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REPUBLIC OF KOREA

FINANCIAL SECTOR ASSESSMENT PROGRAM

September 2020

TECHNICAL NOTE—SYSTEMIC RISK ANALYSIS, FINANCIAL SECTOR STRESS TESTING, AND AN ASSESSMENT OF DEMOGRAPHIC SHIFT IN KOREA

This Technical Note on Systemic Risk Analysis, Financial Sector Stress Testing, and an Assessment of Demographic Shift in Korea for the Republic of Korea 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 September 2020.

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September 1, 2020

TECHNICAL NOTE

SYSTEMIC RISK ANALYSIS, FINANCIAL SECTOR STRESS TESTING, AND AN ASSESSMENT OF DEMOGRAPHIC SHIFT IN KOREA

The content of this Technical Note is based on information available as of end-June/December 2019, before the global intensification of the COVID-19 outbreak. It focuses on the Republic of Korea's medium-term challenges and policy priorities and does not cover the outbreak or the related policy response, which has since become the overarching near-term priority.

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared in the context of an IMF Financial Sector Assessment Program (FSAP) in the Republic of Korea in August 2019 and December 2019 that was led by Udaibir Das. Further information on the FSAP can be found at http://www.imf.org/external/np/fsap/fssa.aspx

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AC	Amortized Cost
AFC	Asian Financial Crisis
BMA	Bayesian Model Averaging
CC	Consumer Credit
CCC	Credit Community Cooperative
CCyB	Countercyclical Capital Buffer
CR	Credit Risk
CU	Credit Union
DBS	Dynamic Balance Sheet
D-SIB	Domestic Systemically Important Institutions
EAD	Exposure at Default
ECL	Expected Credit Loss
EIR	Effective Interest Rate
FVOCI	Fair Value through other Comprehensive Income
FVPL	Fair Value through P&L
GFC	Global Financial Crisis
HF	Korea Housing Finance Corporation
HM	Household Mortgages
HUG	Korea Housing & Urban Guarantee Corporation
IFRS	International Financial Reporting Standard
KFS	Korea Forest Service
IFRS	International Financial Reporting Standard
IRB	Internal Ratings-Based Approach (under Basel II/III)
LCR	Liquidity Coverage Ratio
LGD	Loss Given Default
LL	Loan Loss
LRM	Long-Run Multiplier
MoAFRA	Ministry of Agriculture, Food and Rural Affairs
MoIS	Ministry of the Interior and Safety
MoOaF	Ministry of Oceans and Fisheries
MR	Market Risk
MSB	Mutual Savings Bank
MtM	Mark-to-Market
NFD	Non-Deliverable Forward
NFC	Nonfinancial Corporate
NFCI	Net Fee and Commission Income
NII	Net Interest Income
NIM	Net Interest Margin
NPS	National Pension Service
NSFR	Net Stable Funding Ratio
NTI	Net Trading Income

OCI	Other Comprehensive Income
ODIs	Other Depository Institutions
OOE	Other Operating Expense
PD	Probability of Default
PiT	Point-in-Time
P&L	Profit and Loss
RBC	Risk-Based Capital
RWA	Risk-Weighted Assets
SBS	Static Balance Sheet
SGI	Seoul Guarantee Institution
SME	Small and Medium-Sized Enterprise
SOV	Sovereign
STA	Standardized Approach (under Basel II/III)
TM	Transition Matrix
TR	Transition Rate
TTC	Through-the-Cycle
WEO	World Economic Outlook

EXECUTIVE SUMMARY [1]

This note presents the systemic risk analysis conducted for the Republic of Korea in the course of the 2019 Korea FSAP. It comprises a forward-looking solvency analysis for banks, insurers, and pension funds, a liquidity stress test for banks, and an assessment of network and interconnectedness for a wide range of financial sector entities and their ties to the real economy.

Various structural characteristics of Korea's economy and its financial system informed the features and focus for its forward-looking risk analysis. They include Korea's strong export orientation, limited diversification, and its key role as a node in regional and international supply chains. Korea's financial system has grown by 40 percentage points of GDP since 2013, enhancing the importance of a deep financial sector analysis as conducted through the FSAP. Mortgage insurance schemes are widely used—which was reflected in the way the risk assessment for banks was conducted. Korea's life and non-life insurance sector is large, highly concentrated and saturated. Fintech developments keep accelerating, in terms of its Open Banking system and e-money providers. Demographic developments in Korea are among the most adverse world-wide, implying a continuous drag on demand, downward pressure on interest rates, financial firms' income, and hence their capitalization unless they will be altering their business models.

The bank solvency risk analysis concludes that the Korean banking system is broadly resilient to a severe economic downturn scenario. The performance of banks under a macro-financial downturn scenario would be to an extent heterogeneous, with the drop in specialized banks' capital ratios being most pronounced, and those of ODIs, including Mutual Savings Banks and Credit Cooperatives, being most dispersed. None of the nation-wide, regional, and specialized banks are found to fall short of regulatory capital minima. Fintech-implied rising competition in the banking system can have notable implications in terms of systemic liquidity, implied solvency as well as system-wide operational risks.

The FSAP team's assessment is that the adverse FSAP macro-financial scenario is severe enough to encapsulate a COVID-19 implied fallout on economic activity. This assessment stands both in terms of the expected depth and duration of the shock (the FSAP's scenario's deep downturn spans over two full years before normalizing).

Measures have been taken to strengthen the liquidity of the Korean banking system and banks have ample room to withstand liquidity shocks. Overall, the banking system is likely to maintain adequate liquidity, both in terms of domestic and foreign currency, following hypothetical asset price falls, retail funding and wholesale funding shocks. In general, this is the assessment for all types of banks in Korea. However, state-owned banks' reliance on unsecured wholesale funding would lead to a fall in FX liquidity coverage from 112 percent to 85 percent.

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[1] This author of this note is Marco Gross (overall workstream lead; scenario design, bank solvency, network analysis, demographics analysis), member of the FSAP 2019 team led by Udaibir Das, as well as, Farid Jimmy Boumediene (housing market analysis and bank liquidity stress testing), Timo Broszeit (insurance sector stress testing), and Elizabeth Mahoney (research assistance). Selected inputs were provided by Sohrab Rafiq. The analysis has benefitted from discussions with the staff of the BOK, FSC, FSS, the Korea FSAP team, and reviewers at the IMF. The FSAP team is grateful for the excellent cooperation of the Korean authorities and for sharing all data for conducting the systemic risk analysis.

