mexican corporates are generally healthy, recently reversing the deterioration in the previous decade.[31] Low NPLs in the Mexican banking sector are supported by strong fundamentals among the public Mexican corporates. The 2016 FSSA, for example, found the 50 largest publicly traded non-financial corporates to be highly resilient to external shocks, while Mexican corporate spreads are substantially lower than peers in other Latin American countries or in EMs globally. A sample of 81 Mexican firms had among the lowest baseline and shock default probability levels in a sample of 24 advanced and emerging economies in a global corporate stress test (Tressel and Ding, 2021). These fundamentals weakened over the last decade and the early pandemic, with interest coverage ratios falling and leverage rising. This trend has recently reversed in the early part of the post-pandemic recovery but require continued monitoring going forward to ensure it is sustained (Figure 25).

[30] The Index of Contagion represents the average loss experienced by each entity (expressed as a percentage of the entity's total regulatory capital) due to the triggered failure of one entity. The Index of Vulnerability reports the average loss experienced by each entity (expressed as a percentage of the entity's total regulatory capital) across individual trigged failures of all other entities.

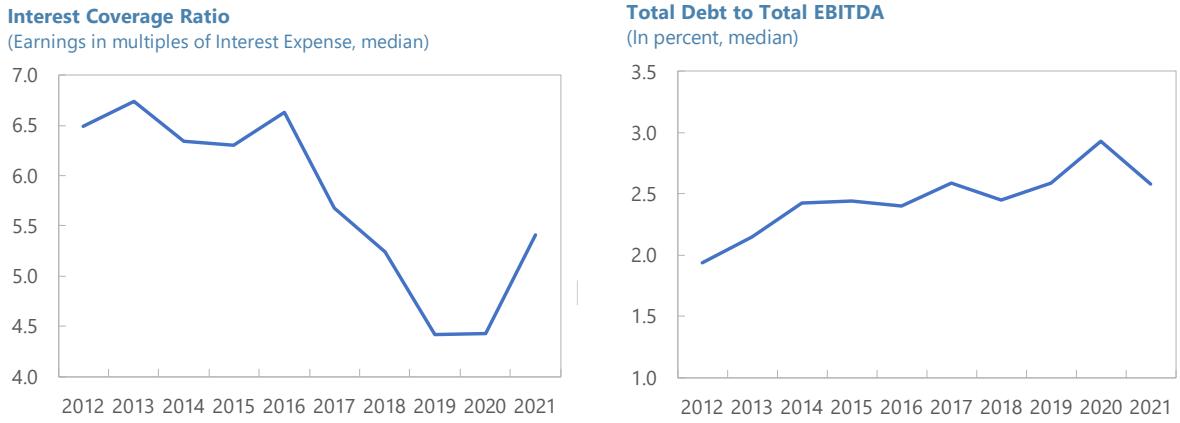
[31] This discussion includes information on large public corporations, notably Petroleos Mexicanos and Comisión Federal de Electricidad where available.

Figure 24. Mexico: Distribution of Contagion and Vulnerability Indices Across Entities



Sources: Banxico; and IMF Staff Calculations.
Note: Contagion Index shows the aggregate capital impairment in the banking system and brokerage firms due to a hypothetical failure of a testing financial institution, similar to the concept of outward spillovers, and vulnerability Index shows the average capital impairment due to hypothetical failures of other financial institutions, similar to the concept of inward spillovers. Note that the regulatory capital data are only available for commercial banks, development banks, and brokerage firms.

Figure 25. Mexico: Interest Coverage Ratios and Leverage of Nonfinancial Corporates



Sources: Worldscope; and IMF staff calculation.
Note: The listed firm data from Worldscope by Thomson Reuters are used. Pemex and CFE are not included.

113. Less is known about other Mexican corporates. The 84 corporates in the Tressel and Ding study represent 43 percent of total NFC debt leaving a substantial fraction of financial sector exposure unobserved. Most other studies present similar coverage. Databases covering a wider range of firms are often limited in terms of indicators, contain substantial rates of missing data, or suggest other data quality issues.

114. Machine learning tools are in many cases well suited to the task of corporate risk estimation. While 'machine learning' describes a wide range of estimation techniques with diverse virtues and limitations, a few key methods are well-suited to firm microdata. Penalized regressions reduce overfitting risks on noisy, collinear, and heavily skewed data. Forest-based methods share these features and offer lower sensitivity to outliers, neutrality to median-imputed observations, and insensitivity to skew in the explanatory variables. Common machine learning practices such as imputing rather than discarding observations with missing data and cross-fold validation further improve the extraction of information from available data and assessed model performance.

115. These tools can also provide more robust inference out-of-sample, including to corporates with different risk profiles. Machine learning models with tight hyperparameters typically attenuate the overfitting that challenges more classical estimation and offers better performance on observations outside the estimation sample. Out-of-sample testing can be designed to simulate the effectiveness of the estimation on dissimilar types of firms. This is highly desirable for corporate risk assessment in Mexico where high-quality risk assessment is available for a small set of typically large and well-known firms but applying this assessment to smaller firms with noisier data would help shed light on additional segments of bank balance sheets.

B. Methodology

116. The model was estimated on high quality firm microdata, mostly from publicly traded firms. Firm balance sheet data was from Capital IQ, covering more than 14,000 observations of firms from Brazil, Chile, Colombia, Mexico, and Peru. The database covered about 860 firms in a typical recent year, of which about 109 are Mexican (Table 10). Expected default frequencies (EDFs) from Moody's were used as the dependent variable and are available for a subset of these firms, typically about 48 in Mexico of which 38 are successfully matched with firm data from the Capital IQ database. These represent some of the largest and best understood non-financial corporations in Mexico.

Table 10. Mexico: Summary of Corporate Balance Sheet Data

Databases	Firms[1]	Date Range	Total Obs.	Mex Firms[1]	Mex Obs.
CIQ Microdata	863	'00-'21	14,523	109	1,936
EDFs	239	'99-'21	5,352	48	1,142
CIQ Microdata + EDFs	170	'00-'21	3,481	38	799
Orbis	22,159	'12-'20	188,308	420	3,242
Expansion 500		'10-'20		313	3,443

[1] Firm counts reflect the number of firms observed in on average per year between 2014-2021

117. Alternative data sources offer coverage of additional corporates. Unmatched observations in the Capital IQ database represent more than half the Mexican observations (more than three-fourths of the full LA5 sample) and may present a different risk profile to those with matched EDFs. Two other databases present a larger set of firms. The Orbis database offers a very large number of firms across Latin America and about 420 firms on average over recent years in Mexico (with substantial variation across years). Expansion 500 is a Mexico-specific database designed to rank Mexico's top 500 corporations by sales, and unlike other databases considered here corporations are not consolidated. All observations missing data on total assets were dropped.

118. Country selection was performed as part of model evaluation. Information from non-financial corporates in other major Latin American emerging markets may improve the quality of the estimation for Mexican corporates, particularly by providing additional observations on the role of macroeconomic indicators where the number of independent observations for Mexico is limited. These observations may, however, be misleading given differences across countries in institutional arrangements and corporate structure. Estimations with and without observations outside Mexico were evaluated on their performance on Mexican firms.

119. A variety of firm-specific and macroeconomic variables were used to estimate firm default risk. Firm-specific variables included 4 liquidity measures, two measures of leverage, 3 measures of earnings, and a measure of firm size relative to the average firm in a country-year. Macroeconomic variables were selected to capture real, external, and financial sector stresses (Table 11).

Table 11. Mexico: List of Explanatory Variables in Corporate Sector Analysis

Firm-specific	Macroeconomic
Quick Ratio	GDP Growth
Current Ratio	GDP Growth Lag
Cash Equivalent to Current Liabilities	Depreciation
Leverage (D/A)	Depreciation lag
Leverage (TL/E)	Financial Conditions Index
EBIT to Current Liabilities.	Financial Conditions Index lag
Revenue Growth	ST Interest Rate
Return on Assets	LT Interest Rate
Return on Equity	
Interest Coverage Ratio	
Firm Size	

120. Estimation methods were evaluated by cross validation. For each method and specification, observations were divided into subgroups or 'folds.' Each subgroup was sequentially removed from the sample and the remaining observations were used to estimate a model. The estimation was then evaluated on the hold-out subgroup. Estimation methods and specifications were evaluated by the simple average of the R^2 on each of the subgroups. For models with hyperparameters, these hyperparameters were themselves selected from a course grid in a nested cross-validation exercise within the non-hold-out sample. The division of the observations into groups can be done randomly, but performance was also assessed when observations were grouped by country, industry, time period, and firm size to better understand how well model estimates apply to observations that are dissimilar to the estimation sample.

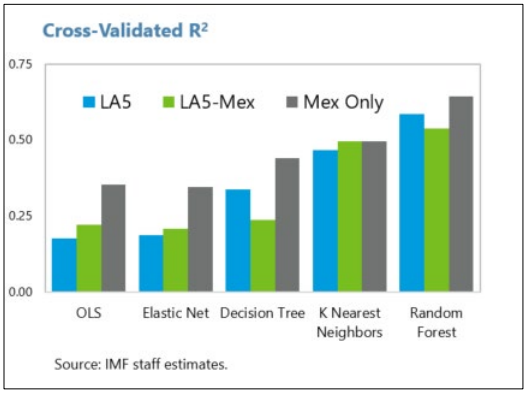
121. A variety of machine learning models were evaluated in a horse-race design. In addition to a classical ordinary least squares regression, penalized regressions (elastic net), decision trees, K-Nearest Neighbors, and Random Forest regressions were estimated. EDFs were transformed by logit and all explanatory variables were normalized to mean zero and unit standard deviation as some methods are sensitive to differences in scale. These methods are among the most commonly used for continuous dependent variables for small datasets and are often more robust than simple linear regression. More flexible but less robust methods like neural networks typically require substantially larger datasets to outperform simpler methods.

122. Model assessments were decomposed using Shapley values. Some of the models evaluated can be complex and do not offer simple coefficients to explain the importance of each explanatory variable. Shapley values are a concept borrowed from cooperative game theory to decompose the role of each explanatory variable in an estimation into additive contributions. It can be shown that this method is the only additive decomposition which satisfies a few uncontroversial criteria like symmetry and independence of irrelevant alternatives. Shapley values are defined as the average marginal contribution of an independent variable across all possible orderings of independent variables. The number of permutations grows exponentially with the number of independent variables, but the computation time can be significantly reduced for specific estimation methods including penalized regression and tree-based methods, while advances in computing power reduce costs more generally over time.

123. The model was then applied to simulated data reflecting the assumptions of the solvency stress test scenario. Macroeconomic variables were updated to reflect the baseline and stress scenario paths. Firm data from 2021 was simulated to evolve over 2022–24 according to simple rules. Earnings and revenue growth evolve with variations in nominal GDP, interest costs with a weighted average of short- and long-term interest rates, and profits with the difference between earnings and interest cost growth.

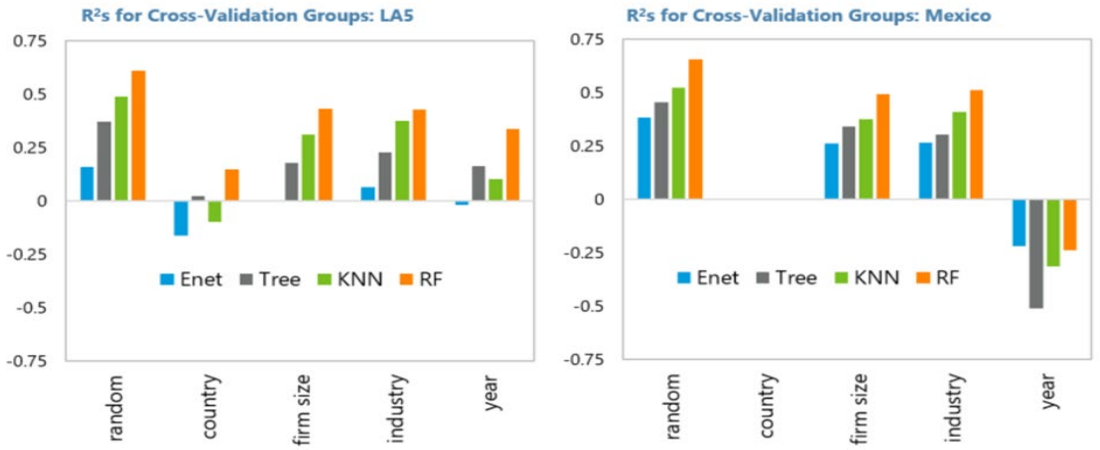
C. Results

124. Random forest models outperformed linear regression and other machine learning methods. Using cross-fold validation with random division into folds, average R^2s on the Mexico sample varied from about 0.35 for linear regression to about 0.65 for Random Forest. An evaluation of the informativeness of the inclusion of non-Mexican corporates was also performed in this context. The text chart presents the results for Mexico-specific estimations, the full LA-5 sample, and the performance of estimations on the full LA-5 sample specifically on Mexican firms. Estimations on the Mexico-only sample outperformed estimations on the larger dataset across all methods but the ranking of methods was broadly unchanged and the variation in model performance across samples was significantly smaller than the variation in performance across models.



125. Model performance was worse for cross-validation by type (Figure 26). Model performance in cross-validation over randomly determined groups provides the best estimate of model performance on data typical of the estimation sample. It is more challenging to say how these estimates would apply to observations that are in some way dissimilar. The charts below present cross validated average R^2s where cross validation folds vary by country, firm size (grouped by tercile), industry (SIC 1-digit classification), and year (5 groups of contiguous years). Model performance is notably degraded for all models and samples, and OLS estimation is not presented here as the average R^2 is badly negative in several cases. Nevertheless, most estimation methods remain informative in most cases, with Random Forest estimation outperforming in all cases. The Mexico-only sample continues to show slightly better results for most grouping methods (grouping by country is obviously not available in this case) but shows very poor results when observations are grouped by time period. This is likely due to the very small number of observations available for macroeconomic variables leading to poor inference about risk for new combinations of these variables. In this case models learn from the diversity of experiences in other countries to get a more balanced view of the role of the macroeconomic variables. This study presents the results of a random forest estimated on the Mexico-only sample as this performs better in general (e.g., for smaller firms over the same time period) but uses instead the model estimated on the LA5 sample when applying the stress scenario as these simulated observations are for a different time period and have different macroeconomic conditions.

Figure 26. Mexico and LA5: R^2 for Cross-Validation Groups



Source: IMF staff estimates.
Note: R^2 here refers to the coefficient of determination which can be negative out-of-sample for overfit models

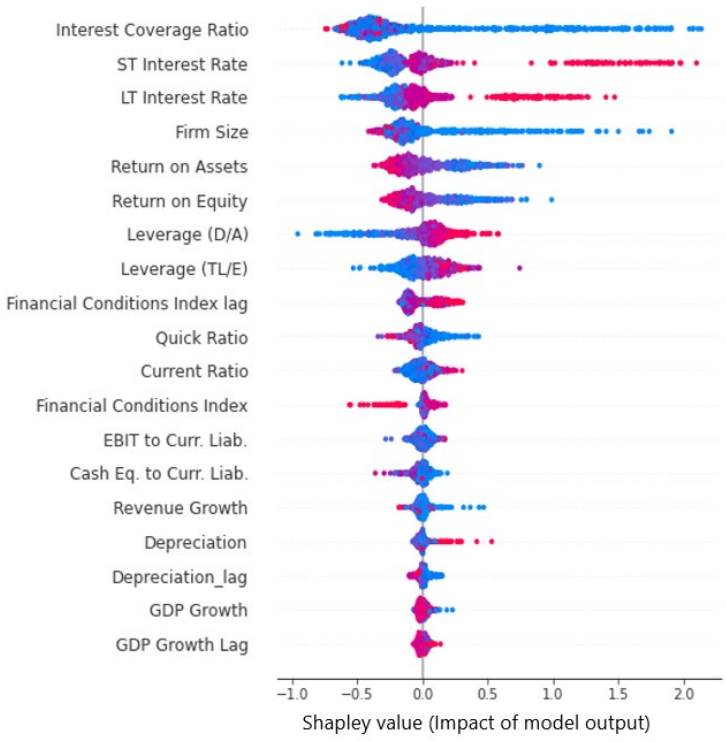
126. The random forest model emphasizes interest rates, the interest coverage ratio and firm size. The chart below presents a "bee swarm" chart of Shapley values for each observation for each independent variable. Distance from the center line indicates positive or negative contribution to risk from that variable and blue (red) color represents a low (high) value for that variable. Variables are listed in order of importance which can also be read from the dispersion of dots around the center line. For some variables like the interest coverage ratio, importance comes from

the very high risks associated with very low levels, while most observations are clustered together. For others like leverage measured as total liabilities over equity, risks are seen to vary more continuously with the data.

127. The random forest model captured non-linearities in the data. Features of the estimation can be read from the model Shapley values. Figure 27 plots model-implied Shapley values on the y-axis against the variable values on the x-axis. In the case of firm size, the model sees a strong relationship between size and risk at the low-end, with risk contributions from firm size falling rapidly between 0 and 0.05. After this level, however, additional size does not substantially further reduce assessed risk. This type of nonlinear relationship is not a necessary feature of random forest estimation—the leverage ratio demonstrates a broadly linear relationship across the full range of the sample (a histogram of observations presented in grey columns along the x-axis). The vertical dispersion in the dots in Figure 28 reflect different levels of risk contribution for the same value of a particular independent variable. This arises due to interaction effects between variables. Firm size can present a greater or lesser risk depending on other firm-specific and macroeconomic characteristics, as highlighted in the chart color bars.

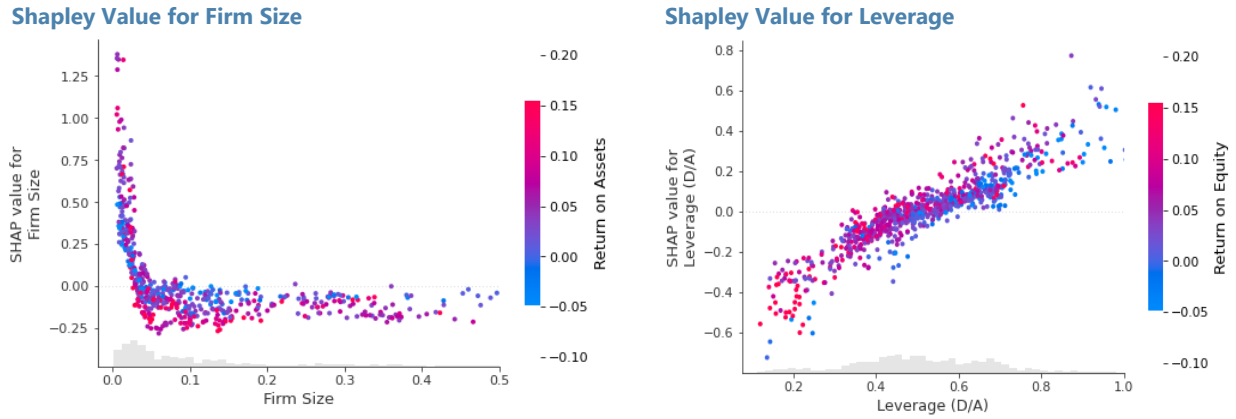
Figure 27. Mexico: Shapley Value from Random Forest Estimation with Corporate EDFs[1/]

The random forest estimation, which performed best in out-of-sample testing, finds that lower interest coverage ratios, higher interest rates, smaller firms, weaker profitability, and higher leverage ratios contribute to higher EDFs in the Mexican corporate sector.[2/]



Sources: Capital IQ; Moody's KMV; and IMF staff calculations.
1/ The Shapley value is the average marginal contributions of an observation for that variable to the overall risk assessment. Marginal contributions are averaged over all possible subsets of variables.
2/ Firms with low (high) value of an indicator are colored in blue (red).