Insurance firms' capital would decline substantially under the stress scenario, while all firms would stay above regulatory thresholds. The top-down solvency stress test for life and non-life insurance firms covered about 75 percent of the market. The same narrative and severity of the scenario from the banking sector solvency analysis were adopted. Under the current accounting regime, held-to-maturity designation is still allowed—and widely used among life insurers—hence a significant portion of insurers' investments were shielded from market price changes. Life insurers specifically would experience a significant decline in income, pointing to the need for them to restructure their business to restore underwriting profitability, and shifting further from guaranteed savings products into lower guarantees and protection business.

The interconnectedness analysis for the Korean financial system suggests that specialized banks are as systemic as nation-wide commercial banks. Nation-wide banks are net lenders to specialized banks, and hence are more vulnerable to specialized banks than the other way around. Insurers are not as systemic but vulnerable to stress, should it arise, in the banking system; insurers are net lenders to all other sub-segments of the financial system in Korea.

The recommendations derived from the systemic risk analysis pertain in many respects to enhancing the Korean authorities' quantitative assessment frameworks (Table 1). They include the urgent need for a detailed quantitative impact analysis of Fintech developments in terms of systemic liquidity and system-wide operational risks which the Open Banking and e-money developments may imply—despite their positive intent and expected benefits. Real estate market structures in Korea, including the Jeonse leasehold system, ought to be better reflected and the related risks be assessed, amid a slowing economy due to adverse demographic developments.

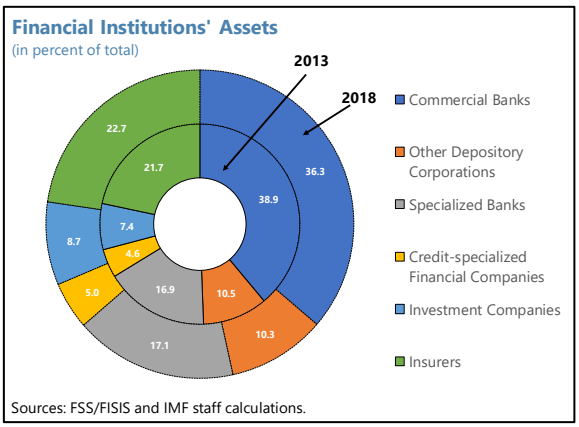
Table 1. Korea: Main Recommendations

Recommendations	Timing*
Systemic Risk Analysis	
Conduct an impact assessment related to Fintech developments (Open Banking, e-money developments); addressing possible repercussions of such developments in terms of systemic liquidity, competition (solvency impact for financial institutions), and system-wide operational risks.	I
Further develop risk assessment models to reflect real estate market structures in Korea, including Jeonse leasehold market system; thereby help assess rollover risk implied by the leasehold system and its inherent connectedness to other financial market segments through leasehold investments.	ST
Categorize ODIs (including Credit Unions, Mutual Savings Banks, and Credit Cooperatives) as banks, not non-banks; to avoid potentially misleading inference about overall banking system dynamics.	MT
Solvency Analysis and Stress Testing	
Further develop analytical capacity for capturing loan insurer structures (e.g. HF, SGI, etc.), accounting for their implied significant nonlinear system behavior under economic downturn scenarios.	MT
Develop solvency stress test models to account for banks' continuous selling of NPLs to the NPL market.	MT
Develop lifetime expected credit loss models to allow K-IFRS 1109-compatible top-down stress testing to help oversight institutions gauge the adequacy of financial institutions' provision coverage.	MT
Broaden range of insurance stress test scenarios, basing them on regularly updated medium-term risk outlook.	ST
After the implementation of the new insurance capital standard (K-ICS), use stress test results as an input factor for the determination of the level of supervisory intensity and, if implemented, capital add-ons.	MT
Liquidity Analysis and Stress Testing	
Continue to improve bank liquidity stress test framework for domestic currency and develop FX liquidity stress test by major currencies.	ST
Expand the methodology of the joint BOK and FSS FX liquidity stress test to include FX LCRs.	MT

Source: IMF staff. * I = immediate, ST = short-term, MT = medium-term.

MACRO-FINANCIAL ENVIRONMENT, SYSTEM STRUCTURE, AND SCOPE OF THE SYSTEMIC RISK ANALYSIS

A. Financial System Structure and Trends



1. As of 2018Q4, total assets of financial institutions in Korea reached about 300 percent of GDP. Since the previous 2013 FSAP, Korea's financial system has grown by about 40 percentage points of GDP. Real estate is the central asset class where leverage is high. The asset management industry and second-pillar pension funds are less developed than other segments of the financial system but are becoming increasingly important amid the material demographic transition observed and further expected in Korea. The rapid growth of Fintech is also adding to such changing dynamics. Growth in the onshore FX derivatives market lags cross-border investment flows while similarly with other emerging currency markets, the offshore NDF market in Korean won remains large and growing, most likely reflecting electronification in NDF markets and global legal and regulatory reforms for derivatives markets which incentivized greater central clearing of NDFs. Selected indicators of the Korean financial system structure are presented in Figure 1.

2. The banking sector comprises a vast spectrum of entities. It is composed of nation-wide and regional commercial banks, specialized (policy) banks and Other Depository Institutions (ODIs); see Table 2. The state-owned financial firms are a prominent part of this landscape. The KHFC provides mortgages insurance and issues fully guaranteed mortgage-backed securities composed of "conforming" loans[2] for which it sets the maximum amount, maturity and interest rates in advance.[3] KAMCO has played an instrumental role after the Asian crisis when it acquired about USD 100bn of bad loans from the banking system and has also bought substantial amounts of NPLs in the wake of the credit card crisis (2003), global financial crisis (2008), and household debt crisis (2013). The National Pension Service (NPS) is the third largest in the world with USD 600bn in assets and is the largest investor in Korea. The Korean Investment Corporation (KIC) is a sovereign wealth fund with about USD 130bn assets under management.

3. Financial holding companies (FHCs) play a systemically important role. As of end-2018, nine FHCs held about 40 percent of total financial institutions' assets (114 percent of GDP) through complex networks of subsidiaries with operations across all segments of the financial system; four FHCs have been identified as D-SIBs. The financial firms belonging to the bank holding companies

[2] A conforming loan is a long-term, fixed-rate mortgage loan provided by the KHFC.
[3] Loans, securities and guarantees issued and provided in 2017 amounted to about 7 percent of GDP.

operate across a broad cross-section of the financial sector, with subsidiaries being engaged in insurance, capital markets and asset management business.