Figure 28. Mexico: Shapley Value Related to Firm Size and Leverage[1,2/]



Sources: Capital IQ; Moody's KMV; and IMF staff calculations.

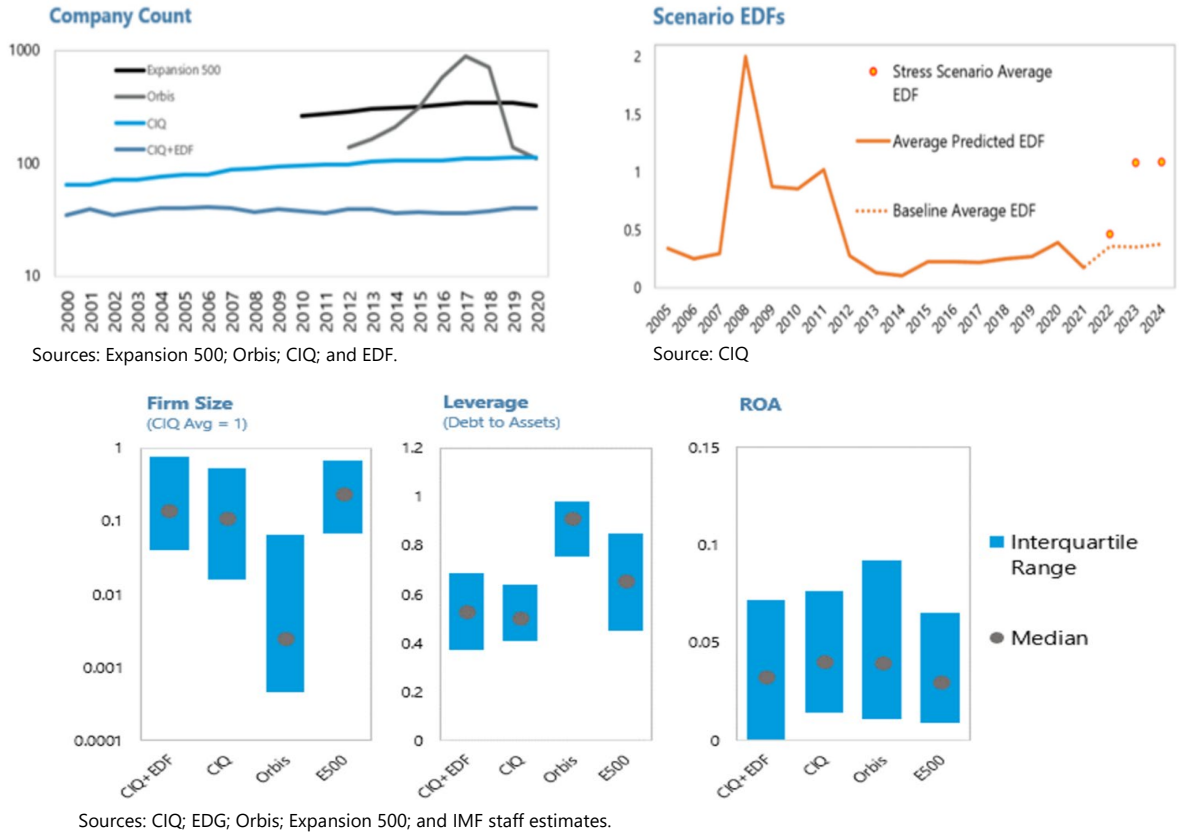
1/ The Shapley value is the average marginal contributions of an observation for that variable to the overall risk assessment. Marginal contributions are averaged over all possible subsets of variables.

2/ Firms with low (high) value of an indicator are colored in blue (red).

128. Alternative datasets offer the opportunity to explore corporate risks across a wider range of firms (Figure 29). The Orbis dataset in particular captured a very large number of firms in the middle of the last decade, reaching nearly 1,000 in 2017, and offers a snapshot of corporate health from that time. Firms in the datasets outside the estimation sample tend to be smaller, more highly levered, and more profitable. This is particularly true for the Orbis dataset. The Expansion 500 firms have been selected for size but do show higher leverage. Adding the unmatched CIQ dataset firms also presents a smaller and more profitable group of firms but with slightly lower leverage.

129. Average corporate risk in the non-estimation sample is higher, and better aligned with bank PDs. The estimated debt-weighted average of corporate EDFs in the estimation sample fell from 5 percent in the early 2000s to below 0.3 percent in the post-GFC era. This contrasts with bank-based corporate PDs which have varied between 2 and 5 percent post-GFC. Applying the random forest estimation to the larger datasets reveals a similar picture to bank-based corporate PDs, where EDFs have varied between 2 and 4 percent in the last decade without a substantial decline from the very early 2010s.

Figure 29. Mexico and LA5: Information of Cross-Validation Groups

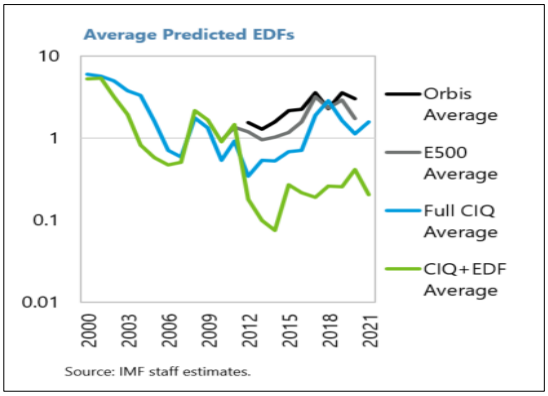


Sources: Expansion 500; Orbis; CIQ; and EDF.

Source: CIQ

Sources: CIQ; EDG; Orbis; Expansion 500; and IMF staff estimates.

130. Model-implied EDFs under a stress scenario approach GFC levels. Applying the model estimation[32] to simulated data consistent with the solvency stress scenario implied large rises in risk (Text Chart). Risks rose even in the baseline due to rising interest rates and normalizing post-pandemic growth. Risks in the stress scenario rose well above these levels, roughly tripling their baseline levels in 2023 and 2024. This rise is worse than the increase estimated in the stress scenario of slightly less than double for these years. While these results should be treated as illustrative, they provide suggestive evidence of meaningful underlying risk in the corporate sector and recommend additional caution about the potential effects of a stress scenario with greater financial tightening.



Source: IMF staff estimates.

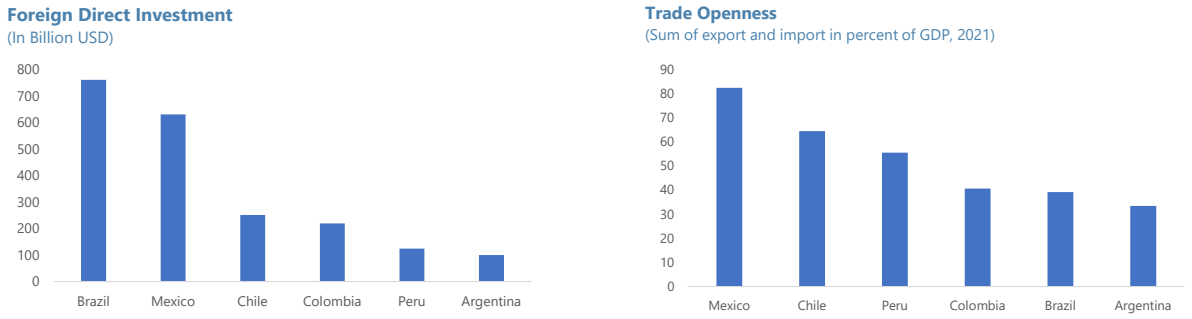
[32] As discussed above, for scenario simulation the version of the model estimated on the full LA5 database was used due to its superior performance in cross validation across dissimilar time periods and macroeconomic conditions.

SYSTEM-WIDE LIQUIDITY ANALYSIS

A. Overview

131. Mexico's integration in global financial and trade networks may expose it to substantial system-wide liquidity risks. Mexico is one of the Latin American countries most open to trade and foreign direct investments (FDIs), with total flow of export and import ranking top at 83 percent of GDP and stock of FDIs recorded at around 600 billion US dollar as of 2021, only next to Brazil. The United States is its largest trading partner and source of FDI, accounting for nearly 80 percent of its exports and 50 percent of FDIs (Figure 30). The Mexican peso is the third most actively traded currency in the Americas (after the United States dollar and Canadian dollar), and the most actively traded currency in Latin America. The deep integration into the global trade and financial network offers ample opportunities for growth and diversification but may also bring downside risks to system-wide liquidity when episodes of large and rapid liquidity outflows materialize, triggered by changes in the global financial conditions, or due to shifts in investors' risk appetite and other relevant domestic and external risk factors.

Figure 30. Mexico: Trade and Financial Openness



Sources: Banxico and IMF staff estimate.

132. Domestically, the Mexican financial sector is composed of several market agents that are also closely interconnected, although the individual exposures are low as illustrated in the previous sections, these are exposed to a common set of domestic and external liquidity risks. As shown in Figure 31, several important market agents contribute to the system-wide liquidity network[33], with each acting either as a funding provider or receiver via direct lending and other forms of short-term and long-term financing instruments, such as the issuance of debt securities or secured and unsecured interbank transactions. In addition to direct exposures, they are also subject to indirect exposures through holdings of common assets, mostly in the form of sovereign and corporate debt securities and thus are exposed to potential market repricing risks associated with fluctuations in both risk-free rates and sovereign and corporate spreads, including the tilting and

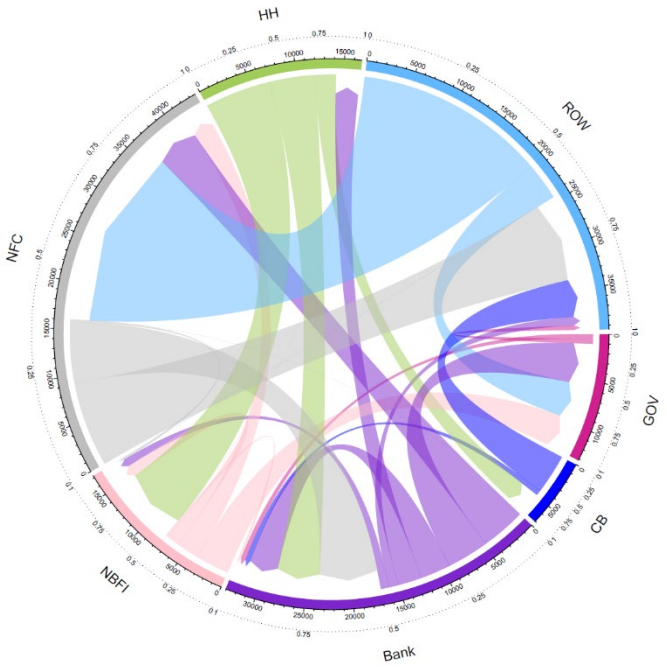
[33] The system-wide liquidity network is defined as the interlinkages of liquidity via balance sheet exposures among market agents in the financial system.

parallel shifts along the yield curve of both types of securities. Finally, the offshore market also plays an important role in the currency trading while providing liquidity to the domestic financial system, mostly through the buying and holding of domestic sovereign bonds and corporate stocks.

Figure 31. Mexico: Cross-Sectoral Interlinkage

(In billions of Mexican pesos, 2021, asset claims)

Mexico's financial intermediaries are exposed to common assets (i.e., sovereign debt securities) and counterparty risk via direct lending and repo operations, and NFCs are exposed to off-shore refinancing risks

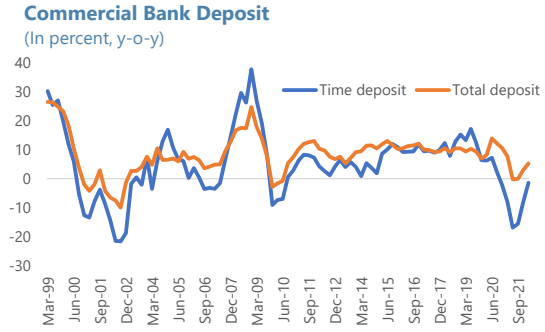


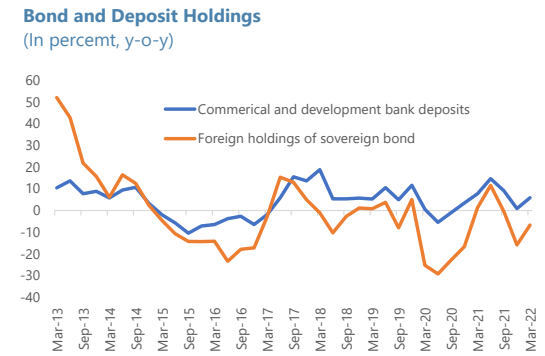
- HH=household,
- NFC=non-financial corporation,
- NBFI=nonbank financial institution,
- CB=central bank,
- Bank=commercial and development banks
- GOV=general government.
- ROW = rest of world

Sources: IMF Balance Sheet Approach Matrix; and IMF staff.
Note: The direction of an arrow shows exposures from a fund provider to a receiver. Nonbank financial institution contains development banks.

133. Historical evidence also suggests that liquidity shocks can be strongly correlated under stress. This may introduce material downside risks that are further compounded by concurrent liquidity strains of various market agents in the financial system. For example, sales of Mexican sovereign securities by foreign investors, when taking place in a large scale, may lead to rising sovereign yields and rapid adjustment of market prices, which in turn may diminish the value of existing liquid assets held by market agents to fend off large liquidity outflows. Such liquidity strains can be exacerbated when they materialize in parallel with deposit outflows and triggering of credit lines by both corporates and households, potentially leading to liquidity shortfall of individual agents spilling over to the entire financial system. The correlation between different channels of liquidity shocks can be more pronounced under stress, as evidenced by the March 2020 episode, when there were strong co-movements among reduction on sovereign securities by international investors, commercial bank deposit outflows, and liquidation by foreign investors of Mexican corporate stocks (Figure 32). Such synchronized episodes may be potentially contributing to the buildup of tail risks of liquidity shortage for the entire system.

Figure 32. Mexico: Deposit, Bond, and Stock Holdings



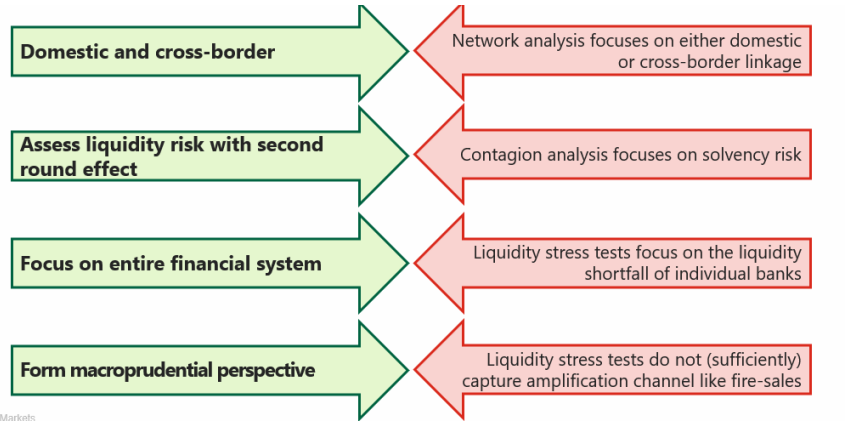


Sources: Banxico, CEIC database and IMF staff estimate.

134. Against this backdrop, the FSAP developed a novel analytical approach to assess resilience and identify vulnerabilities associated with system-wide liquidity. The system-wide liquidity analysis differs in several ways from traditional liquidity and interconnectedness analyses (Figure 33). First, it brings together the liquidity and interconnectedness approaches by not only looking at a single market agent (e.g., commercial banks), but also the interaction between agents within the entire system, to trace the flow of funding from one agent to another, thereby assessing liquidity resilience and weaknesses in an integrated and holistic way. Second, it combines both domestic and cross-border networks by allowing simultaneous realization of domestic and external shocks (e.g., domestic deposits' outflows and foreign investors' selling of sovereign bonds) to jointly determine the counterbalancing capacity of the system and prevent any potential underestimation of liquidity shocks under a partial analysis where only domestic linkage is considered. Furthermore, the analysis complements traditional contagion analysis – which focuses solely on solvency risks - by targeting the liquidity layer of the network, while also taking into account any second-round effects induced by behavioral responses such as liquidation of assets. Finally, the analysis brings to the fore the macroprudential perspective by looking at economy-wide liquidity risks, rather than risks associated to individual institutions or a single sector, while enabling multiple sensitivity and counterfactual analyses, such as imposing or relaxing regulatory binding constrains on liquidity, to inform ongoing policy decisions.

135. The objective of the system-wide liquidity analysis is manifold. First, it is essential to understand the extent of the interconnectedness among agents and have a system-wide view of liquidity conditions because the resilience of an individual sector or institution cannot itself assure the stability of the entire system, since they may be transferring liquidity risks to other sectors or segments in the system. Second, an assessment of the contribution of each agent to system-wide liquidity stress can help improve the understanding of the transmission channels of liquidity shocks, as well as any amplification mechanism associated with the willingness and capacity of each agent to intermediate in the market. Third, the analysis aims to assess resilience against various adverse narratives pertinent to the Mexican financial system. Finally, the framework can also be used as a diagnostic tool to inform policy discussions, with measurable and quantifiable data, aiming at ensuring sufficient liquidity buffers in the system. Although the analysis was at this stage tailored to address Mexico's specific risks and vulnerabilities, it can serve as a proof of concept and can easily be extended or generalized to other economies with different macroeconomic and financial structure features that contribute to their unique liquidity profiles.

Figure 33. Mexico: System-wide Liquidity—A Comparison of Methodology



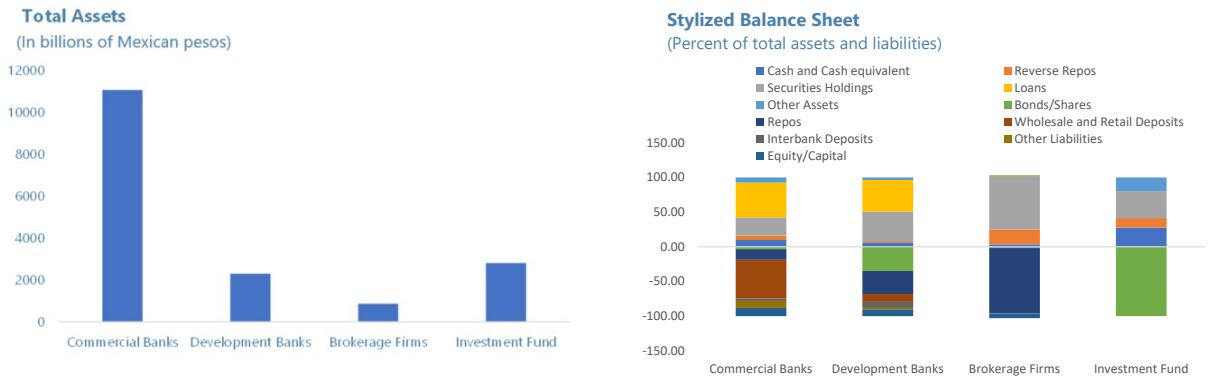
Source: IMF staff.

B. An Overview of the Agents Contributing to System-Wide Liquidity

136. Stylized balance sheets data across agents highlight features of their business models and interlinkages. Commercial and development banks have a similar business model, as both conduct maturity transformation by leveraging short-term funding to finance the longer-term holdings of sovereign securities and loan portfolios. However, their funding profiles appear to be quite different. Commercial banks rely mostly on retail and wholesale deposits, whereas development banks obtain wholesale funding from investment funds and nonfinancial corporations via short term repo transactions and short-term bond issuance, with minimal exposure to direct deposits from the public. Investment funds finance themselves almost exclusively via issued fund shares and invest mostly in sovereign securities while providing financing to other financial agents in the form of reverse repos and hold large amount of cash and other assets (such as equity investments) on their balance sheet. As a result, they are considered more liquid than both commercial and development banks. Finally, brokerage firms, which typically act as a market maker

or agent in securities trading and offer investment advice, have much simpler balance sheets, by obtaining short term repo-financing while investing in securities and participating in reverse repo transactions, and therefore were excluded in the analysis, also given their relatively small size (Figure 34).

Figure 34. Mexico: Sectoral Balance Sheet



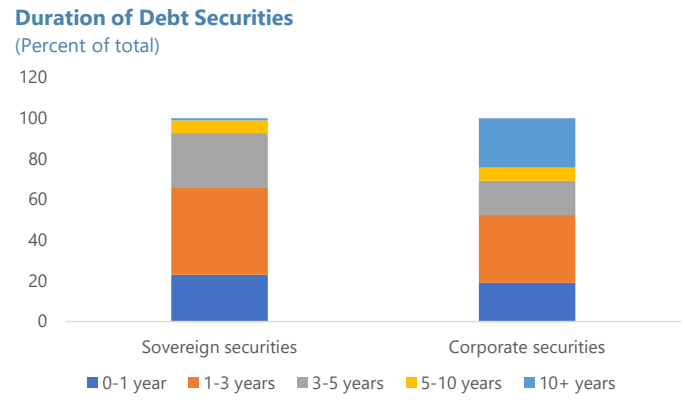
Sources: Banxico; and IMF staff estimate.
Note: Balance sheet for investment fund is approximated using total assets, agent specific bilateral exposures by instrument and information on securities holding composition.

137. Bilateral exposures between agents are important and are concentrated in certain sectors and instruments. For example, commercial banks hold most claims against corporates, households, and the government in the form of loans and sovereign securities. They accept wholesale and retail deposits mainly from corporates and households and have little financial obligations to other agents in the economy. In contrast, the development banks obtain wholesale funding mostly from investment fund and corporates via repos or issuance of securities, both of which are short-term, thus introducing higher funding risks. Counterparties also vary as development banks often seek funding from commercial banks and other nonbank agents (e.g., investment funds and corporates) and use this funding to extend loans to SMEs or invest in sovereign securities.

138. Large holdings of sovereign securities may expose multiple agents to sudden increases in sovereign yields and associated market revaluation risks. While development banks and investment funds hold a higher share of sovereign securities than commercial banks, all agents are exposed to sovereign securities, making them susceptible to rising sovereign risk premium, decline in market value of unencumbered collaterals, and triggering of margin calls on encumbered collaterals. The levels of encumbrance are elevated for sovereign securities, which may considerably limit their capacity to utilize available liquid assets to counteract large and rapid liquidity outflows under stress. The sensitivity of market repricing to rising sovereign yield is moderate, as the duration of the bulk of sovereign securities is between one to five years, with only a small share having maturity beyond ten years (Figure 35). Corporate securities, although having a notable share at maturity beyond 10 years, are not expected to prompt system-wide market losses and liquidity stress due to the significant lower amount of market holdings.

139. Contingent credit lines could be a source of vulnerability for system-wide liquidity. At around 3 trillion pesos including both revocable and irrevocable credit and liquidity lines,[34], the off-balance sheet exposure extended by commercial banks to corporates and other private sectors can be an important source of liquidity risk in the system, especially when the sudden outflows associated with the triggering of credit lines are displaced outside of the system due to heightened risk aversion or tightened global liquidity and/or financial conditions.

Figure 35. Mexico: Duration of Debt Securities



Source: Banxico and IMF staff estimate.

C. Methodology

Scope and Data

140. The analysis covers a comprehensive set of financial agents in the system. The system-wide scope of the analysis ensures the inclusion of all major market agents, including the central bank and the government, commercial banks, development banks, investment funds, non-financial corporations, households, as well as foreign investors who provide external funding and liquidity to the domestic financial system. The financial agents collectively represent about 64 percent of the total financial sector assets[35] and are closely connected with each other through direct lending and deposits, short-term repos and reverse repos, securities financing, and other types of short and long-term debt issuance.

141. The value of system wide liquidity analysis rises with the use of a wide range of financial data with sufficient granularity to support a comprehensive assessment. The data was compiled by Banxico as of December 2021 at the highest consolidation level and at an aggregate balance-sheet level (by agent type) and is collected in a data template designed by IMF staff. It includes agent-specific balance sheet composition and bilateral exposures between agents informed by who-to-whom holdings which, on the asset side includes holdings of loans, debt securities, and reverse repo, and on the liability side includes deposits, issuance of debt securities and shares, as well as any form of repo financing. Additionally, for the purpose of estimating market revaluation effects on trading securities due to a systemic liquidity shock, data on existing collateral, both encumbered and unencumbered, and split into central bank eligible and non-eligible, was collected by type of issuer and remaining maturities (Figure 36). Margin positions covered with debt securities under derivative transactions were also provided to capture second-round effects on margin calls

[34] As of May 2022, revocable credit lines were 2.5 trillion pesos, irrevocable credit lines were 0.25 trillion pesos and liquidity lines were 0.15 trillion pesos.

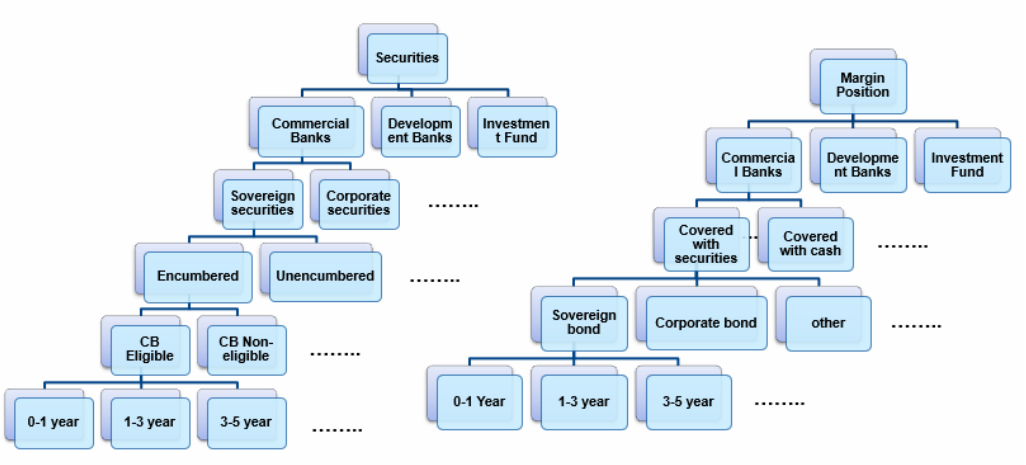
[35] Due to data limitation, the analysis does not include pension funds and insurance companies, which account for the majority of the remaining assets of the system.

associated with volatility in market price of the underlying collateral. Lastly, haircut information in repo transactions were collected by maturity buckets and split into central bank operations and transactions taking place in the secondary market.

Workflow and Key Features of the Analysis

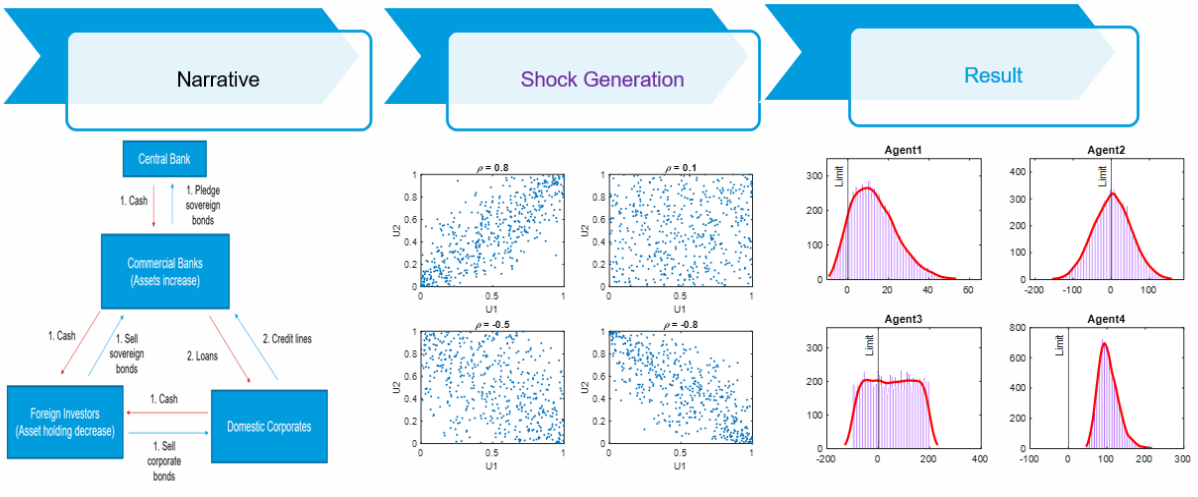
142. The system-wide liquidity analysis was performed according to three distinct steps: narrative design, shock generation and Monte Carlo simulation (Figure 38). The first step formulates four narratives (specifically designed for Mexico), each simulating a unique liquidity stress event facing the Mexican financial system. The second step generates a series of liquidity shocks impacting market agents' balance sheets according to each pre-defined narrative; a large number of scenario shocks is defined, each one containing a value for each of the corresponding layers of the narrative. The initial balance sheet impact due to the liquidity shocks is expected to propagate through the entire system via the bilateral exposures between agents. The third step carries out the Monte Carlo simulation using the generated shocks and quantifies the net liquidity position for each market agent after each simulation to capture both the direct impact from the funding and market stress, as well as any second-round revaluation effects (calls on encumbered collateral for existing funding or margin positions).

Figure 36. Mexico: Data Input for Debt Securities and Margin Position



Source: IMF staff.

Figure 37. Mexico: Workflow of System-Wide Liquidity Analysis



Source: IMF staff.

143. A novel concept of the analysis is to use correlated distributions for the generation of shocks. As a result, each shock is drawn from a distribution specified by a copula, a multivariate distribution function with pre-defined correlation factors between shocks, as well as the shape and boundary of each marginal distribution characterizing the shock. The correlation factor can be flexibly adjusted to tailor country-specific realizations of historical liquidity stresses, or to better capture the desired level of correlation between each pair of liquidity shocks. For example, wholesale deposit outflows can be correlated more closely with the triggering of credit lines of corporates and less pronouncedly with foreign investors' exiting from domestic sovereign securities, even though both relationships can be stronger under a systemic liquidity stress. A separate sensitivity analysis can also be beneficial when there are no sufficiently long time series or pre-existing stress episodes to estimate such correlations.

144. Finally, the framework can also be used to inform liquidity relevant policy decisions. For example, if the access of investment funds to the repo market increases, it could enhance their liquidity positions and also positively contribute to the resiliency of the system. This is because they can play an important role in relieving supply pressures in the sovereign bond market while fully utilizing access to the repo markets, without withdrawing residual liquidity from the financial system. Moreover, the framework can impose or relax regulatory binding constraint (e.g., simulate various LCR constraints), simulate corresponding behavioral responses, and be used to quantify and assess system-wide impacts of such policy actions. Finally, any liquidity surplus or shortfalls identified in the analysis can facilitate future design of supportive policy measures under stress, such as the calibration of central bank's emergency lending assistance (ELA) or increase in the perimeter of eligible collateral or eligible counterparts.

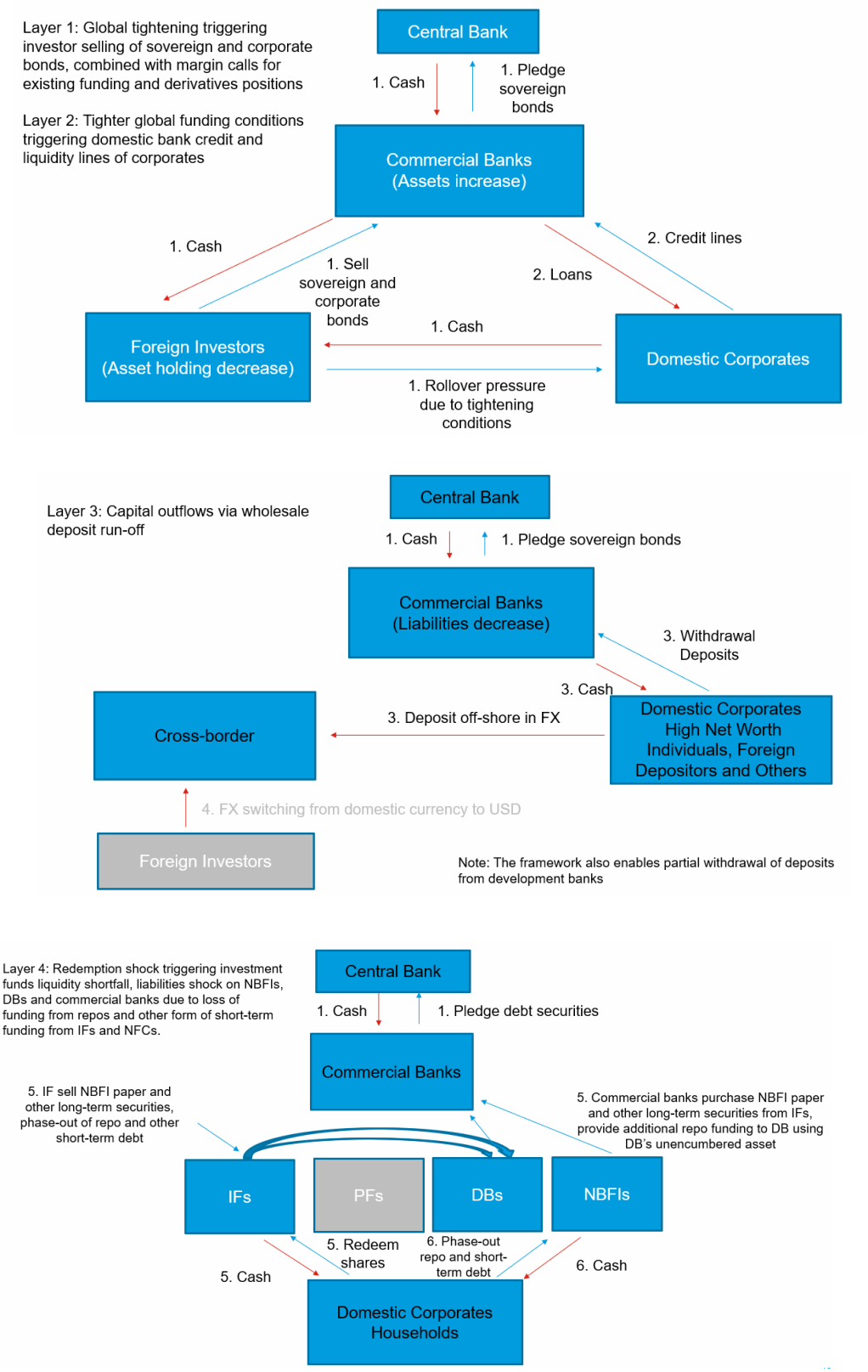
Narrative Design

145. There are four layers of narratives featured in the analysis, each reflective of a storyline tailored to specific liquidity risks facing the Mexican financial system:

- **Layer 1: Global tightening triggering investor selling off sovereign and corporate bonds; margin calls for existing funding and derivatives positions are triggered.** As a large open economy, Mexico can be vulnerable to sudden capital outflows from the country's sovereign debt market. This can materialize for various reasons, such as tighter US monetary policies, a deteriorating fiscal position, or a subdued risk appetite of foreign investors due to a negative growth outlook or other geopolitical reasons. The March 2020 event is a timely reminder that system-wide stability can indeed be threatened by a sudden freeze of funding following a loss of market confidence or increased uncertainty. The high share of foreign holdings of domestic sovereign securities and corporate shares, currently at around 20 and 33 percent, can form an important external transmission channel to domestic system-wide liquidity stress. A strong selling pressure is often accompanied with a decline in the market value of tradable sovereign securities which comprise most of the liquidity buffers of the market agents in the system.
- **Layer 2: Tighter global funding conditions triggering credit and liquidity lines of corporates.** This layer aims to capture liquidity risks associated with large contingent credit lines commercial banks extend to domestic corporates. At around 3 trillion pesos, these credit lines may be triggered at a high rate during episodes of global liquidity stress, as firms that are used to receive external funding look for funding alternatives when facing funding constraints abroad associated with tighter global financial conditions. While credit lines were not drawn en masse during the pandemic shock, the global environment is now much less supportive.
- **Layer 3: Capital outflows via wholesale deposit run-off.** In addition to the risk-off events triggered by foreign investors in layer 1, wholesale deposit run-offs can be another major source of capital outflows whereby firms move their deposits from on-shore to off-shore market on fears of deteriorating domestic financial and economic conditions and weakened currency due to persisting inflationary pressure, further U.S. monetary policy tightening or new waves of COVID-19 pandemic or the need to refinance operations abroad.
- **Layer 4: Redemption shocks triggering investment funds liquidity strains.** Such redemptions would trickle down to funding pressure on development banks, commercial banks and other nonbank financial institutions due to loss of repo financing or refinancing options for other maturing short-term funding from investment funds. The impact, however, can be mitigated by the collateralized nature of the transactions, provided that funds' counterparties find other institutions, able and willing to engage in similar transactions.

Figure 38 presents the four layers of narratives with a visualization of flow of funding between agents to delineate the transmission of shocks throughout the system.