4. The business models of Korea's banks are broadly conventional (Figure 2). Banks, including ODIs, are primarily funded by retail deposits. Assets are concentrated in loans, mostly related to real estate. Bank loans are split about equally across lending to households and firms, with 80 percent of the stock of corporate bank loans outstanding to SMEs. Most SME loans are collateralized against real estate. Commercial banks have a relatively diversified loan portfolio and securities' holdings. State-owned banks are focused on lending to SMEs, which is reflective of Korea's economic policy priorities.

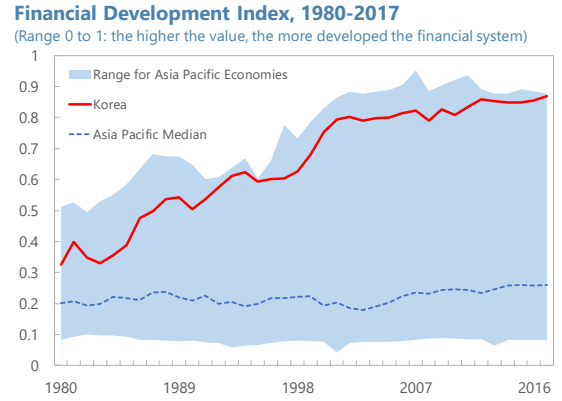
5. The insurance sector is large, highly concentrated, and saturated (Figure 3). The sector comprises 24 life insurance firms and 30 non-life insurers, managing KRW 1170 trillion in total. Insurance penetration (premiums to GDP) is one of the highest in the world, exceeded only by Taiwan Province of China and Hong Kong SAR. This reflects, in part, the central role that life insurance has played as a conduit of savings in Korea, where life insurance assets account for more than 20 percent of household financial assets, well above the OECD average. Cross-sectoral linkages exist as insurers typically also offer financial consulting services and are involved in asset management. The bancassurance market is well developed and 50 percent of new business in life is sold via banks. The market is dominated by large firms owned by FHCs and Korea's largest conglomerates (chaebols).

6. The Korean capital market is one of the most active markets in Asia. The equity market has a market capitalization of around USD 1.8 trillion with foreigners holding around 35 percent of the listed Korean stocks. The largest five conglomerates account for over 50 percent of market capitalization. Compared with major advanced and emerging market economies, the price-to-book and price-to-earnings ratios of Korean companies are notably lower, which has been coined the "Korea discount" and attributed to various factors, such as in relation to North Korea, and the complicated ownership and governance structure of many Korean corporations and especially large firm conglomerates.

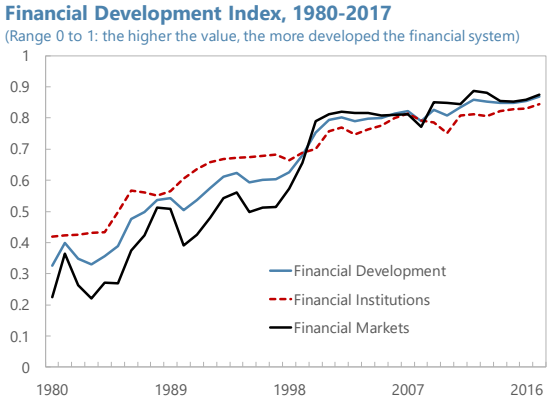
7. The Korean bond market is dominated by government and other public debt, while 'green' or ESG bonds' importance is rising. Korea's asset management industry has experienced robust growth over the past few years reflecting changing saving patterns but also a search for yield by households and other investors. Assets under the management of privately placed funds, derivatives-linked products such as equity-linked securities, etc., all grew at double digit rates over the past year and now amount to about KRW 500 trillion; roughly 30 percent of GDP.

Figure 1. Korea: Financial System Structure

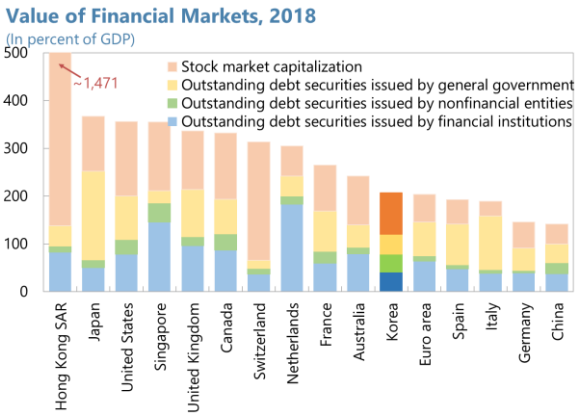
Korea's financial system is among the most developed in Asia[1]…



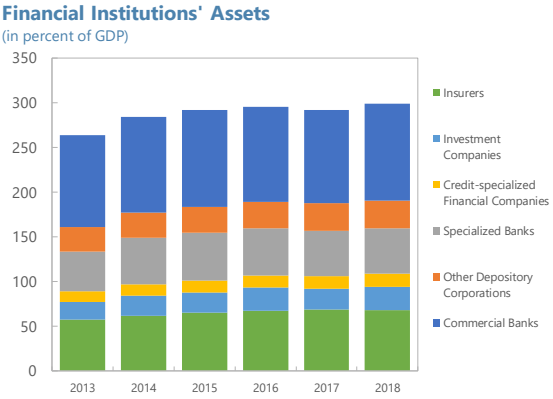
…with both financial markets and institutions broadly developed.



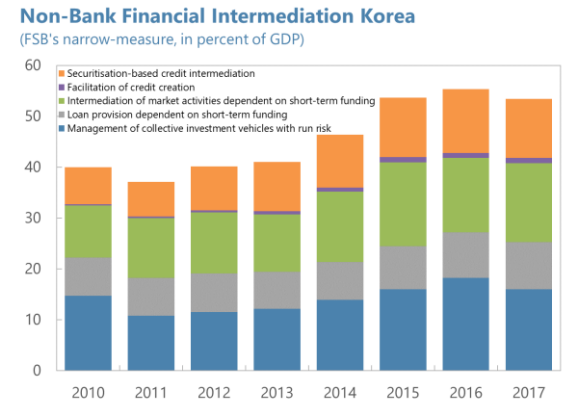
Market-based financing is low but comparable with other advanced economies…



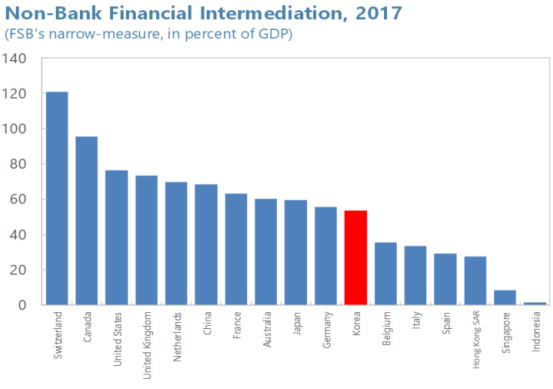
…while banks and other depository institutions hold most financial institutions' assets.