Figure 38. Mexico: Narrative Design of System-Wide liquidity Analysis



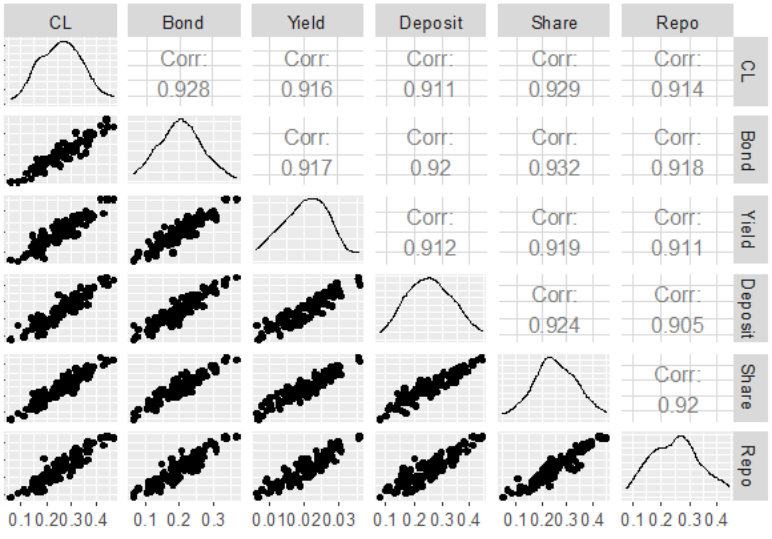
Source: IMF staff.

Shock Specification

146. Shocks were calibrated for variables which were specified as triggering points within each layer of the narratives. For instance, the deposit outflow rate was specified as an exogenous shock because it is considered the source of liquidity stress under layer 3. Similarly, sovereign bond yield shocks induced by foreign selloffs of securities, credit line triggering and share redemption were calibrated for layer 1, 2, and 4, respectively. Adopting the concept of copula, a pre-defined beta distribution with a symmetric bell-curve shape (close to a normal distribution) and an upper and lower bound were assigned to each of the shock with a correlation factor of 0.9 to simulate high correlation under stress.[36] Figure 39 provides further details on variable selection and parameter calibration under the analysis.

Figure 39. Mexico: Shock Calibration of System-Wide liquidity Analysis

Variable	Range (In percent)
Credit line triggering rate	[0,40]
Bond selling rate	[0,40] based on historical maximum selloff
Sovereign bond yield shock	[0,4] with average shock at 200 bps
Corporate bond yield shock	[0,8] with average shock at 400 bps
Wholesale deposit run-off rate	[0,50]
Retail deposit run-off rate	[0,20]
Share redemption	[0,40]
Short term debt phase-out rate	[0,40]



Source: IMF staff.
Note: All units in the bottom figure are in fraction (not percent).

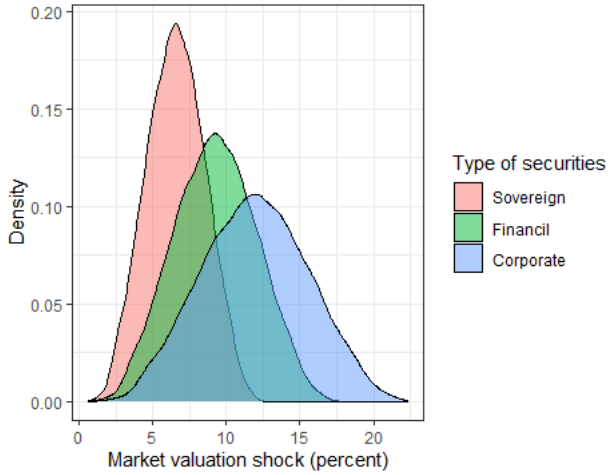
[36] Unlike a normal distribution, the beta distribution allows the imposition of upper and lower bounds which is helpful as it ensures precision in the calibration of the severity of the shocks.

147. Shocks to market value of sovereign securities follow a modified duration approach. The initial calibration of yield shocks for sovereign and corporates simulates a series of parallel shifts of both yield curves along the maturity buckets, while assuming a higher upper bound shift for corporate securities given their inherently higher risk premium. Shocks to yields on bank bonds were assumed to be higher than sovereign and lower than corporate securities under each simulation (Figure 40). As the next step, granular information on holdings of corporate and sovereign securities by market agents, status of encumbrance, eligibility for central bank operations and by maturity buckets were used as input, in conjunction with the calibrated yield shocks, to derive market valuation impacts using the modified duration approach according to the following formula:

$$\Delta P_i = \frac{D_i}{(1 + r_i + s_i)} * \Delta B_i * M_i$$

where P represents bond valuation, D represents the duration of debt securities which is selected at the midpoint within each maturity bucket for a given type of instrument, B represents bond yield, M represents the outstanding amount, r represents the risk-free rate and s represents bond spread assumed in the shock calibration.

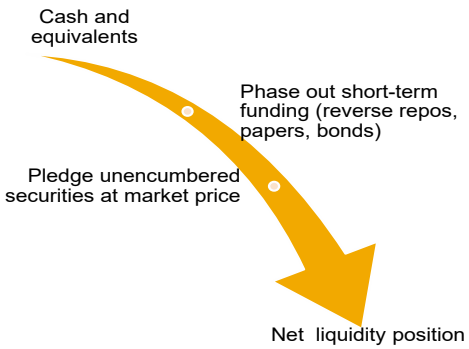
Figure 40. Mexico: Market Valuation Shock on Debt Securities



Sources: Banxico; and IMF staff estimate.

148. Such market impacts can manifest themselves on the balance sheet of each agent via two main channels: a reduced market value (or higher market discount) on unencumbered collateral and margin calls on encumbered collateral underlying both funding and derivative margin transactions. Both channels can reduce the liquidity buffers of a single agent which, if the y both occur simultaneously on a broad scale, may increase the tail risks of a system-wide liquidity stress.

Figure 41. Mexico: Pecking Order of Market Clearing



Source: IMF staff.

Market Clearing

149. The analysis follows a specific pecking order of market clearing that mimic the behavioral response of each agent under stress (Figure 41). A preference for highly liquid assets over less liquid assets is assumed for all agents. This means agents are expected to use cash and cash equivalents as the first line of defense to absorb a liquidity outflow, and only if this is not sufficient, phase out (or not rollover) any outstanding reverse repo transactions or short-term bond investments. In other words, the starting assumption is that the utilization of counterbalancing capacity is very accommodative, and agents start to withdraw liquidity from other agents after they exhaust their own buffers. Finally, depending on remaining liquidity gaps after utilizing cash positions, a repo transaction might be needed to pledge any unencumbered collateral for additional liquidity support. In this case, commercial banks and the central bank are the main counterparties for such repo transactions to backstop the entire system.

150. The sovereign securities that are sold off by foreign investors under layer 1 of the narrative are assumed to be absorbed in a pro-rata fashion by all market agents. The amount of absorption by each agent is allocated based on their existing holdings of sovereign securities, as long as they still have sufficient liquidity to purchase these securities from the market after the initial liquidity shock on their balance sheet. As such purchase is completely voluntary, development banks and investment funds may halt their purchase as soon as their cash and any cash equivalents are fully depleted, while leaving the remaining to commercial banks as they can more flexibly trade with the central bank via repo arrangements (in this case a CB repo is treated as a back-to-back transaction even if they do not have sufficient cash at hand).

151. The phase-out of a reverse repo contract is considered liquidity neutral as it entails both an outflow and inflow of liquidity for a counterparty. When a reverse repo contract matures or is revoked by an agent, cash is withdrawn from the counterparty's balance sheet while the underlying collateral, mostly in the form of debt securities, is returned to the counterpart of the transaction. This automatically converts existing encumbered assets back to unencumbered assets, first by reversing the original haircut applied to the repo transaction and then applying the discounted market price specified by the shock, thus increasing the liquid buffer for the counterparty. Due to limited information on the composition of the encumbrance of a repo contract, the released amount of the encumbered collateral upon the termination of a repo is allocated into unencumbered collateral in a pro-rata fashion, based on the relative share of the starting point encumbered corporate and sovereign securities for each agent.

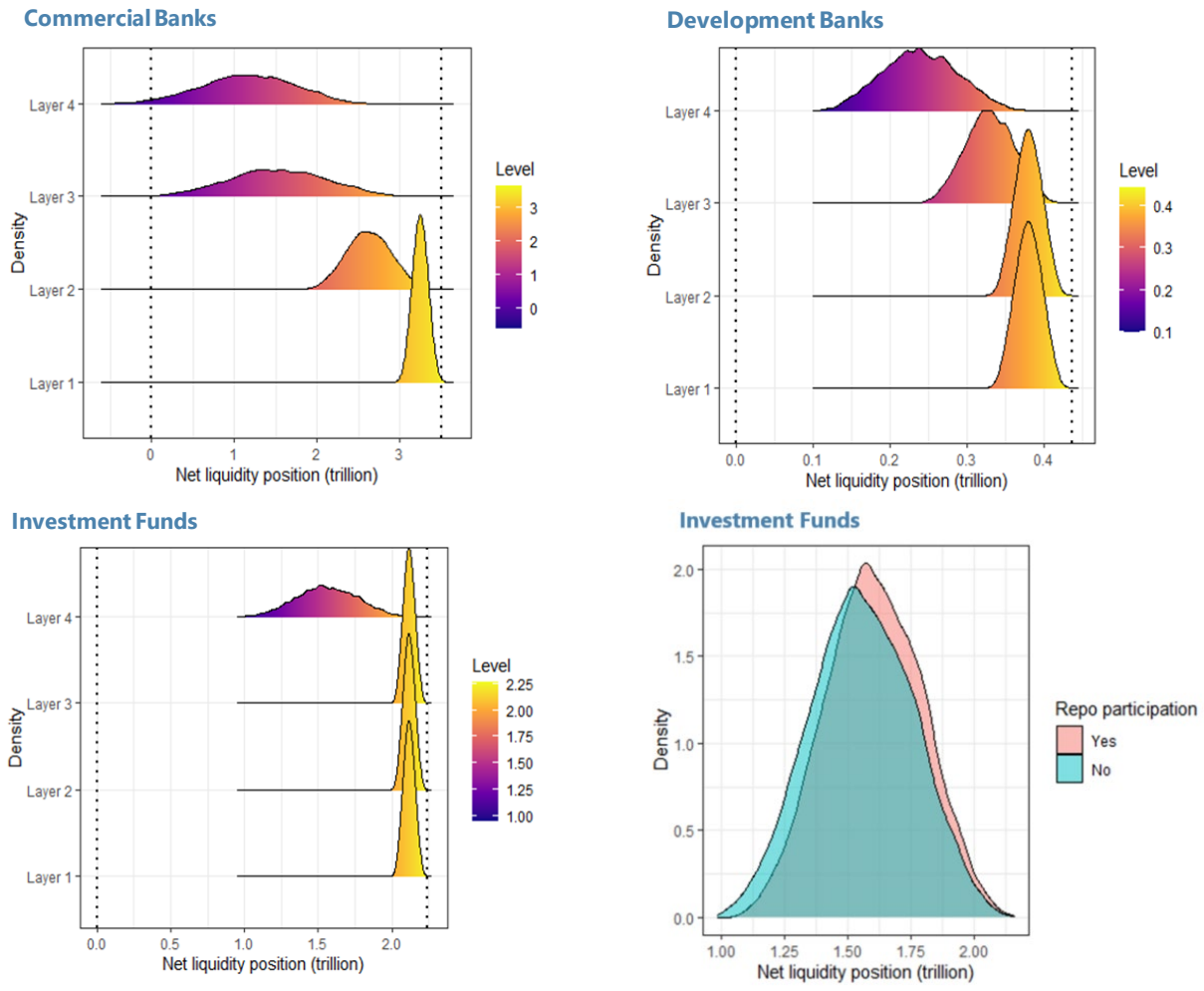
D. Results

152. The analysis suggests that the financial system remains resilient against the four narratives with commercial banks backstopping liquidity needs of all agents in the system (Figure 42). Under the most severe test with combined shocks and assuming no binding regulatory constraints for all agents, commercial banks show only marginal liquidity shortfalls (a thin negative tail in their liquidity distribution) mainly driven by the triggering of contingent credit lines and

wholesale deposits' outflows, while acting as a shock absorber by providing liquidity to other agents through repo transactions.

153. Development banks and investment funds can withstand significant liquidity outflows, although risks could arise depending on commercial bank behavior. However, with binding liquidity constraints for commercial banks (e.g., a mandatory LCR or equivalently, behavioral assumptions on minimum liquidity buffers that banks might prefer to hold) or minimum liquidity buffers for investment funds, liquidity positions of agents could deteriorate, and larger liquidity shortfalls could materialize, including for development banks. Finally, the results confirm that the access of investment funds to the repo market could enhance their liquidity position and positively contribute to the resiliency of the entire system (bottom right panel of Figure 42).

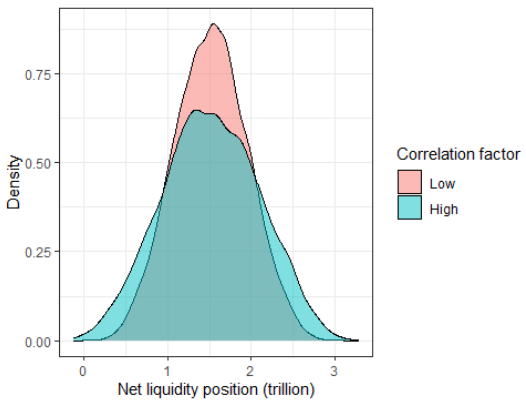
Figure 42. Mexico: Results of the System-Wide Liquidity Analysis



Source: Banxico and IMF staff estimate.

154. A higher correlation of liquidity shocks under stress intensifies the downside risks for system-wide liquidity. An ex-post comparison between different levels of correlation factors gives a flatter distribution of net liquidity position for commercial banks under a high correlation factor, supporting the hypothesis that a stronger co-movement of liquidity outflows can amplify liquidity stress in the system, evidenced by a fatter tail to the left of the distribution pointing to worsening liquidity condition post shock (Figure 43).

Figure 43. Mexico: A Comparison of Correlation Factor



Sources: Banxico; and IMF staff estimate.

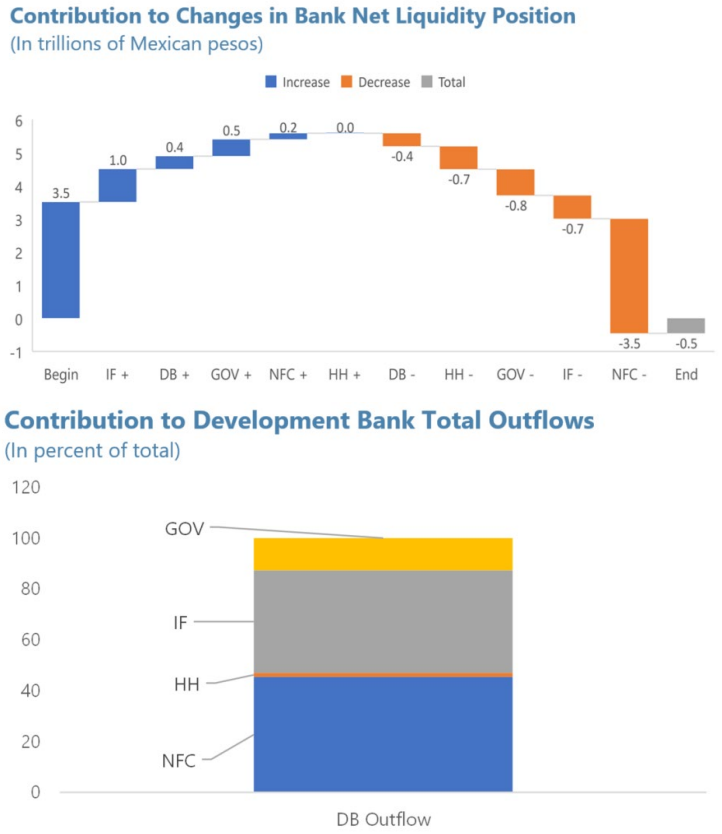
155. A deeper dive into the contribution to the changes in the net liquidity position of commercial banks reveals larger transmission of shocks from corporates and investment funds (Figure 44, top panel). Liquidity outflows from corporates contributes the most to the decline of net liquidity position of commercial banks, given their high exposure to wholesale deposits and contingent credit and liquidity lines. This is only marginally offset by a small reduction of margin calls and an increase in unencumbered assets due to the phase-out of the short-term repo financing provided by corporates to commercial banks.

156. Investment funds, although ranked second in terms of contribution to the liquidity outflows, bring roughly an equal amount of inflows to commercial banks. Most of their transactions with the commercial banks take the form of either repo transactions (e.g., investment funds provide material repo financing to the rest of the system) or a direct sale of debt securities (e.g., fire-sales) which are liquidity neutral. As a result, any transactions under stress between the two would be an exchange of liquidity, as both cash and debt securities are considered as liquid assets, instead of withdrawing liquidity from the commercial banks.

157. Similarly, development banks place little deposits into or obtain credit lines from commercial banks and therefore do not play a significant role in draining liquidity out from the system via capital flight. However, they appear to have an illiquid asset profile as several of their assets are lending to the private sector and the rest are holdings of sovereign securities with a high share already encumbered for short term funding.

158. The Government, although not directly interacting with other agents in the framework, could indirectly influence the dynamics of the system-wide liquidity via price impact and transaction of sovereign securities. Decline in the value of sovereign securities would reduce liquid asset holdings of commercial banks (akin to a liquidity outflow), while the purchase of sovereign securities by commercial banks is considered liquidity neutral as such transaction only entails an exchange of cash with another form of liquid assets. Hence the net impact from both channels on the liquidity of commercial banks is negative. Finally, the contribution from households is minimal as they only place retail deposits into commercial banks which are mostly considered as stable deposits.

Figure 44. Mexico: Contribution to System-Wide Liquidity Stress



Sources: Banxico; and IMF staff estimate.

159. Similarly, development banks are vulnerable to outflows from corporates and investment funds (Figure 44, bottom panel)**.** Another approach by breaking down the total liquidity outflows from development banks reveals a high contribution from corporates and investment funds, at 45 and 40 percent, respectively. This can be explained by the high share of short-term financing, such as repo and short-term bond investment, extended by both the corporate sector and investment funds to development banks, at 35 and 27 percent out of total short-term financing as of end-2021.

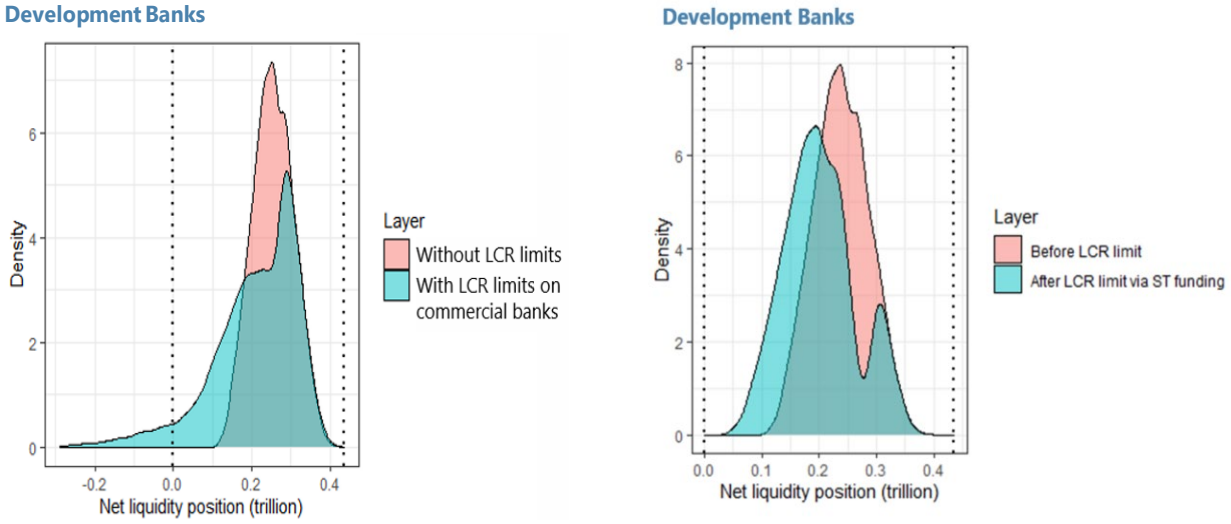
E. Sensitivity Analysis and Policy Experiment

160. Were commercial banks liquidity preference to change in a downside scenario, development banks could face stress. This could also arise from the implementation of liquidity binding constraints on commercial banks. These factors may compel development banks to resort to the central bank for liquidity support, which merits closer monitoring under stress. An ex-post sensitivity analysis was conducted by freezing repo activities of the commercial banks as soon as they reach a 100-percent LCR limit (Figure 45 left panel). This can create knock-on effects to development banks given that a subset of the simulations requires development banks to pledge additional collateral to commercial banks for liquidity via a repo transaction. As a result, a part of the

distribution of the development banks is pushed to the left into the negative territory, suggesting liquidity strains induced by the behavioral response of the commercial banks.

161. A similar pattern can be observed if commercial banks are assumed to pullback on short-term funding instead of freezing repo activities under the regulatory constrain (Figure 45 right panel). This can take the form of deposit withdrawal or of not willing to offer refinancing for the rollover of the short-term debt issued by development banks. This behavioral response is consistent with the initial shock calibration shown in Figure 42, also pushes the distribution of the net liquidity position of the development banks to the left, even though it is not as severe as in the first experiment. This assumption is deemed to be closer to the likely response of the commercial banks under stress, as pulling back short-term funding increase liquidity buffers of the banks while the freeze of repo operations are considered liquidity neutral.

Figure 45. Mexico: Policy Experiment of the System-Wide Liquidity Analysis



Sources: Banxico; and IMF staff estimate.

162. Overall, the results confirm commercial banks' role in ensuring the liquidity of the financial system by backstopping liquidity needs of all other agents, while signaling potential vulnerabilities in development banks when facing market behavioral constraints under stress. Commercial banks act as a final shock absorber by providing liquidity to other agents through repo transactions. Their liquidity shortfalls are only marginal even under the most severe narratives. Development banks, on the other hand, appear more vulnerable due to their funding concentration. This vulnerability becomes more pronounced when binding liquidity constraints (e.g., mandatory LCRs for commercial banks or minimum liquidity buffers for investment funds) are considered. Under a scenario of binding constraints or banks' behavioral reactions to heightened end-state uncertainty, larger liquidity shortfalls could materialize in the system for some agents. This can be attributed to the fact that agents with liquidity surplus might be less willing or able to roll-over existing funding transactions, and, therefore, they would amplify stress on development banks' liability side. In a similar vein, a simple policy assessment experiment also suggests that expanding access of investment funds to the repo market could further strengthen system-wide resiliency.

Appendix I. FSAP Risk Assessment Matrix

Sources of risks	Relative likelihood	Impact and transmission channels
Commodity price shocks due to the Russia's war in Ukraine and geopolitical tensions Commodity prices are volatile and trend up amid supply constraints and the Russia's war in Ukraine, keeping inflationary pressure upward.	**High**	**Medium** • Pressure on inflation and inflation expectations due to rising energy and food prices. • Deterioration of current account, exchange rate pressure and purchase power. • Prompting Banxico to tighten policies faster than anticipated, causing an increase in funding costs.
De-anchoring of inflation expectations and stagflation and abrupt global slowdown or recession Worsening supply-demand imbalances, higher commodity prices and higher nominal wage growth lead to persistently higher inflation and/or inflation expectations, prompting central banks to tighten policies faster than anticipated, resulting in a hard landing globally, housing market correction, and a stronger U.S. dollar.	**Medium**	**High** • Rising the U.S. interest rates pressuring sovereign and corporate funding costs. • A reassessment of market fundamentals causing a widespread risk-off event in the global financial markets, capital outflows from Mexico, currency depreciation, and liquidity stress. • Financing difficulties to the sovereign, resulting in higher sovereign credit spreads and material mark-to-market revaluation and associated losses. • Higher funding cost leading to sharp deterioration of financial condition of corporate borrowers and associated credit quality. • A wave of bankruptcies and devaluation of debt securities eroding bank capital buffers. • Transmission of the hard landing to Mexico through reduced external demand and remittances.
Local COVID-19 outbreaks of lethal and highly contagious variants Rapidly increasing hospitalizations and deaths due to low vaccine protection or vaccine-resistant variants force more social distancing and/or new lockdowns.	**Medium**	**Medium** • Renewed costly containment efforts, including broad-based lockdowns resulting in economic contraction, financial market turmoil, high unemployment, and corporate distress. • A reassessment of growth prospects, triggering capital outflows, financial tightening, notable currency depreciations. • Extended supply chain disruptions and inflationary pressures.
Increasing frequency and severity of climate events Natural disasters can lead to severe physical damages and losses to the economy in terms of capital stock destructions, productivity losses, business interruption, and affect the financial sector.	**Medium**	**Medium** • Economic damages from frequent and severe climate events, e.g., tropical cyclones/hurricanes, floods. • Deterioration of financial conditions of households and corporates leading to large credit losses in the financial sector, amplified by productivity losses and collateral devaluations. • The global and domestic decarbonization efforts to mitigate the impact of climate change, leading to side-effects, i.e., transition risks to the financial sector depending on the global/domestic policy ambitions and degree of exposures to the carbon intensive firms and industries.
Cyberthreats	**Medium**	**Medium** • Cyber-attacks on critical infrastructure and interconnected financial systems that trigger systemic financial instability or widely disrupt socio-economic activities and remote work arrangements.

Source: IMF staff.

Appendix II. Stress Testing Matrix

Domain		Top-down Stress Test by FSAP Team—Assumptions
Banking Sector: Solvency Risk		
1. Institutional Perimeter	Institutions included	• All D-SIBs (6 banks) and other important banks (4 additional mid-tier commercial banks for top-down (TD) ST at the highest level of consolidation.
	Market share	• For the 10 commercial banks within scope, approximately 84 percent of banking sector assets.
	Data Source and Baseline Date	• Banxico's regulatory returns and supervisory data. • Historical data on bank parameters based on Banxico's statistical data warehouse. • Balance sheet and financial statement data available in the public domain. • Moody's Analytics: CreditEdge data on corporate default probabilities. • Data as of December 2021 (cut-off). End-2019 data might also be used for comparisons and sensitivity analysis purposes. • Scope of financial consolidation: group-wide at the domestic level.
2. Channels of Risk Propagation	Methodology	• Balance sheet approach. • Projections of key balance sheet, income statement and capital account items. • Static balance sheet assumption. • Credit risk, market risk, net interest income and non-interest income projections are produced for all banks within scope for two scenarios: baseline and macro adverse. • Granular projections of credit risk parameters are performed, including probabilities of default (PDs) losses given default (LGDs) for each asset class. • Five different loan segments are used: corporates, mortgages, financials, government, and consumer credit. Segmentation is based on current prudential rules and availability of historical data for the estimation of satellite models. PD PIT satellites are based on historical data series of PDs for the system and by individual bank. LGD PiTs were produced for each loan segment by applying the Frye-Jakobs method. • Net interest income is projected based on its sensitivity to macrofinancial conditions for both reference rates and effective spread margins across all interest rate sensitive asset and liability segments. Liability reference and margin rate shocks are linked to the macroeconomic scenario and econometric models are used to estimate pass-through rates for both asset and liability sides together with scenario anchored assumptions. • The impact on P&L and OCI due to FVTPL and FVOCI positions is also estimated as part of the market risk impact. Market risk is based on the estimation of FV and OCI impact on the securities portfolios. The impact of the scenario on mutual fund, equity and FX exposures will also be measured. • Net fee and commission income are stressed based on its historical volatility in combination with haircuts based on a conservative methodology reflecting the conditions prevailing the scenario narrative.

Domain		Top-down Stress Test by FSAP Team—Assumptions
		• Operational expenses over total assets are kept at the same level as in 2021 (cut-off). • RWAs are adjusted to reflect changes in the quality of credit exposures.
	Satellite models for macro-financial linkages	• Several satellite model estimation alternatives are explored: o PD PIT models for each segment based on country aggregate historical PD time series and scenario translation of bank-specific starting points in the distance to default space. Bayesian Model Averaging (BMA) techniques are used to control for model uncertainty, o Panel PD PIT econometric estimation models on bank-specific historical PD PIT time series using BMA techniques to control for model uncertainty, o Moody's EDF data series may also be explored for the calibration of econometric satellites for the corporate segments. • Cross-sector country proxies could also be used for the projection of parameters where a direct calibration is not feasible due to data constraints (e.g., governments and financials may be proxied using corporate PD paths).
	Stress test horizon	• Three years (2022 Q1 – 2024 Q4).
3. Tail Shocks	Scenario analysis	• Based on two macroeconomic and financial scenarios (baseline and macro adverse). • The scenarios specify key macrofinancial variables (e.g., real GDP growth, inflation rate, unemployment rates, exchange rates, equity prices, house prices, interest rates and credit growth) for Mexico, as well as global variables (e.g., oil and other commodity prices). • The baseline scenario is based on April 2022 World Economic Outlook (WEO) projections. • The macro adverse scenario is calibrated using the Global Macrofinancial Model (GFM) model and it assumes the materialization of the systemic risks highlighted in the RAM. The adverse scenario features a protracted global COVID-19 pandemic and supply-side disruptions that lead to higher inflation. The scenario assumes that supply-side disruptions and higher commodity prices continue to weigh on the global economy, which brings out a difficult trade-off between output and inflation for policymakers. Inflation in major economies including the U.S. surprises on the upside, and the Fed tightens monetary policy faster than expected, by about one percentage point within the first year. Higher U.S. interest rates and tighter financial conditions globally trigger capital outflows, depreciations, and higher long-term interest rates in emerging markets. The domestic layer introduces additional confidence shocks that applies downward pressure on domestic demand with subdued consumption and investment aggravating the sharp correction on both real estate and equity prices. These losses, most of which are absorbed by the banking system, subsequently curtail banks' profitability, and prompt a broad-based tightening in the interbank market, echoing market concerns towards banks' financial soundness. Finally, monetary policy is assumed to maintain its accommodative stance under the domestic layer and short-term interest rates are assumed to decrease towards the 4 percent effective lower bound.

Domain		Top-down Stress Test by FSAP Team—Assumptions
		• In terms of severity, the adverse scenario features a deviation of Mexico real GDP from its baseline of 11.3 percent by 2023, with a 2.3 Standard Deviation move in two-year cumulative real GDP growth rate, a 6.3 percent increase in unemployment rate from its baseline.
	Sensitivity analysis	• The impact of triggering credit lines to NFCs and financial entities will be covered by targeted sensitivity analysis. • A more pronounced interest rate shift will also be captured by the solvency sensitivity analysis. • A partial credit and market risk analysis exercise on Development banks and the twenty largest credit-providing NBFIs are attempted to increase the coverage of the solvency analysis. The FSAP adverse macroeconomic scenario is used to produce top-down estimates for PDs and LGDs for these entities using CNBV's TD models and infrastructure. Market risk impact will also be simulated using data and models developed internally at CNBV.
4. Risks and Buffers	Risks/factors assessed	• Credit risk captures all on-balance/off-balance sheet exposures at amortized cost by regulatory exposure sector. Exposures are largely domestic; therefore, no scenarios and parameter paths would be required for geographies outside Mexico. • Market risk is reflected in valuation effects of FVTPL and FVOCI positions, as well as net open financial positions (i.e., equities, funds, and inflation-linked instruments exposures). Scenario-based Interest rate curves are used to infer reference interest rate changes. The adverse macro scenario is further augmented to include financial variables that are needed to produce accurate projections for fair value positions (like corporate spread rate shock or bank issued bonds spread shock). • Net interest income is affected by projecting effective interest rates by asset/liability class. Policy rates and wholesale/interbank rates will directly follow the macroeconomic scenario paths and a panel econometric approach will be used to define the velocity of passthrough rates to all remaining asset and liability segments. • Shocks to non-interest income are simulated to capture varying degrees of market-sensitive components of non-interest income. • Projected RWA densities are also capturing a twofold impact: deterioration of credit quality and partial/full unwinding of relevant policy support measures.
	Behavioral adjustments	• Under the static balance sheet assumption exposures remain constant and do not evolve in accordance with credit growth assumptions of scenarios. • For NII, maturing assets/liabilities are assumed to be replaced by instruments of the same type, maturity but at current rates. • There is no recognized interest on non-performing exposures. • If banks' capital falls below regulatory requirements, no prompt corrective action is assumed. • Banks are assumed to pay 30 percent of their profits as tax. Dividend payout ratio is assumed to be the maximum of 40 percent or the payout ratio of the cut-off year unless the capital conservation buffer falls below 2.5 percent.
5. Regulatory and Market Based Standards and Parameters	Calibration of risk parameters	• Currently the banking system is regulated under a full Basel III prudential framework. • Accounting provisions are set by CNBV regulations (IFRS 9 was only implemented in January 2022 and CNBV has the mandate to set

Domain		Top-down Stress Test by FSAP Team—Assumptions
		requirements for the accounting loan loss provisioning). In this context the stress test analysis will follow regulatory definitions of PDs and LGDs where applicable. • Currently credit exposure portfolios are under the Standardized (STA) and the Advanced Internal Rating Based (A-IRB) regulatory approach. • Risk-weighted asset densities are either assumed to remain constant for STA portfolios and following the PD PIT path (making use of a smoothening factor for the TTC effect).
	Regulatory/ accounting and market-based standards	• In the baseline, hurdle rates include the regulatory minimum (CET1: 4.5 percent, Tier1: 6 percent, Total Capital: 8 percent) and any applicable capital buffers (CCB, D-SIB surcharge, P2R). D-SIB charge ranges from 0.6 percent to 1.5 percent for the banks within scope. • In the adverse scenario, the regulatory minimum (including D-SIB surcharge and P2R) is assumed to be the hurdle rate, as banks can draw down the CCB. Note that D-SIB surcharge is not considered as a buffer in Mexico. • Hurdle rates are based on the CET1, Tier1, and Total Capital ratios.
6. Reporting Format for Results	Output presentation	• System-wide evolution of aggregate CET1 and capital ratios. • Distribution of banks' capital positions • Contribution to key drivers to system-wide net income and capital position, including differences between the baseline scenario and the adverse scenario. • Share of institutions with capital below the hurdle rates.
Banking Sector: Liquidity Risk		
1. Institutional Perimeter	Institutions included	• The fifty commercial banks in Mexico at the highest level of consolidation.
	Market share	• 100 percent of commercial banking sector assets.
	Data and baseline date	• Banxico's regulatory reports monitoring the Liquidity Coverage Ratio and the Net Stable Funding Ratio and the additional (synthetically constructed) monitoring report capturing liquidity contractual maturity ladder. • Data as of December 2021; December 2019 data will also be used to highlight the impacts of the pandemic on liquidity positions of banks. • Scope of financial consolidation: group-wide at the highest level.
2. Channels of Risk Propagation	Methodology	• The exercise is based on three types of tests—LCR test, cash-flow analysis and NSFR revision. • The LCR test is in line with the standard Banxico (and Basel compliant) monitoring tool, featuring total consolidated liquidity and liquidity in significant currencies (mainly USD). • A set of scenarios for LCR outflows and HQLA haircuts is used to produce stressed LCR ratios (by currency and at the consolidated level). • For the LCR test, the stress test horizon is 30 days. • The cash-flow analysis analyzes the net cash balance (as a proxy of banks' resiliency to liquidity stress events), accounting for available unencumbered assets, contractual cash inflows and outflows, and behavioral flows.

Domain		Top-down Stress Test by FSAP Team—Assumptions
		• For the cash-flow analysis, a range of scenarios featuring funding run-off rates, liquid assets haircuts and assumptions on inflows and outflows of increased severity for different durations of liquidity stress are explored (a stress-horizon of 3 months is used as the central assumption). Positive counterbalancing capacity post-scenario implies bank resiliency, negative is an indication of liquidity stress. • For the cash-flow analysis, asset haircuts reflect two components: (i) shocks to interest rates and asset prices as captured the macrofinancial scenarios; and (ii) additional haircuts required by counterparties to accept specific assets as collateral for secured funding transactions. • The NSFR became a binding requirement for Mexican banks in March 2022. For monitoring purposes, banks have been reporting NSFR calculations to competent authorities since 2017.
3. Risks and Buffers	Risks	• Funding liquidity risk is reflected in funding run-off rates and asset roll-over rates, the latter providing cash inflows related to non-renewal of maturing assets. • Market liquidity risk is reflected in asset haircuts, which could be influenced by market movements, potential fire sales and collateral supply considerations.
	Behavioral adjustments	• Liquidity from the central bank's emergency lending assistance (ELA) is not considered. • Inflows from maturing loans are ignored (cash-flow analysis, after a certain level of scenario severity) capturing a systemic liquidity stress scenario vs a bank-idiosyncratic one. • The cash-flow analysis may consider some behavioral assumptions about a counterparty's ability or willingness to transact based on banks' solvency and liquidity conditions.
4. Tail shocks	Scenario analysis	• For the LCR test, 12 scenarios are considered as a combination of: (i) three scenarios on liquid assets shocks (regulatory, mild, and severe), and ii) four scenarios on liability outflows; regulatory, one reflecting retail outflows, one reflecting higher wholesale outflows, and one combining the retail and wholesale outflows. • For the cash-flow analysis, a series of scenarios are considered, with a range from mild to severely adverse liquidity conditions. The cash-flow analysis considers both funding and market liquidity risks.
5. Regulatory and Market-Based Standards and Parameters	Calibration of risk parameters	• LCR tests are based on regulatory and stress parameters. • Cash-flow analysis may incorporate relevant second-round effects. • Stress funding run-off rates, asset roll-over rates, and asset haircuts are calibrated based on empirical evidence and relevant international experiences.
	Regulatory/accounting and market-based standards	• LCR per Basel III; the hurdle at 100 percent. • Net cash balance for the cash-flow analysis; to pass, a non-negative net cash balance is required, where the balance reflects net funding outflows and counterbalancing capacity. • NSFR per Basel III; the hurdle at 100 percent.
6. Reporting Format for Results	Output presentation	• Changes in the system-wide liquidity position, including important drivers for cash outflows, cash inflows and counterbalancing capacity. • Distribution of banks' liquidity positions.