Nonbank financial intermediation is dependent on short-term funding…



…but remains relatively small compared to other major jurisdictions.



Sources: Bloomberg, IMF Financial Development Index, IMF World Economic Outlook, FSB Global Monitoring Report on Nonbank Financial Intermediation 2018, FSS.

1/ For more details about the financial development index and its financial institutions and markets subcomponents see IMF SDN/15/08 and IMF WP/16/5.

Table 2. Korea: Financial System Structure

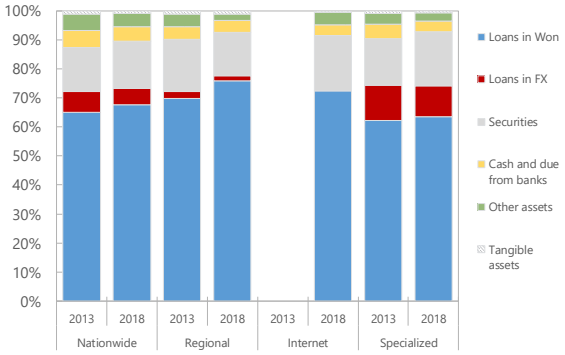
	Size					
	Percent of GDP		Percent of Financial System Assets		Number of Institutions	
	2013	2018	2013	2018	2013	2018
Depository Financial Institutions (Banks)	175.0	190.2	66.3	63.6	2,435	2,373
Domestic Commercial Banks	89.3	93.6	33.8	31.3	58	57
Nationwide (including internet-only)	79.1	83.0	30.0	27.8	7	8
Local	71.6	76.3	27.1	25.5	5	6
Foreign Subsidiaries	7.6	6.7	2.9	2.2	2	2
Regional	10.2	10.5	3.9	3.5	6	6
Foreign Bank Branches	13.4	14.8	5.1	5.0	40	38
Specialized Banks	44.5	51.1	16.9	17.1	5	5
Mutual Savings Banks	2.5	3.7	0.9	1.2	79	79
Credit Unions	3.9	4.7	1.5	1.6	915	888
Agricultural Cooperatives	19.8	20.4	7.5	6.8	1,161	1,122
Fisheries Cooperatives	1.2	1.6	0.5	0.5	86	90
Forestry Cooperatives	0.4	0.4	0.1	0.1	136	137
Non-Depository Financial Institutions	89.1	108.7	33.7	36.4	440	660
Credit-Specialized Financial Firms	12.2	14.9	4.6	5.0	67	105
Credit Card Companies	6.0	7.1	2.3	2.4	8	8
Leasing Companies	2.4	3.2	0.9	1.1	26	25
Installment Finance Companies	3.3	3.9	1.3	1.3	19	21
New Technology Venture Capital Companies	0.4	0.7	0.2	0.2	14	51
Investment Companies	19.6	26.0	7.4	8.7	315	501
Securities Companies	18.9	24.9	7.2	8.3	63	56
Futures Companies	0.2	0.3	0.1	0.1	7	5
Asset Management Companies	0.3	0.4	0.1	0.1	85	243
Investment Advisory Companies	0.1	0.0	0.0	0.0	148	185
Real Estate Trust Companies	0.1	0.2	0.0	0.1	11	11
Merchant Banks	0.1	0.1	0.0	0.0	1	1
Insurance Companies	57.2	67.8	21.7	22.7	58	54
Life Insurance Companies	45.3	51.7	17.1	17.3	27	24
Nonlife Insurance Companies	12.0	16.1	4.5	5.4	31	30
Total Financial System	264.1	299.0	100.0	100.0	2,875	3,033
of which: Financial Holding Companies	136.2	113.8	51.6	38.1	13	9

Sources: FSS/FISIS; IMF, World Economic Outlook database; and IMF staff calculations.
Note: 2018 as of 2018Q3. Excludes community credit cooperatives.

Figure 2. Korea: Depository Institutions' Business Models

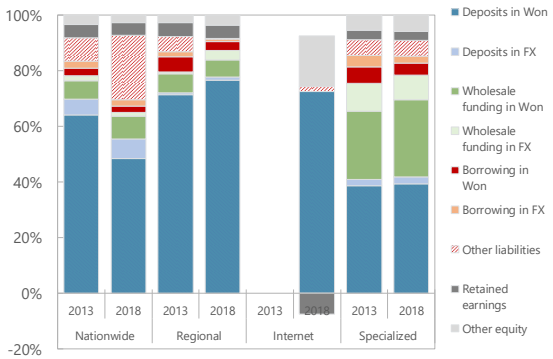
Domestic bank assets are concentrated in domestic currency loans…

Composition of Banks' Assets, 2013-18
(in percent of total assets)



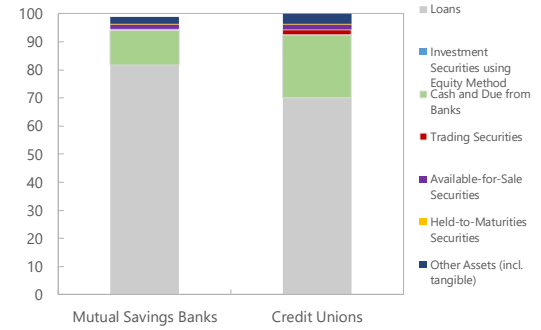
……primarily funded by deposits, exception for specialized banks which rely extensively on wholesale funding.

Composition of Banks' Liabilities, 2013-18
(in percent of total liabilities)



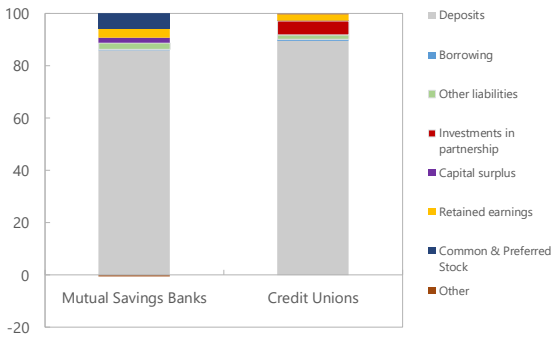
Other depository corporations' assets are also concentrated in domestic lending…

Other Depository Corporations' Assets
(in percent of total assets)



…funded by deposits.