Domain		Top-down Stress Test by FSAP Team—Assumptions
		• Number of institutions with LCR/NSFR below 100 percent and/or negative net cash balance. • Amount of liquidity shortfalls, including by currencies.
7. Sensitivity Analysis	Output presentation	• The analysis would cover policy support measures and will identify how such measures have impacted regulatory liquidity metrics. • As a natural result, the analysis will also assess how the gradual measure unwinding will have affect liquidity positions of banks.
8. Infrastructure	Infrastructure used	• For the LCR test, Banxico's infrastructure to run the scenario developed by IMF staff and Banxico's Liquidity at Risk tests. For cash flow analysis, fully comprehensive infrastructure developed by IMF staff using newly introduced (March 2022) Banxico's regulatory reports as a data repository. MATLAB and Excel based.
Financial System: Contagion Risk		
1. Institutional Perimeter	Institutions included	• All commercial and development banks, brokerage houses, investment and pension funds and the largest credit providing NBFIs (subject to data availability) in Mexico, at the highest level of consolidation
	Market share	• Almost the entire system in terms of asset coverage
	Data and baseline date	• Source: Supervisory data and ad-hoc data request • Data as of December 2021 (random day cut-off, to avoid window dressing effects) • BIS consolidated banking statistics, data as of end-Sept 2021
2. Channels of Risk Propagation	Methodology	• Interbank and cross-border network model by Espinosa-Vega and Solé (2010)
3. Risks and Buffers	Risks	• Credit and funding losses related to interbank/inter-entity cross-exposures (and cross-border banking exposures)
	Buffers	• Banks' and brokerage houses' own capital buffers, other entities are not assumed to default in the simulation (internal loss absorption)
4. Tail shocks	Size of the shock	• Pure contagion: default of individual institutions • Several types of cross-entity exposures considered: secured, unsecured, crossholdings of debt instruments, settlement exposures. Different LGDs might be used, depending on exposure type. • Simulation of multiple concurrent defaults may also be examined.
5. Reporting Format for Results	Output presentation	• Contagion and vulnerability indicators • System-wide capital shortfall • Bank-level capital shortfall • Number of undercapitalized and/or failed institutions, and their shares of assets in the system • Evolution and direction of spillovers.
Financial System: System-Wide Liquidity (SWL) Analysis		
1. Institutional Perimeter	Entities included	• Most economic agent type present in the financial system: ○ Central Bank ○ Government ○ Commercial Banks ○ State-owned banks ○ Investment Funds

Domain		Top-down Stress Test by FSAP Team—Assumptions
		○ NFCs ○ Households ○ Foreign investors
	Data and baseline date	• Ad-hoc data request template provided by the FSAP team to Banxico, capturing: ○ Available collateral (encumbered and unencumbered) by asset class, remaining maturity bucket and eligibility for CB operations ○ Existing collateralized funding and margin positions for all agents ○ Composition of the most important segments of B/S assets and liabilities by agent type, as well as bilateral exposure between agents informed by who-to-whom holdings. • Data as of December 2021, at the aggregate B/S level and on a best effort basis. • Scope of financial consolidation: group-wide at the highest level
2. Channels of Risk Propagation	Methodology	• The analysis is conducted at the aggregated B/S data for each type of economic agent. • For each scenario, the liquidity counterbalancing capacity for each type of economic agent is measured, in response to direct shocks (funding and market) and after considering second round effects due to calls on available collateral for existing funding and margin positions. • Shocks are generated based on correlated distributions (copula) with flexibility of adjusting ranges of the distributions and correlation factors between distributions to reflect different level of severity. • Cash and unencumbered collateral are considered as accessible liquidity buffers. • Pecking order of the utilization of liquid assets: 1. Cash and equivalences 2. Short term assets including short term paper and outstanding reverse repos 3. Repos using unencumbered assets • Willingness and capacity to roll-over existing funding positions across agents are assessed after measuring liquidity excess or shortfalls. • The resilience of the system (and of individual agents) is assessed based on the net liquidity distribution across the number of simulated scenarios (shortfall probability density). • Agents will be classified in accordance with their liquidity shortfall propensity and with respect to their contribution to the overall system-wide resiliency or vulnerability. • Existing counterbalancing capacity of unencumbered collateral is measured against severe tail events as the point in the distribution that would force Banxico to increase the perimeter of eligible collateral.
3. Risks and Buffers	Risks	• Funding liquidity risk is reflected in funding run-off rates, capital outflows, share redemption and offshore switching. • Market liquidity risk is reflected in asset haircuts, influenced by market movements, potential fire sales and collateral supply considerations.
	Buffers	• Available unencumbered collateral (CB eligible and non-eligible), cash position and capacity to absorb pressure in all market segments considered (sovereign, repo, and derivatives markets, etc.)

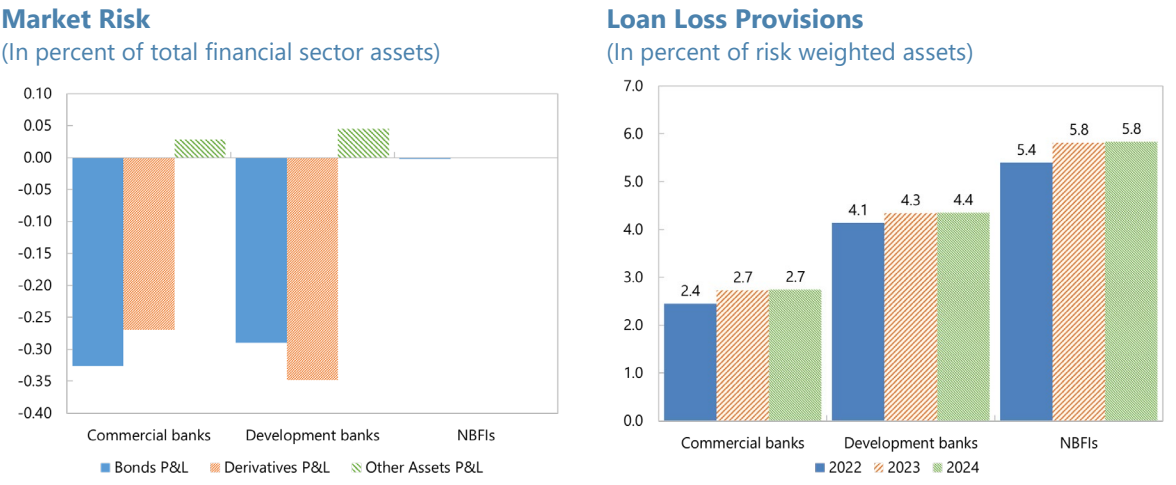
Domain		Top-down Stress Test by FSAP Team—Assumptions
4. Behavioral Assumptions	Behavioral adjustments	• Liquidity from the central bank's emergency lending assistance (ELA) or any other increase in the perimeter of eligible collateral or eligible counterparts is not considered. • Pecking order in the way agents with excess (insufficient) liquidity decide to (not) roll-over funding positions may be important. • Binding liquidity requirements (LCR constraints) can be switched on/off.
5. Tail shocks	Scenario analysis	• The analysis narrative would entail the simulation of a material number of scenarios consisting of a series of random (but correlated) layers of shocks: o Sovereign market repricing shocks due to capital outflows and risk premia reassessment o Drawdown of existing credit and liquidity facilities by NFCs due to global tightening funding conditions o Run-offs on wholesale and retail deposits and switch to offshore accounts due to rebalancing of funding requirements o Investment Fund redemption shocks and associated short-term funding stress (e.g., via the repo market) o FX depreciation and shocks attributed to the shortage of sufficient FX reserves (*implemented but muted*) o Shocks attributed to dislocated derivatives markets and margin requirements and derivative basis shocks (*implemented but muted*)
6. Sensitivity analysis	Shock severity and policy experiment	• Single factor sensitivity analysis by increasing of correlation factor between shock parameters • Mute repo or pull back other short-term funding (deposits or short-term paper) from commercial banks to other agents as commercial banks reach liquidity regulatory threshold (e.g., LCR) • Allow expanded access of investment fund to repo market to assess benefit of repo participation
7. Regulatory and Market-Based Standards and Parameters	Regulatory Standards	• LCR and other liquidity constraints are not used for the identification of bank pass/failure since the analysis is performed at the aggregate level (not entity specific).
8. Reporting Format for Results	Output presentation	• Probability distribution of excess/shortfall for the system and by agent type • Impact attribution by agent type in the overall resiliency or vulnerability • Shortfall thresholds for different agents • Contribution of each layer of shocks to the overall liquidity shortfalls
9. Infrastructure		• Fully comprehensive and novel infrastructure developed by IMF staff using the ad-hoc data request as a data repository. MATLAB based.

Appendix III. Credit and Market Risks in Development Banks and Nonbank Financial Institutions

1. CNBV has conducted a stress-test analysis of credit and market risks for all commercial banks, development banks and the largest NBFIs using the FSAP adverse scenario. While the FSAP team has independently conducted a fully-fledged top-down solvency stress test for the top-10 commercial banks (see Section IV. B), collaboration with CNBV has allowed the team to partially expand the analysis by assessing the impact on credit and market risk for commercial banks, the six development banks and the twenty largest NBFIs[1] within CNBV's regulatory perimeter. This is important because, even if the largest banks dominate the Mexican financial landscape and the development banks and largest NBFIs represent only 17 percent and 1.4 percent of total assets respectively, they are highly interconnected and could transmit shocks to the rest of the system (see Section IV).

2. The results show that the impact of market and credit risks is limited (Figure 47). Market risk is contained and driven mainly by the revaluation of bonds and the impact on P&L from derivatives' exposures for both commercial and development banks (NBFIs do not have material market risk exposures in their portfolio). Reflecting the different credit quality of the loan portfolios, expected losses (loan loss provisions) as a share of risk weighted assets under the adverse scenario are higher for NBFIs and development banks compared to commercial banks, and increasing in the scenario horizon. A direct comparison with the results of the FSAP team's exercise for the overlapping banks is not feasible, given the major differences in the methodology used, particularly regarding satellite model estimation, granularity of data sources and modeling differences.

Figure 1. Mexico: Market and Credit Risks for Commercial Banks, Development banks and Large NBFIs



Sources: CNBV; and IMF staff calculation.

[1] The term NBFI is hereby used to denote the segment of smaller non-deposit taking credit provisioning entities and does not include insurance companies or pension and investment funds.

Appendix IV. The Estimation of Satellite Models

Credit Risk

1. A series of panel econometric models were estimated to produce scenario dependent forward paths for Point-in-Time (PiT) default probabilities (PD) for different exposure segments. The selection of the modelling approach was largely driven by the quality and availability of bank level historical data for calibration purposes. Obtaining reliable and informative bank specific default rates is a challenging task because any approach that would back out default rates from impairment flows might suffer from the presence of significant outliers because of spike of individual exposure impairments or random write-off decisions might introduce distortionary impact on the inferred historical PD rates. The lack of cyclicality or volatilities for corporate and mortgage portfolios over time may compound the complexity and challenges in the estimation and projections of bank specific probability of default.

2. The analysis used bank specific PD data obtained from country authorities and covers three economic segments that are considered most relevant for credit risk assessment. Quarterly PD time series starting 2007 were obtained for corporate, household retail and household mortgage segments for each bank considered in the stress test. PDs for corporate segment are relatively lower than other segments and are akin to those of the large corporates given the dominance of large corporate borrowers in banks' credit portfolios. A cutoff date of 2021Q4 was used to capture the entire time series to maximize sample coverage, while taking into account the fact that most of the policy measures, including debt moratoria, have been phased out by the end of 2021 and that banks' credit portfolios have seen some notable deterioration in credit quality since the outset of the pandemic.

3. A model averaging technique was employed for modelling and projecting default rates at the individual bank and portfolio levels. The approach adopts panel fixed effect regression and operates on a pool of equations per dependent variable, to which weights are assigned that reflect their relative predictive performance, and then results in a "posterior model" equation.[1] The pool of equations contains a large number of equations for each credit risk indicator per portfolio segment, by considering all possible combinations of predictors from a pool of potential predictor variables, including variables such as real GDP growth, unemployment rates, housing prices, short- and long-term interest rates and others.

4. Various techniques were used to capture PD dynamics. To ensure that the models only produce PD predictions between 0 and 1 (or, equivalently, between 0 and 100 percent) and to capture nonlinearities in the relationship between the dependent and explanatory variables, the

$$Y_{it} = ln\left(\frac{PD_{it}}{1 - PD_{it}}\right)$$

following logit transformation was applied to the original PD:

[1] For more details see Kamil Barton (2020) https://cran.r-project.org/web/packages/MuMIn/MuMIn.pdf.

To estimate the impact of shocks of macro-financial variables on PDs, the logit-transformed PDs were modeled as a linear function of the aforementioned exogenous macroeconomic and financial factors (regressors). The model specification also allows inclusion of lags or rolling sums of the explanatory variables, to account for backward looking nature of credit risks. The conditional PD PiT forecast for each segment and each bank were then generated based on estimated coefficients and fixed effects under both the baseline and adverse scenarios.

5. A wide set of explanatory variables were used for the estimation of credit risk satellite models. For segments included in the analysis, similar set of input variables, which were sourced from IMF World Economic Outlook (WEO), Datastream and Haver Analytics, were used to explain and project PiT PDs. They include real GDP growth, unemployment rate, short-term and long-term interest rate, term spread, as well as housing price, which are deemed to be important in driving the credit quality of Mexican borrowers. Input other than interest rates and unemployment rates are subject to annual growth transformation, while interest rates and unemployment rates were taken as original level in percent. The sample period used for calibration ranges between 2007 and 2021 and a quarterly frequency was used in accordance with standard method.

6. The model selection follows several criteria. A unique benefit of the model averaging technique is for the users to select different model specifications, such as number of explanatory variables under permutation and number of lags for each explanatory variable. Main information criteria used to determine the best specification for each model are R-square, adjusted R-square, AIC, the quality of in-sample forecast, and ultimately, the size of the impact in the forecasting period. The ideal candidate would have a relatively high R-square, a small root-mean-square-error and a historically consistent size of impact under stress.

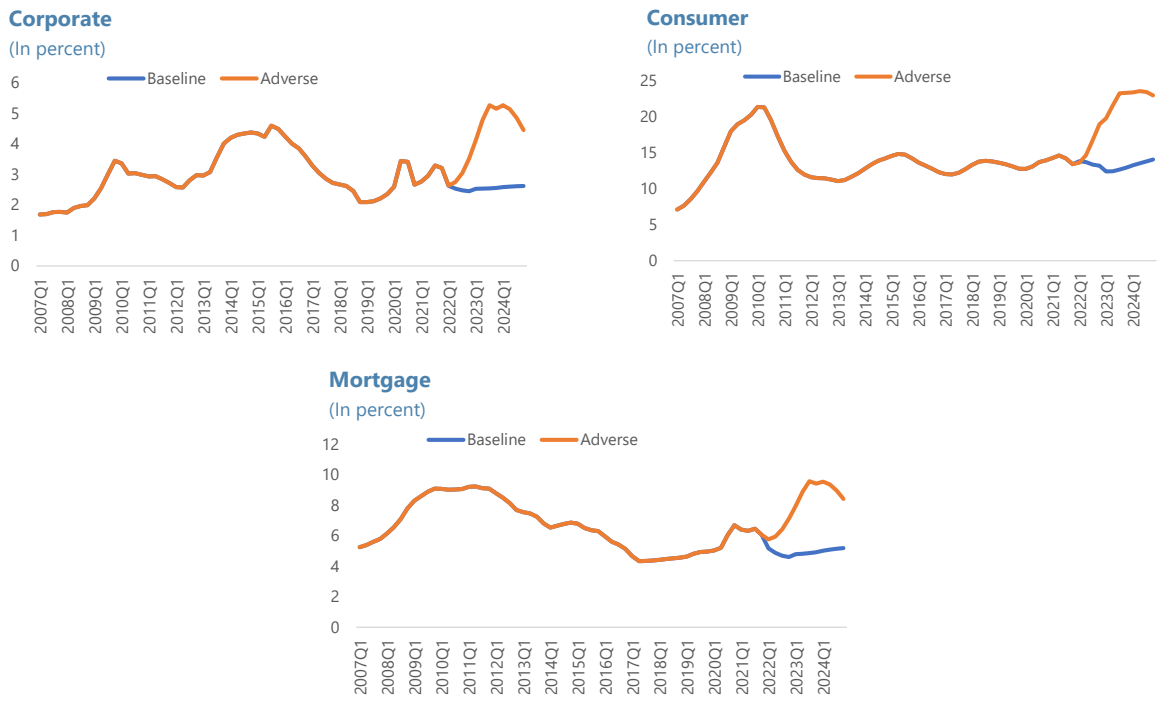
Table 1. Mexico: Estimation of Probability of Default (PiT)

(Dependent variables: probability of defaults in logit form)

	(1) Corporate Loans	(2) Consumer Loans	(3) Mortgage Loans
GDP growth, percent, yoy	-0.002	-0.007*	0
Unemployment rate, percent	0.179*	0.124*	0.337*
Short term interest rate, percent	0	0.096*	0
Long term sovereign bond yield, percent	0	0	0.035*
Term spread, percent	0	0.17*	0.020
House price growth, percent, yoy	0	0	-0.002
Intercept	-3.941*	-3.12*	-4.448*
Number of observations	585	600	600
R square	0.35	0.33	0.62
Fixed effect	Yes	Yes	Yes

Source: Banxico, IMF World Economic Outlook, Haver, Datastream, and IMF staff calculations.
Note: * denote p value less than 0.1.

Figure 1. Mexico: Projections of Probability of Default (piT)



Source: IMF staff estimation.

7. Unemployment rate plays a significant role in the determination of underlying credit risks across all portfolios. (Table 12) This is reflected in the high P values and sizable coefficient estimates for PDs in all segments considered. Intuitively, the output growth exhibits a negative relationship with PDs while the rise in unemployment and short-term interest rates appear to drive PDs up due to lower affordability and higher borrowing costs. Finally, the term spread, measured as the difference between long-term and short-term rates, appears to have a significant positive impact on consumer loans, and housing price growth is negatively correlated with mortgage PDs, as expected.

8. As a result, the scenario dependent PD projections reveal larger shocks for household retail portfolios and are broadly in line with historical stress episodes. (Figure 48) This is reflected in the forward-looking PD paths for all segments, in which the size of impact for Mexico is broadly in line with the stress experienced during the GFC. Nonetheless, the results display salient idiosyncrasies among segments, with the relatively higher PDs under stress assigned to the household retail segment due to its lack of collateralization, followed by mortgage and corporate segments.

Interest Rate Risk

9. Interest rates on both assets and liabilities were approximated by the effective rates for each bank. Due to data limitation on interest rates for newly acquired business of the banks, granular data were provided instead by the authorities on total outstanding amount of various asset and liability items as well as periodic interest income and expense flows associated with each item, on a quarterly basis from 2008Q1 to 2021Q4. As the next step, effective lending and funding rates were computed for both front and back book and then used as input for the satellite models. Similar to the credit risk modeling, the macroeconomic data, which were included as independent variables, were sourced from the IMF World Economic Outlook (WEO) database, Datastream and Haver Analytics. The macroeconomic series for the adverse scenario followed the scenario set for this stress test.

10. Bank effective interest rates were used as the input for interest risk assessment on the banking book. Using the same model selection and averaging techniques as the credit risk modeling, the satellite models estimate aggregate funding and lending rates on individual bank and portfolio level, which include interest rates on corporate, household retail, mortgage loans and securities holdings on the asset side, and overnight retail deposits, term retail deposits, whole deposits and securities issuance on the liability side. Subsequently, the model outputs were used to project bank specific interest rate paths by attaching the period changes of the effective interest rates in the forecasting horizon to the bank specific starting point.[1]

11. The input for interest rate models bears close resemblance to that of credit risk models. Most of the explanatory variables for the credit risk model were kept for use in the interest rate models, such as GDP growth, unemployment rate, short-term and long-term interest rates, and

[1] Such attachment to actual bank data is used to minimize forecasting errors at the starting point.

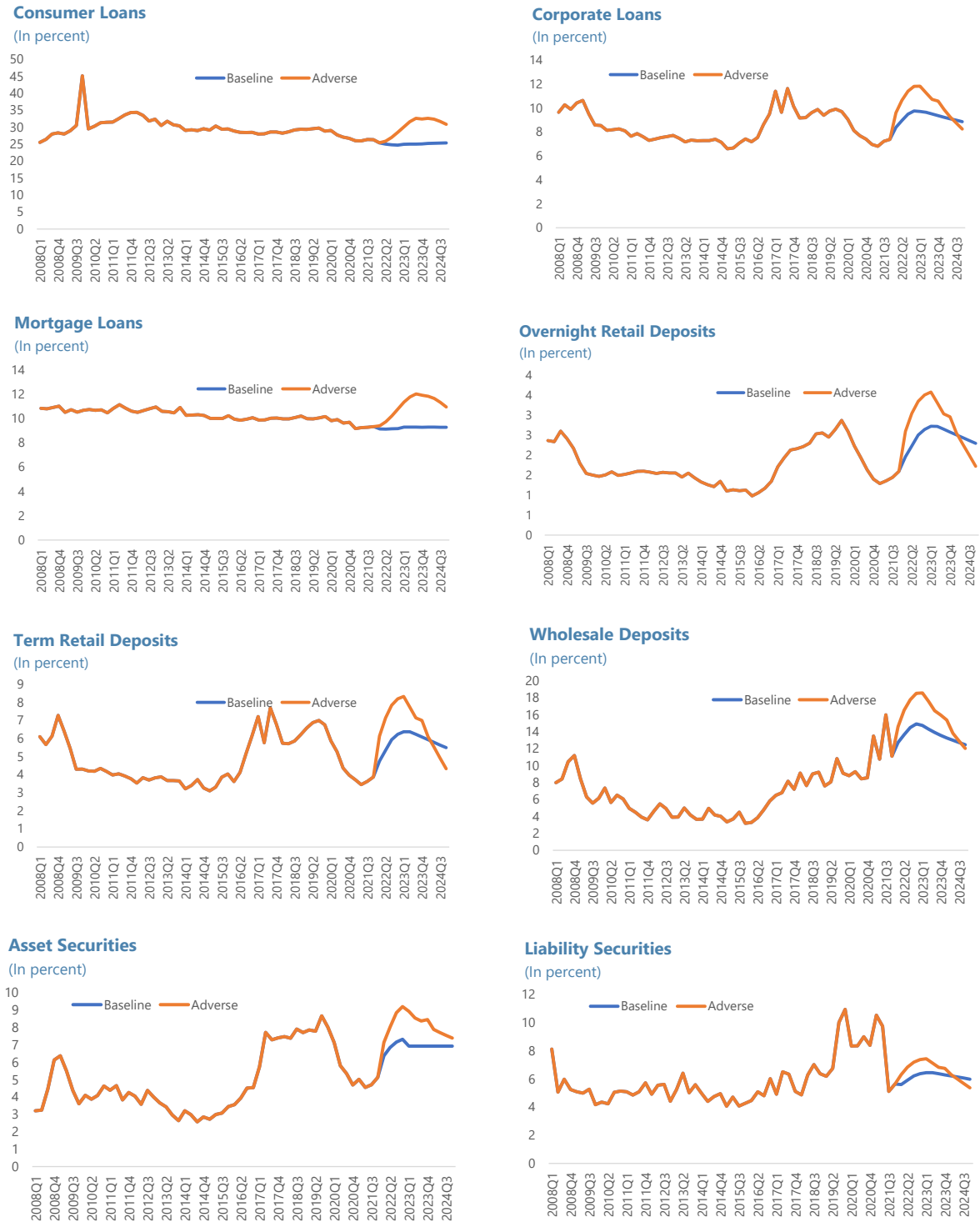
inflation. Since interest rates were received in a blended form but reflect mainly domestic exposures, most explanatory variables came under the form of Mexican specific indicators, to account for country specific interest risk associated with domestic creditors/borrowers.

12. To simulate bank specific risk behavior and allow for a partial passthrough of the rising funding cost to the lending rate, staff includes banks' funding cost as an additional explanatory factor in the projection of the lending rate. Therefore, the model was performed sequentially by first estimating the funding rate, which was then used as input for the projection of the lending rates.

13. The projected interest rates paths were broadly in line with banks' portfolio characteristics (Figure 49). On the liability side, this is reflected by a more severe impact on the long term and unsecured debt portfolios, such as term deposits and wholesale deposits, as opposed to highly liquid and short-term funding such as overnight deposits. On the asset side, the increase on the lending rate could be hindered by a potential rise in the PDs of the existing borrowers. Therefore, to be conservative, the partial passthrough was enabled from funding to lending rates to factor in the constrain faced by the banks.

14. Variables related to unemployment rate and short-term money market rate are the main contributors in the projections of bank interest income and funding cost (Table 13). The coefficients for variables associated with short term interest rate turn out to be significant in the determination of most funding rates, which echo the maturity transformation as part of the banks' business model. Specifically, on the funding side, 3-month money market rate explains the majority of the movement in the interest expense; on the lending side, the unemployment rate outweighs the short-term interest rate in explaining consumer and mortgage loans. The coefficient of term spread, inflation, and pass through from overnight and term retail deposits appear to be significant for corporate loans with sizable impact particularly from term retail deposits, reflecting high dependency of corporate lending from stable long-term funding.

Figure 2. Mexico: Projections of Interest Rates



Source: IMF staff estimation.

Table 2. Mexico: Estimation of Interest Rates

(Dependent variables: interest rates in percent)

	(1) Corporate Loans	(2) Consumer Loans	(3) Mortgage Loans	(4) Assets Debt Securities	(5) Overnight Retail Deposits	(6) Term Retail Deposits	(7) Wholesale Deposits	(8) Liabilities Debt Securities
Unemployment rate, percent	0	1.679*	0.572*	0	0	0	0	0
Short term interest rate, percent	0	0	0.124*	0	0.273*	0.596*	0.803*	0.371*
Long term sovereign bond yield, percent	0.015	0	0.073	0.914*	0.055	-0.279	0.387	0
Term spread, percent	0.195*	0.966	0	0	-0.165	0.224	-0.317	0
Inflation, percent, yoy, lagged	0.092*	0	0	0	0.004	0	0.539*	0
Overnight retail deposit, percent	0.182*	0.497	0	0	0	0	0	0
Term retail deposit, percent	1.023*	0.080	0	0	0	0	0	0
Intercept	3.442*	23.671*	7.245*	-3.349*	0.845*	3.691*	1.157*	22.458*
Number of observations	560	549	560	560	560	560	560	464
R square	0.90	0.64	0.16	0.51	0.78	0.15	0.15	0.33
Fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Sources: Banxico; IMF World Economic Outlook; Haver Analytics; Datastream; and IMF staff calculations.
Note: * denote p value less than 0.1.

Appendix V. LCR-Based Stress Scenario Parameters

Haircuts

	Regulatory scenario 1	Haircut Scenario 2	Haircut Scenario 3
HEADING		***Weights***	
UNENCUMBERED ASSETS			
LEVEL 1 ASSETS			
Cash (not to include the cash balances allocated to cover operating costs)	100%	100%	100%
Deposits at Bank of Mexico			
Monetary Regulation Deposits	100%	100%	100%
Other unencumbered deposits (single account balance, deposits: IEIR (Interbank Equilibrium Interest Rate) and OMO (open market operations) or any other deposit at Bank of Mexico)	100%	100%	100%
Demand deposits at other central banks	100%	100%	100%
HOLDING OF UNENCUMBERED DEBT SECURITIES AND SHARES (INCLUDES THOSE RECEIVED IN REPURCHASE TRANSACTIONS OR AS A LOAN, THAT HAVE NOT BEEN ENCUMBERED IN ANY OTHER OPERATION)			
DEBT SECURITIES TO WHICH A CREDIT RISK WEIGHTING OF 0 PERCENT IS ASSIGNED, IN ACCORDANCE WITH THE PROVISIONS IN TITLE 1(b) OF THE SINGLE BANKING RULEBOOK*[CIRCULAR ÚNICA DE BANCOS]*, ISSUED OR BACKED BY:			
Government of Mexico, Bank of Mexico, and the Bank Savings Protection Institute	100%	**95%**	**90%**
Mexican development banks	100%	**95%**	**90%**
Foreign governments, foreign central banks, and decentralized agencies of foreign governments	100%	100%	100%
International bodies: Bank for International Settlements, International Monetary Fund, European Commission, and multilateral development agencies	100%	100%	100%
DEBT SECURITIES TO WHICH A CREDIT RISK WEIGHTING IS ASSIGNED OTHER THAN 0 PERCENT, IN ACCORDANCE WITH THE PROVISIONS IN TITLE 1(b) OF THE SINGLE BANKING RULEBOOK (ONLY THOSE WITH A DEGREE OF RISK OF WHICH IS LOWER THAN OR EQUAL TO 2), ISSUED OR BACKED BY:			
Governments or central banks in the local currency of the country in which the liquidity risk is being calculated, subject to the institution having subsidiaries established in the countries of said governments or central banks	100%	**95%**	**90%**
Governments or central banks in foreign currency, provided this corresponds to the currency in which the liquidity needs of the institution are denominated, subject to the institution having subsidiaries established in the countries of those governments or central banks	100%	**95%**	**90%**
LEVEL 2A ASSETS			
DEBT SECURITIES TO WHICH A CREDIT RISK WEIGHTING IS ASSIGNED IN ACCORDANCE WITH THE PROVISIONS IN TITLE 1(b) OF THE SINGLE BANKING RULEBOOK , ISSUED OR BACKED BY:			
Decentralized agencies of the federal government	85%	**80%**	**75%**
Mexican federal entities and municipalities and by the bodies under them	85%	**75%**	**65%**
Foreign governments, foreign central banks, and decentralized agencies of foreign governments	85%	**80%**	**75%**
Multilateral development agencies	85%	**75%**	**65%**
Mexican development banks and Mexican public development *[fomento]* funds and trusts	85%	**75%**	**65%**
Debt securities eligible as Level 2A assets issued by nonfinancial institutions other than sovereigns, central banks, and public sector entities	85%	**75%**	**65%**

HEADING	Regulatory scenario 1	Haircut Scenario 2	Haircut Scenario 3
	Weights		
LEVEL 2B ASSETS			
Debt securities eligible as residential mortgage-backed Level 2B assets	75%	**70%**	**65%**
Debt securities eligible as Level 2B assets, issued or backed by nonfinancial institutions other than sovereigns, central banks, and public sector entities	50%	**40%**	**30%**
Shares of nonfinancial enterprises that are included in the main index of the Mexican Stock Exchange (BMV) that have high or medium marketability *[bursatilidad]* in accordance with the classification of the BMV, and that without a historically cumulative decline in their price greater than 40 percent over a period of 30 days.	50%	**25%**	**0%**
Debt securities eligible as Level 2B assets issued or backed by foreign governments or foreign central banks	50%	**40%**	**30%**
Assets that fulfill the criteria of Level 2A assets but that have a historical cumulative decline in their market price greater than 10 percent but not more than 20 percent over a period of thirty days.	50%	**40%**	**30%**

Run-off rates for Outflows

	Regulatory scenario 1		Retail scenario 2	Wholesale scenario 3	Combined scenario 4
HEADING			***Weights***		
UNSECURED FUNDING					
RETAIL DEPOSITS					
DEPOSITS THAT ARE FULLY INSURED BY THE IPAB OR BY THE CORRESPONDING DEPOSIT INSURANCE INSTITUTION IN THE COUNTRY WHERE SAID DEPOSITS HAVE BEEN MADE, RECEIVED FROM INDIVIDUALS, INCLUDING INDIVIDUALS WITH A BUSINESS ACTIVITY AND NON-FINANCIAL ENTITIES DIFFERENT FROM SOVEREIGN, CENTRAL BANKS AND PUBLIC SECTOR (includes deposits through nonnegotiable securities not issued to the bearer):					
Deposits in local currency that pay an interest rate lower than or equal to the 28-day Interbank Equilibrium Interest Rate, and deposits in foreign currency that pay an interest rate lower than or equal to the Secured Overnight Financing Rate (SOFR)					
IN TRANSACTIONAL ACCOUNTS OR AMOUNT THAT FULFILLS OPERATIONAL PURPOSES					
Payable on demand *[de exigibilidad inmediata]*	5%		**10%**	5%	**10%**
Maturity	5%		**10%**	5%	**10%**
IN ACCOUNTS OTHER THAN TRANSACTIONAL ACCOUNTS AND THAT DO NOT FULFILL OPERATIONAL PURPOSES					
Payable on demand	10%		**20%**	10%	**20%**
Term deposit	10%		**20%**	10%	**20%**
Deposits in local currency that pay an interest rate greater than the 28-day Interbank Equilibrium Interest Rate, and deposits in foreign currency that pay an interest rate greater than the Secured Overnight Financing Rate (SOFR)					
IN TRANSACTIONAL ACCOUNTS, OR AMOUNT THAT FULFILLS OPERATIONAL PURPOSES					
Payable on demand	5%		**10%**	5%	**10%**
Term deposit	5%		**10%**	5%	**10%**
IN ACCOUNTS OTHER THAN TRANSACTIONAL ACCOUNTS AND THAT DO NOT FULFILL OPERATIONAL PURPOSES					
Payable on demand	10%		**20%**	10%	**20%**
Term deposit	10%		**20%**	10%	**20%**
DEPOSITS THAT ARE NOT FULLY INSURED BY THE IPAB OR BY THE CORRESPONDING DEPOSIT INSURANCE INSTITUTION IN THE COUNTRY WHERE SAID DEPOSITS HAVE BEEN MADE, RECEIVED FROM INDIVIDUALS, INCLUDING INDIVIDUALS WITH A BUSINESS ACTIVITY (includes deposits through nonnegotiable securities not issued to the bearer):					
Deposits in local currency that pay an interest rate lower than or equal to the 28-day Interbank Equilibrium Interest Rate, and deposits in foreign currency that pay an interest rate lower than or equal to the Secured Overnight Financing Rate (SOFR)					
Part covered by the IPAB deposit insurance or by the corresponding deposit insurance institution in the country where said deposits have been made					
IN TRANSACTIONAL ACCOUNTS					
Payable on demand	5%		**15%**	5%	**15%**
Term deposit	5%		**15%**	5%	**15%**
IN NONTRANSACTIONAL ACCOUNTS					
Payable on demand	10%		**20%**	10%	**20%**
Term deposit	10%		**20%**	10%	**20%**
Part NOT covered by the IPAB deposit insurance or by the corresponding deposit insurance entity in the country where said deposits have been made					
IN TRANSACTIONAL ACCOUNTS					
Payable on demand	10%		**20%**	10%	**20%**
Term deposit	10%		**20%**	10%	**20%**
IN NON TRANSACTIONAL ACCOUNTS					
Payable on demand	10%		**20%**	10%	**20%**
Term deposit	10%		**20%**	10%	**20%**

Run-off rates for Outflows (continued)

	Regulatory scenario 1		Retail scenario 2	Wholesale scenario 3	Combined scenario 4
HEADING			*Weights*		
Deposits in local currency that pay an interest rate greater than the 28-day Interbank Equilibrium Interest Rate, and deposits in foreign currency that pay an interest rate greater than the Secured Overnight Financing Rate (SOFR)					
Part covered by the IPAB deposit insurance or by the corresponding deposit insurance institution in the country where said deposits have been made					
IN TRANSACTIONAL ACCOUNTS					
Payable on demand	5%		**10%**	5%	**10%**
Term deposit	5%		**10%**	5%	**10%**
IN NON TRANSACTIONAL ACCOUNTS					
Payable on demand	10%		**20%**	10%	**20%**
Term deposit	10%		**20%**	10%	**20%**
Part NOT covered by the IPAB deposit insurance or by the corresponding deposit insurance entity in the country where said deposits have been made					
IN TRANSACTIONAL ACCOUNTS					
Payable on demand	10%		**20%**	10%	**20%**
Term deposit	10%		**20%**	10%	**20%**
IN NON TRANSACTIONAL ACCOUNTS					
Payable on demand	10%		**20%**	10%	**20%**
Term deposit	10%		**20%**	10%	**20%**
WHOLESALE DEPOSITS					
Demand deposits					
Deposits in local currency that pay an interest rate lower than or equal to the 28-day Interbank Equilibrium Interest Rate, and deposits in foreign currency that pay an interest rate lower than or equal to the Secured Overnight Financing Rate (SOFR)					
AMOUNT THAT FULFILLS OPERATIONAL PURPOSES					
Part covered by the IPAB deposit insurance or by the corresponding deposit insurance institution in the country where said deposits have been made					
Sovereigns, central banks, federal entities and municipalities, public sector entities, government entities, development banking sector, and public development funds and trusts	5%		5%	**15%**	**15%**
Nonfinancial institutions not included in other categories, that are not fully secured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	5%		5%	**15%**	**15%**
Part NOT covered by the IPAB deposit insurance or by the corresponding deposit insurance entity in the country where said deposits have been made					
Sovereigns, central banks, federal entities and municipalities, public sector entities, government entities, development banking sector, and public development funds and trusts	25%		25%	**35%**	**35%**
Domestic and foreign financial entities (excluding development banking sector and public development funds and trusts)	25%		25%	**35%**	**35%**
Nonfinancial institutions not included in other categories, that are not fully secured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	25%		25%	**35%**	**35%**
AMOUNT THAT DOES NOT FULFILL OPERATIONAL PURPOSES					
Sovereigns, central banks, federal entities and municipalities, public sector entities, government entities, development banking sector, and public development funds and trusts					
Amount fully secured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	20%		20%	**40%**	**40%**
Part not covered by the IPAB or the corresponding deposit insurance entity in the country where said deposits have been made, received from nonfinancial institutions not included in other categories	40%		40%	**60%**	**60%**
Domestic and foreign financial entities (excluding development banking sector and public development funds and trusts)	100%		100%	100%	100%
Nonfinancial institutions not included in other categories, that are not fully secured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	40%		40%	**60%**	**60%**

Run-off rates for Outflows (continued)