Other Depository Corporations' Liabilities
(in percent of total assets)

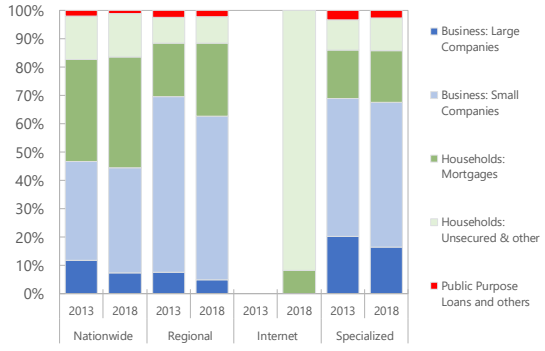


Sources: FSS/FISIS and IMF staff calculations.

Sources: FSS/FISIS and IMF staff calculations.

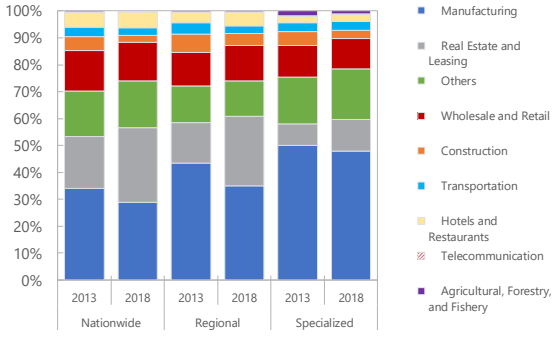
Banks' exposures to property markets has increased through their mortgage lending…

Composition of Banks' Loans by Borrower, 2013-18
(in percent of total loans)



…and lending to firms for real estate and leasing.

Composition of Banks' Loans by Industry, 2013-18
(in percent of total loans)

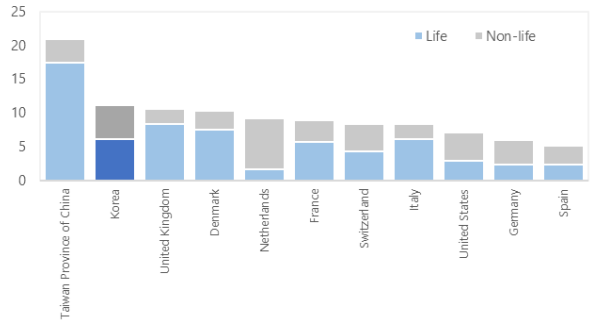


Source: FSS/FISIS and IMF staff calculations.

Figure 3. Korea: Structure of the Insurance Sector

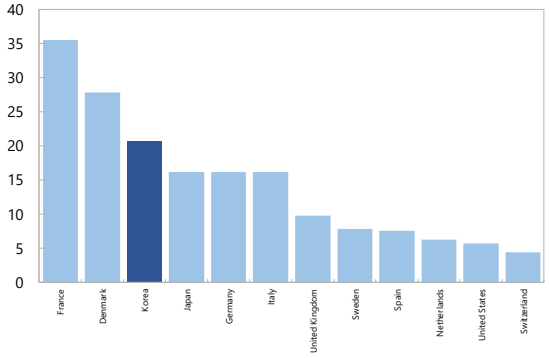
Insurance penetration in Korea is amongst the highest in the world…

Insurance Penetration
(premiums in percent of GDP)



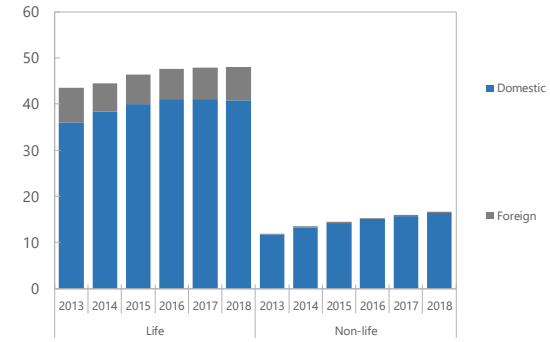
…as insurers play an important role in household wealth management, with a life insurance reserves representing a significant share of household financial assets

Life Insurance Reserves
(In percent of total household financial assets)



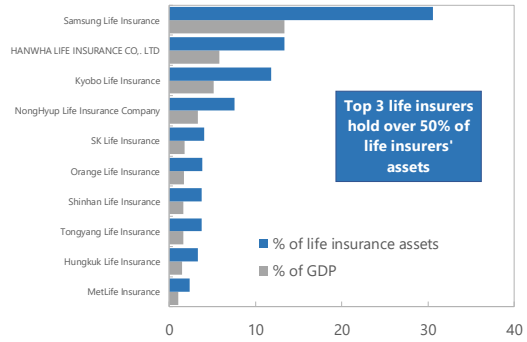
Total assets of the insurance account are sizeable, with limited foreign ownership.

Insurance Assets by Ownership, 2013-18
(in percent of nominal GDP)



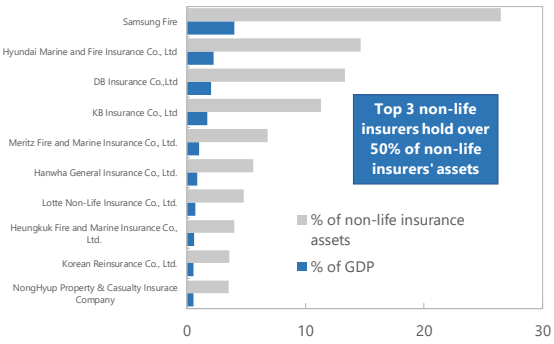
The top 3 life insurers hold over 50 percent of the life sector's assets…

Top Ten Life Insurers by Asset Size
(in percent of life insurance assets & GDP)



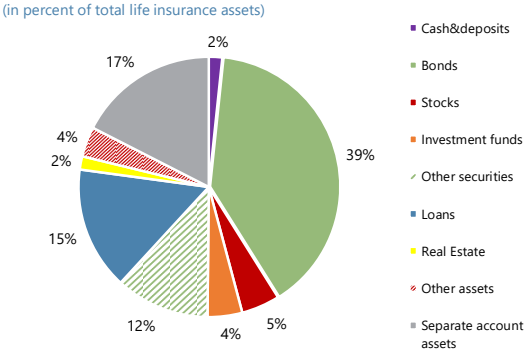
…as do the top 3 non-life insurers.

Top Ten Non-Life Insurers by Asset Size
(in percent of non-life insurance assets & GDP)



Assets are concentrated in bonds, but loans are also sizeable.

Life Insurance Assets
(in percent of total life insurance assets)



Sources: FSS, IMF World Economic Outlook Database, and IMF staff calculations.

8. Fintech innovations are rapidly taking root in the retail payments service sector and altering the market structure. The ongoing push to foster Fintech innovation by the Government is facilitating this. Defining features of the Korean retail banking sector include great financial institution depth and a saturated credit card market, high smartphone penetration, and customer eagerness to embrace cutting-edge technologies—providing a fertile environment for mobile payment services to thrive. The entry of large technology companies in the payment services market (as providers of stored value payment products and of payments-initiation interfaces) is beginning to alter the market structure. These developments affect the degree of concentration and competition, catalyzed by the authorities' work plan to facilitate innovation, specifically the introduction of an "Open Banking" system, in parallel with loosening of legal restrictions for electronic financial transactions and use of personal data.

9. Korean banks have improved their capital position and asset quality since the 2013 FSAP (Table 3, Figures 4 and 5). Banks' aggregate capital ratio at about 16 percent of risk-weighted assets does not stand out compared to other banks in the region. NPL ratios are structurally low but must be interpreted cautiously because banks sell NPLs swiftly into an active market for distressed assets[4]. Korean banks underperform their regional peers in terms of profitability. The share of foreign business in total assets remains relatively small at about 6 percent, up from 4 percent in 2013[5]. Nation-wide banks' asset exposures are diversified, regional banks' and mutual savings banks' exposures are concentrated in SME lending, and ODIs' lending is concentrated in consumer credit (Figure 6).

10. Insurers are currently well capitalized but low interest rates are weighing on profitability (Figure 7). The median life insurers recorded a coverage of its risk-based capital (RBC) at end-2018 of 239 percent, well above the regulatory minimum of 100 percent and the recommended level of 150 percent. In the non-life sector, the RBC coverage was even higher, at 263 which is the highest level since 2012. Increasing difficulties to match higher interest rate guarantees with dwindling returns have led most insurers to extend asset durations (such as through foreign investments) and to offer more 'protection' instead of savings products. Still, profitability is low; the sector's return on assets stood at 0.3 percent in 2018, reflecting decreasing investment yields which declined continuously from 5.1 percent in 2012 to 3.4 percent in 2018. With unfavorable demographics and competition from other financial institutions, growth prospects are limited, triggering foreign expansion and cooperation with fintech providers. Non-life companies, too, have material exposure to long-term saving and protection business. Profitability is impacted by underwriting losses, especially in health insurance where the government aims for lower cost of private coverage. For the non-life sector, the combined ratio hovered slightly above 100 percent in recent years, indicating that claims and operating costs exceed premium income. Nevertheless, the return on assets is still higher than in the life sector, with 1.3 percent for the median company in 2018.

[4] There are several Asset Management Corporations and an active NPL market around them in Korea. Their presence is deemed to foster cost efficiency since banks outsource the NPL management process to specialized firms.
[5] Nation-wide banks' largest exposure is to China, amounting to 1.7 percent of total assets in 2018 (1.1 percent in 2013).

11. While well capitalized under the current regime, additional capital needs are expected under the new regime, which requires close supervisory attention. The new solvency regime, which is going to be aligned with IFRS 17, will introduce a market-consistent valuation of assets and liabilities by 2022. An initial quantitative impact study in 2018, based on the IAIS' Insurance Capital Standards and Solvency II, showed a notable capital shortfall in the life insurance sector. A more recent study in 2019 implies substantially smaller capital needs as several parameters were adjusted to local market conditions[6]. The transition to the new regime has already triggered an increased issuance of subordinated debt. An increased re-classification of fixed-income assets from available-for-sale to held-to-maturity, observed recently, would need to be reverted when transitioning to a fully market-consistent asset valuation.

Table 3. Korea: Core Financial Soundness Indicators, 2012–17

	2012	2013	2014	2015	2016	2017
			(In percent)			
Core FSIs						
Regulatory capital to risk weighted assets	14.3	14.5	14.0	13.9	14.8	15.2
Regulatory Tier 1 capital to risk-weighted assets	11.1	11.4	11.4	11.7	13.1	13.1
Non-performing loans net of provisions to capital	3.1	3.6	2.8	2.1	2.1	1.7
Non-performing loans to total gross loans	0.6	0.6	0.5	0.5	0.5	0.4
Return on assets	0.7	0.3	0.5	0.5	1.9	0.7
Return on equity	8.2	4.0	6.0	6.6	24.3	8.5
Interest margin to gross income	78.3	82.2	62.1	62.9	65.0	58.7
Non-interest expenses to gross income	71.4	75.3	73.5	59.6	65.4	65.6
Liquid assets to total assets	36.2	33.8	37.9	34.4	32.9	29.9
Liquid assets to short-term liabilities	111.3	107.9	122.0	105.0	102.6	101.2
Net open position in FX to capital	0.2	-0.2	0.5	0.0	0.0	-1.0
Sectoral distribution of loans						
Domestic residents	93.2	92.5	92.5	91.0	92.6	92.6
Deposit takers	3.5	3.5	4.0	3.7	3.6	4.3
Central bank	0.5	0.4	0.6	0.5	1.2	0.5
Other financial corporations	0.8	0.8	0.7	0.8	0.9	1.1
General government	0.3	0.6	0.8	1.0	2.0	0.7
Nonfinancial corporations	53.3	50.7	50.0	48.7	49.5	46.1
Households	34.8	36.5	36.3	36.3	35.3	39.9
Nonresidents	6.8	7.5	7.5	9.0	7.4	7.4
Additional FSIs						
Capital to assets (leverage ratio)	8.2	8.3	8.1	8.0	7.9	8.0
Large exposures to capital	76.3	72.9	64.4	70.0	46.6	37.9
Gross assets position in derivatives to capital	19.0	15.0	16.6	17.0	20.2	17.1
Gross liabilities position in derivatives to capital	18.1	16.8	17.8	18.5	21.9	18.0
Trading income to total income	2.1	2.5	5.8	9.3	8.4	6.2
Personnel expenses to total income	29.6	32.2	32.5	41.5	38.2	31.6
Customer deposits to total non-interbank loans	84.1	84.1	81.6	76.0	71.2	75.4
FX loans to total loans	13.2	12.8	13.4	12.2	11.7	10.9
FX liabilities to total liabilities	14.4	14.3	14.6	13.7	11.6	13.2

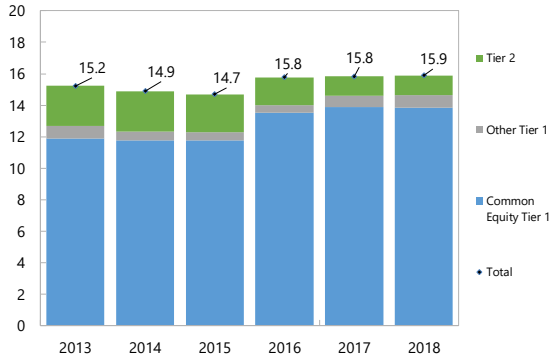
Sources: IMF Financial Soundness Indicators.