	Regulatory scenario 1		Retail scenario 2	Wholesale scenario 3	Combined scenario 4
HEADING			***Weights***		
Deposits in local currency that pay an interest rate greater than the 28-day Interbank Equilibrium Interest Rate, and deposits in foreign currency that pay an interest rate greater than the Secured Overnight Financing Rate (SOFR)					
AMOUNT THAT FULFILLS OPERATIONAL PURPOSES					
Part covered by the IPAB deposit insurance or by the corresponding deposit insurance institution in the country where said deposits have been made					
Sovereigns, central banks, federal entities and municipalities, public sector entities, government entities, development banking sector, and public development funds and trusts	5%		5%	**15%**	**15%**
Nonfinancial institutions other than the foregoing, that are not one hundred percent secured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	5%		5%	**15%**	**15%**
Part NOT covered by the IPAB deposit insurance or by the corresponding deposit insurance entity in the country where said deposits have been made					
Sovereigns, central banks, federal entities and municipalities, public sector entities, government entities, development banking sector, and public development funds and trusts	25%		25%	**35%**	**35%**
Domestic and foreign financial entities (excluding development banking sector and public development funds and trusts)	25%		25%	**35%**	**35%**
Nonfinancial institutions not included in other categories, that are not fully insured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	25%		25%	**35%**	**35%**
AMOUNT THAT DOES NOT FULFILL OPERATIONAL PURPOSES					
Sovereigns, central banks, federal entities and municipalities, public sector entities, government entities, development banking sector, and public development funds and trusts					
Amount fully insured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	20%		20%	**40%**	**40%**
Part not covered by the IPAB or the corresponding deposit insurance entity in the country where said deposits have been made, received from nonfinancial institutions not included in other categories	40%		40%	**60%**	**60%**
Domestic and foreign financial entities (excluding development banking sector and public development funds and trusts)	100%		100%	100%	100%
Nonfinancial institutions other than the foregoing, that are not one hundred percent secured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	40%		40%	**60%**	**60%**
Term deposits					
Deposits in local currency that pay an interest rate lower than or equal to the 28-day Interbank Equilibrium Interest Rate, and deposits in foreign currency that pay an interest rate lower than or equal to the Secured Overnight Financing Rate (SOFR)					
Sovereigns, central banks, federal entities and municipalities, public sector entities, government entities, development banking sector, and public development funds and trusts					
Amount fully insured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	20%		20%	**40%**	**40%**
Part not covered by the IPAB or the corresponding deposit insurance entity in the country where said deposits have been made	40%		40%	**60%**	**60%**
Domestic and foreign financial entities (excluding development banking sector and public development funds and trusts)	100%		100%	100%	100%
Nonfinancial institutions not included in other categories, that are not fully secured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	40%		40%	**60%**	**60%**
Deposits in local currency that pay an interest rate greater than the 28-day Interbank Equilibrium Interest Rate, and deposits in foreign currency that pay an interest rate greater than the Secured Overnight Financing Rate (SOFR)					
Sovereigns, central banks, federal entities and municipalities, public sector entities, government entities, development banking sector, and public development funds and trusts					
Amount fully insured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	20%		20%	**40%**	**40%**
Part not covered by the IPAB or the corresponding deposit insurance entity in the country where said deposits have been made	40%		40%	**60%**	**60%**
Domestic and foreign financial entities (excluding development banking sector and public development funds and trusts)	100%		100%	100%	100%
Nonfinancial institutions not included in other categories, that are not fully insured by the IPAB or by the corresponding deposit insurance entity in the country where said deposits have been made	40%		40%	**60%**	**60%**

Run-off rates for Outflows (continued)

HEADING	Regulatory scenario 1	Retail scenario 2	Wholesale scenario 3	Combined scenario 4
	Weights			
Loans				
Sovereigns, central banks, federal entities and municipalities, government entities, and public sector entities	40%	40%	**60%**	**60%**
DEVELOPMENT BANKING SECTOR AND PUBLIC DEVELOPMENT FUNDS AND TRUSTS				
Call money loans	100%	100%	100%	100%
Other loans	40%	40%	**60%**	**60%**
Domestic and foreign financial entities (excluding development banking sector and public development funds and trusts)	100%	100%	100%	100%
Nonfinancial institutions not included in other categories, not fully insured by IPAB or the corresponding deposit insurance entity in the country where said deposits have been made	40%	40%	**60%**	**60%**
DEBT SECURITIES ISSUED BY THE ENTITY (INCLUDES ANY KIND OF SECURITY WITH A SECONDARY MARKET, FOR EXAMPLE PROMISSORY NOTES, BANK BONDS, STOCK CERTIFICATES, DEPOSIT CERTIFICATES, BANKS' ACCEPTANCES, SUBORDINATED DEBT, ETC.)				
Debt from money market (debt securities other than those indicated in concept 10025)	100%	100%	100%	100%
Subordinated debt in circulation	100%	100%	100%	100%
TRANSACTIONS CARRIED OUT BY BROKERAGE HOUSES IN THE SAME OWNERSHIP STRUCTURE THAT THE COMMERCIAL BANK				
Amount of the financing received through repo transactions backed with debt securities with a residual term to maturity greater than 30 days, issued by the commercial bank	100%	100%	100%	100%
SECURED FUNDING				
Amount of the funding backed with Level 1 assets	0%	0%	0%	0%
AMOUNT OF THE FUNDING BACKED WITH LEVEL 2A ASSETS				
with Bank of Mexico	0%	0%	0%	0%
with counterparties other than Bank of Mexico	15%	15%	**25%**	**25%**
AMOUNT OF THE FUNDING BACKED WITH LEVEL 2B ASSETS (ONLY WITH ELIGIBLE RESIDENTIAL MORTGAGE- DEBT SECURITIES)				
with Bank of Mexico	0%	0%	**25%**	**25%**
with the federal government, government entities, federal entities and municipalities, public sector entities, development banking sector, and public development funds and trusts	25%	25%	**50%**	**50%**
with counterparties other than the federal government, government entities, federal entities and municipalities, public sector entities, the development banking sector, and the public development funds and trusts	25%	25%	**50%**	**50%**
AMOUNT OF THE FUNDING BACKED WITH LEVEL 2B ASSETS OTHER THAN RESIDENTIAL MORTGAGE-BACKED				
with Bank of Mexico	0%	0%	0%	0%
with the development banking sector and with public development funds and trusts	25%	25%	**50%**	**50%**
with the federal government, government entities, federal entities and municipalities, and public sector entities	25%	25%	**50%**	**50%**
with counterparties other than the federal government, government entities, federal entities and municipalities, public sector entities, the development banking sector, and the public development funds and trusts	50%	50%	**100%**	**100%**
AMOUNT OF THE FUNDING BACKED WITH NONLIQUID ASSETS				
with Bank of Mexico	0%	0%	0%	0%
with the development banking sector and with public development funds and trusts	25%	25%	**100%**	**100%**
with the federal government, government entities, federal entities and municipalities, and public sector entities	25%	25%	**100%**	**100%**
with counterparties other than the federal government, government entities, federal entities and municipalities, public sector entities, the development banking sector, and the public development funds and trusts	100%	100%	100%	100%
Premiums and interest deliverable for operations of secured financing received	100%	100%	100%	100%

Run-off rates for Outflows (continued)

HEADING	Regulatory scenario 1		Retail scenario 2	Wholesale scenario 3	Combined scenario 4
	Weights				
OTHER OUTFLOWS:					
CURRENCY TO BE PROVIDED FOR FOREIGN EXCHANGE VALUE-DATED TRANSACTIONS (24, 48, 72, and 96 HOURS)					
Currency deliverable for value-dated foreign exchange transactions (the outflows shall not be offset by the inflows)					
Sum of the outflows resulting from offsetting the currency receivable with the currency to be provided for each one of the foreign exchange transactions	100%		100%	100%	100%
Sum of the outflows resulting from offsetting currency with the securities, of each one of the value-dated securities purchase/sell transactions	100%		100%	100%	100%
DETERMINATION OF OUTFLOWS FOR DERIVATIVES TRANSACTIONS CARRIED OUT ON OVER-THE-COUNTER MARKETS					
Outflows for contractual payments of transactions with derivative financial instruments pending settlement	100%		100%	100%	100%
Contingent outflow for transactions with derivative financial instruments (Look Back Approach, LBA)	100%		100%	100%	100%
Total contractual outflows that have been scheduled during the next 30 days, for over-the-counter derivative financial instruments that may NOT be offset, due to not making up part of a master clearing agreement. These flows are to be presented net of the Level 1, 2A, and 2B guarantees delivered.	100%		100%	100%	100%
Total of contractual outflows that have been scheduled during the next 30 days, for derivatives transactions offset by the inflows that have been scheduled to be received over the next 30 days, due to making up part of a master clearing agreement. These flows are to be presented net of the Level 1, 2A, and 2B guarantees delivered.	100%		100%	100%	100%
MARKET VALUE OF THE LEVEL 1, 2A, and 2B GUARANTEES DELIVERED					
Sum of the Level 1, 2A, and 2B guarantees delivered for derivatives transactions for which a master clearing agreement has been concluded					
Sum of the Level 1, 2A, and 2B guarantees delivered for derivatives transactions for which a master clearing agreement has NOT been concluded					
Due to rating deterioration (increase in the liquidity needs related to derivatives transactions and those for financing, as a result of a decline in the credit rating of the institution)	100%		100%	100%	100%
MARKET VALUE OF THE GUARANTEES PROVIDED IN DERIVATIVES TRANSACTIONS AND IN OTHER TRANSACTIONS					
Level 1 guarantees provided in derivatives transactions	0%		**10%**	**10%**	**10%**
Level 1 guarantees provided in other transactions	0%		**10%**	**10%**	**10%**
Level 2A guarantees provided in derivatives transactions	20%		**35%**	**35%**	**35%**
Level 2A guarantees provided in other transactions	20%		**35%**	**35%**	**35%**
Level 2B guarantees provided in derivatives transactions	20%		**35%**	**35%**	**35%**
Level 2B guarantees provided in other transactions	20%		**35%**	**35%**	**35%**
Guarantees other than Level 1, Level 2A, and Level 2B provided in derivatives transactions and other transactions	20%		**35%**	**35%**	**35%**
Due to unsegregated surplus guarantees held by the institution, that could contractually be demanded by the counterparty	100%		100%	100%	100%
Due to a shortfall in guarantees (increase in liquidity needs due to a shortfall in guarantees provided by the institution, whose repayment the counterparty has not yet demanded but that contractually it has the right to demand)	100%		100%	100%	100%
Due to substitution of guarantees (increase in liquidity needs related to contracts permitting the substitution of guarantees received by the institution in the form of Level 1, 2A, or 2B assets, by others of a level other than the foregoing)	100%		100%	100%	100%
DUE TO PARTICIPATION IN STRUCTURED VEHICLES AS ADMINISTRATOR, ORIGINATOR, ISSUER, OR PROVIDER OF IMPLICIT OR EXPLICIT SUPPORT TO THE STRUCTURE.					
Liabilities generated by securitizations and any other structured product issued by the institution	100%		100%	100%	100%
Contingent liabilities associated with securitizations and special-purpose vehicles with initial maturity less than or equal to one year	100%		100%	100%	100%

Run-off rates for Outflows (continued)

HEADING	Regulatory scenario 1		Retail scenario 2	Wholesale scenario 3	Combined scenario 4
	Weights				
CREDIT COMMITMENTS: CREDIT LINES AND LIQUIDITY LINES					
CREDIT COMMITMENTS: IRREVOCABLE CREDIT LINES GRANTED TO:					
Individuals and SMEs	5%		**15%**	**30%**	**30%**
Corporates, sovereigns, central banks, public sector entities	10%		**20%**	**40%**	**40%**
Commercial banks	40%		**60%**	**100%**	**100%**
Other financial entities not included in other categories	40%		**75%**	**100%**	**100%**
CREDIT COMMITMENTS: REVOCABLE CREDIT LINES GRANTED TO:					
Individuals and SMEs	5%		**15%**	**10%**	**15%**
Corporates, sovereigns, central banks, public sector entities	5%		**10%**	**20%**	**20%**
Commercial banks	10%		**20%**	**40%**	**40%**
Other financial entities not included in other categories	10%		**20%**	**40%**	**40%**
CREDIT COMMITMENTS: LIQUIDITY LINES PROVIDED TO:					
Individuals and SMEs	5%		**50%**	**50%**	**50%**
Corporates, sovereigns, central banks, public sector entities	30%		**60%**	**80%**	**80%**
Commercial banks	40%		**100%**	**100%**	**100%**
Other financial entities not included in other categories	100%		100%	100%	100%
Guarantees by endorsement *[avales]* provided	30%		**40%**	**50%**	**50%**
Letters of credit	0%		**10%**	**10%**	**10%**
Other international trade instruments	0%		**10%**	**10%**	**10%**
Other cash outflows not included in other categories					
Contractual	100%		100%	100%	100%
Noncontractual	100%		100%	100%	100%

Appendix VI. Cash Flow Analysis Scenario Parameters

Segment Name	Type	Value Min	Value Max	Collateralization
Liabilities resulting from securities issued (if not treated as retail deposits)	Outflows			
Unsecured bonds due	Outflows	0	1	1
Regulated covered bonds	Outflows	0	1	1
Securitizations due	Outflows	0	1	1
Other	Outflows	0	1	1
Liabilities resulting from secured lending and capital market driven transactions collateralized by:	Outflows			
Level 1 tradable assets	Outflows			
Level 1 excluding covered bonds	Outflows	0.1	0.3	1.02
Level 1 central bank	Outflows			
Level 1 (CQS 1)	Outflows	0	0.3	1.02
Level 1 (CQS2, CQS3)	Outflows	0.1	0.5	1.02
Level 1 (CQS4+)	Outflows	0.2	0.5	1.02
Level 1 covered bonds (CQS1)	Outflows	0.2	0.5	1.02
Level 2A tradable assets	Outflows	0.2	0.5	1.02
Level 2A corporate bonds (CQS1)	Outflows			
Level 2A covered bonds (CQS1, CQS2)	Outflows	0.2	0.5	1.02
Level 2A public sector (CQS1, CQS2)	Outflows	0.2	0.5	1.02
Level 2B tradable assets	Outflows			
Level 2B ABS (CQS1)	Outflows	0.2	0.5	1.05
Level 2B covered bonds (CQS1-6)	Outflows	0.2	0.5	1.05
Level 2B: corporate bonds (CQ1-3)	Outflows	0.2	0.5	1.05
Level 2B shares	Outflows	0.35	1	1.5
Level 2B public sector (CQS 3-5)	Outflows	0.35	1	1.5
Other tradable assets	Outflows	0.35	1	1.5
Other assets	Outflows	0.35	1	1.5
Liabilities not reported in 1.2, resulting from deposits received (excluding deposits received as collateral)	Outflows			
Stable retail deposits	Outflows	0.05	0.1	1
Other retail deposits	Outflows	0.1	0.2	1
Operational deposits	Outflows	0.05	0.25	1
Non-operational deposits from credit institutions	Outflows	0.2	1	1

Segment Name	Type	Value Min	Value Max	Collateralization
Non-operational deposits from other financial customers	Outflows	0.2	1	1
Non-operational deposits from central banks	Outflows	0	0.25	1
Non-operational deposits from non-financial corporates	Outflows	0.2	0.4	1
Non-operational deposits from other counterparties	Outflows	0.2	0.4	1
FX-swaps maturing	Outflows	0	0	1
Derivatives amount payables other than those reported in 1.4	Outflows	0	0	1
Other outflows	Outflows	0	0	1
Total outflows	Outflows			
Monies due from secured lending and capital market driven transactions collateralized by:	Inflows			
Level 1 tradable assets	Inflows			
Level 1 excluding covered bonds	Inflows	0.1	0.3	1.02
Level 1 central bank	Inflows			
Level 1 (CQS 1)	Inflows	0	0.3	1.02
Level 1 (CQS2, CQS3)	Inflows	0.1	0.5	1.02
Level 1 (CQS4+)	Inflows	0.2	0.5	1.02
Level 1 covered bonds (CQS1)	Inflows	0.2	0.5	1.02
Level 2A tradable assets	Inflows	0.2	0.5	1.05
Level 2A corporate bonds (CQS1)	Inflows			
Level 2A covered bonds (CQS1, CQS2)	Inflows	0.2	0.5	1.05
Level 2A public sector (CQS1, CQS2)	Inflows	0.2	0.5	1.05
Level 2B tradable assets	Inflows			
Level 2B ABS (CQS1)	Inflows	0.2	0.5	1.05
Level 2B covered bonds (CQS1-6)	Inflows	0.2	0.5	1.05
Level 2B: corporate bonds (CQ1-3)	Inflows	0.2	0.5	1.05
Level 2B shares	Inflows	0.35	1	1.5
Level 2B public sector (CQS 3-5)	Inflows	0.35	1	1.5
Other tradable assets	Inflows	0.35	1	1.5
Other assets	Inflows	0.35	1	1.5
Monies due not reported in 2.1 resulting from loans and advances granted to:	Inflows			
Retail customers	Inflows	0	1	1
Non-financial corporates	Inflows	0	1	1
Credit institutions	Inflows	0	1	1

Segment Name	Type	Value Min	Value Max	Collateralization
Other financial customers	Inflows	0	1	1
Central banks	Inflows	0	1	1
Other counterparties	Inflows	0	1	1
FX-swaps maturing	Inflows	0	1	1
Derivatives amount receivables other than those reported in 2.3	Inflows	0	1	1
Paper in own portfolio maturing	Inflows	0	1	1
Other inflows	Inflows	0	1	1
Withdrawable central bank reserves	CBL	0	0	1
Level 1 tradable assets	CBL			
Level 1 excluding covered bonds	CBL	0	0.1	1
Level 1 central bank	CBL			
Level 1 (CQS 1)	CBL	0	0.1	1
Level 1 (CQS2, CQS3)	CBL	0	0.1	1
Level 1 (CQS4+)	CBL	0	0.1	1
Level 1 covered bonds (CQS1)	CBL	0	0.2	1
Level 2A tradable assets	CBL	0.05	0.2	1
Level 2A corporate bonds (CQS1)	CBL	0.05	0.2	1
Level 2A covered bonds (CQS 1, CQS2)	CBL			
Level 2A public sector (CQS1, CQS2)	CBL	0.05	0.2	1
Level 2B tradable assets	CBL	0.1	0.2	1
Level 2B ABS (CQS1)	CBL	0.1	0.2	1
Level 2B covered bonds (CQS1-6)	CBL			
Level 2B corporate bonds (CQ1-3)	CBL	0.1	0.2	1
Level 2B shares	CBL	0.1	0.2	1
Level 2B public sector (CQS 3-5)	CBL	0.1	0.2	1
Other tradable assets	CBL	0.1	0.2	1
Central government (CQS1)	CBL			
Central government (CQS 2 & 3)	CBL	0	0.2	1
Shares	CBL	0	0.2	1
Covered bonds	CBL	0	0.2	1
ABS	CBL	0	0.2	1
Other tradable assets	CBL	0	0.2	1
Non tradable assets eligible for central banks	CBL	0	0.2	1
Undrawn committed facilities received	CBL			

Segment Name	Type	Value Min	Value Max	Collateralization
Level 1 facilities	CBL	0.8	1	1
Level 2B restricted use facilities	CBL	0.8	1	1
Level 2B IPS facilities	CBL	0.8	1	1
Other facilities	CBL			
From intragroup counterparties	CBL	1	1	1
From other counterparties	CBL	1	1	1
Outflows from committed facilities	Contingencies			
Committed credit facilities	Contingencies			
Considered as Level 2B by the receiver	Contingencies	0.15	0.3	1
Other	Contingencies	0.15	0.4	1
Liquidity facilities	Contingencies	0.5	1	1
Outflows due to downgrade triggers	Contingencies	0.5	1	1

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