[6] Most notably, the ultimate forward rate used in the interest rate term structure modeling for deriving the value of insurance liabilities was increased to 5.2 percent, which is significantly above the 3.9 percent used in the EU's Solvency II regime for KRW-denominated liabilities.

Figure 4. Korea: Financial System Performance

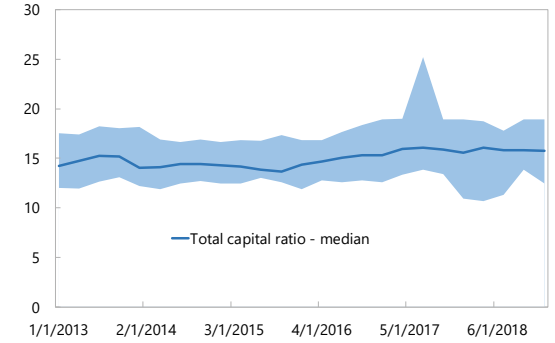
Capitalization of Korean banks has improved with the implementation of Basel III…

Capital Adequacy
(Commercial banks, in percent of risk-weighted assets)



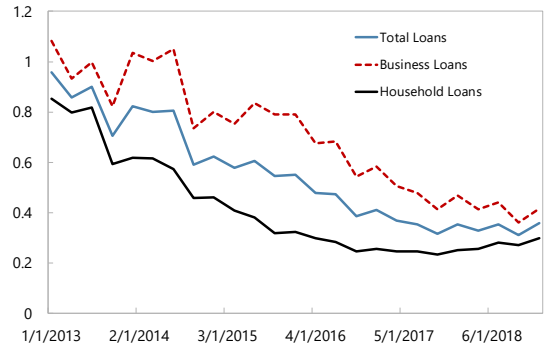
…and across Korean commercial banks.

Capital Adequacy
(Commercial Banks, total capital in percent of risk-weighted assets)



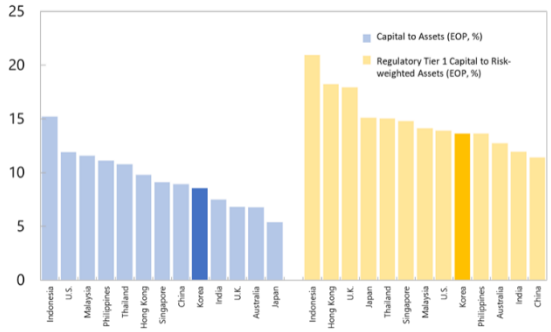
NPLs are low across all loan categories…

Bank Asset Quality
(Non-performing loans in percent of total loans, commercial banks)



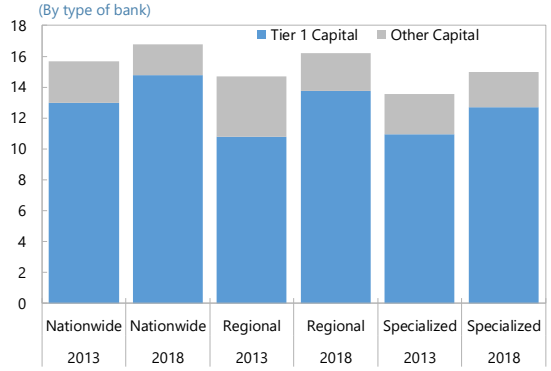
…and capital is of high quality compared to a broad set of comparator countries.

Capital Adequacy and Leverage
(Commercial banks, 2019Q2 or latest, in percent)



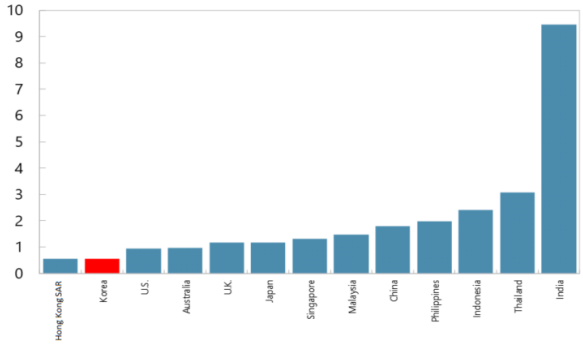
Specialized banks have seen also some improvement in capital adequacy but from a lower base.

Capital Adequacy
(By type of bank)



…and in comparison, to other jurisdictions reflective of rapid disposable of bad loans to asset management companies.

Bank Asset Quality
(Non-performing loans in percent of total loans, 2019Q1 or latest)



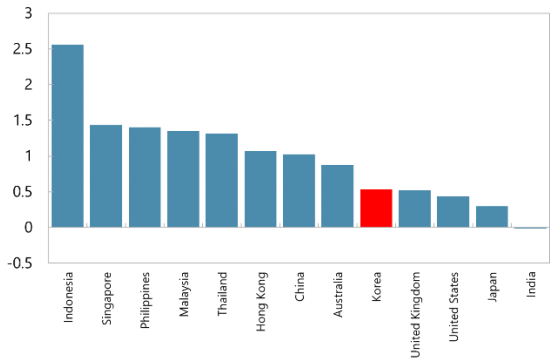
Sources: FSS, Haver, and IMF staff calculations.

Figure 5. Korea: Bank Profitability (Significant Institutions):[1] Key Trends

Korean banks have experienced comparably low profitability relative to neighboring economies in the region.

Return on Assets (ROA)[2]

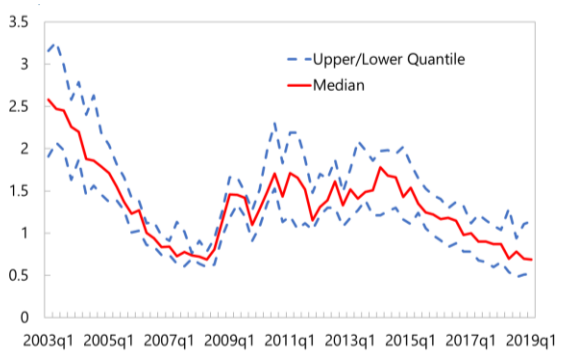
(Percent, 2019Q1 or latest)



Bank asset quality has been improving since 2013, though there has recently been some dispersion across banks.

NPL ratio

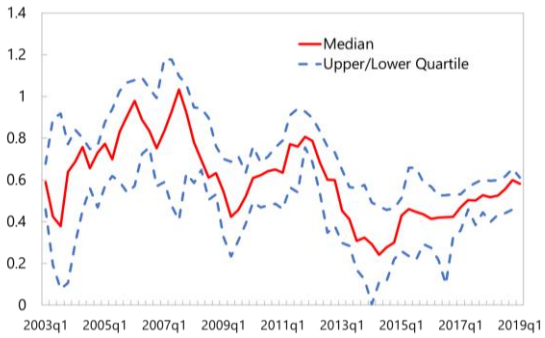
(Percent)



While NPL ratios are dispersed across banks, there is no significant dispersion in profitability…

Return on Assets (ROA)

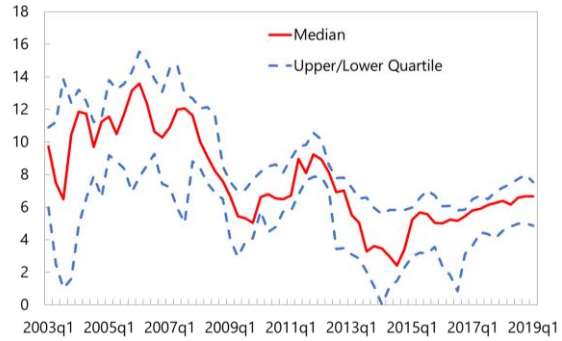
(Percent)



…though across all quartiles, profitability remains low.

Return on Equity (ROE)

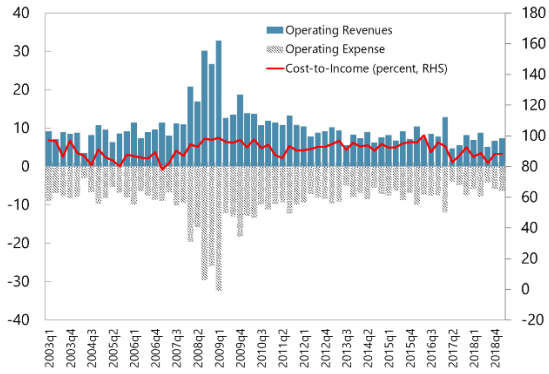
(Percent)



Bank's cost-to-income ratio has remained stable since the GFC…

Cost-to-Income

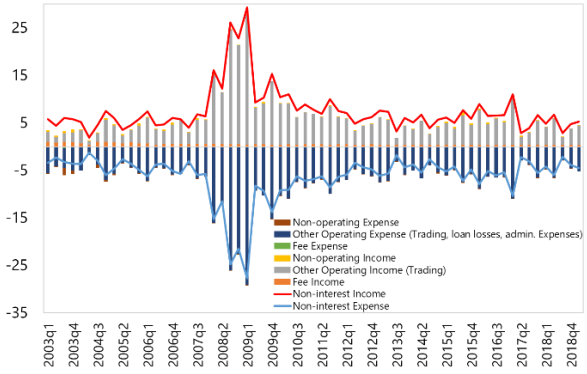
(Percent of total assets)



…with trading income making up a significant portion of non-interest income.

Non-interest Components

(Percent of total assets)



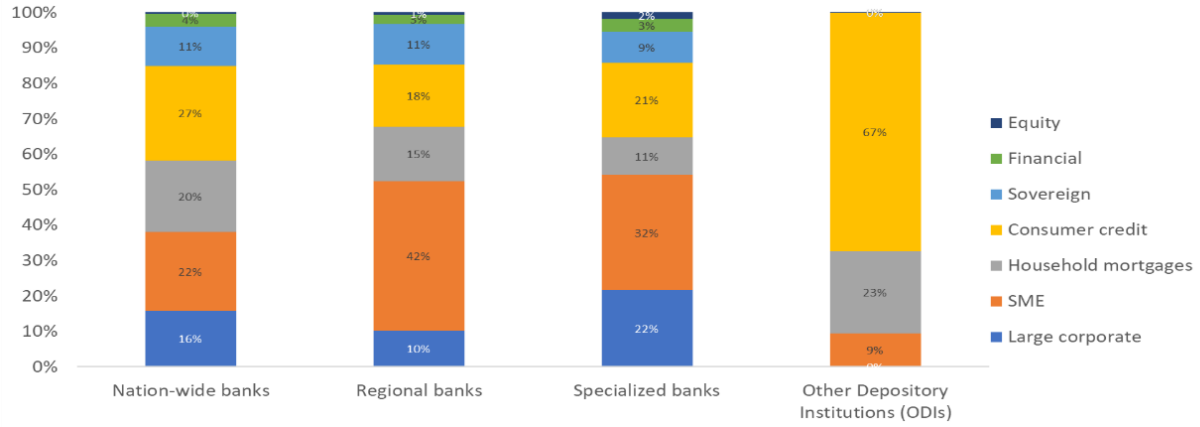
Sources: Haver, FISIS, IFS.

[1] Includes commercial and specialized banks that are currently active.

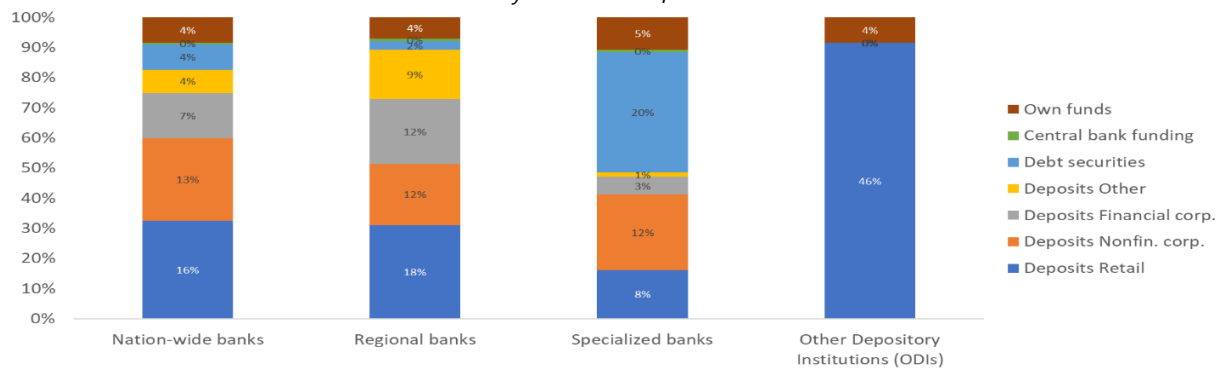
[2] Includes internet-only banks.

Figure 6. Korean Banks' Asset Portfolio Structure, Liability Structure, and P&L Components

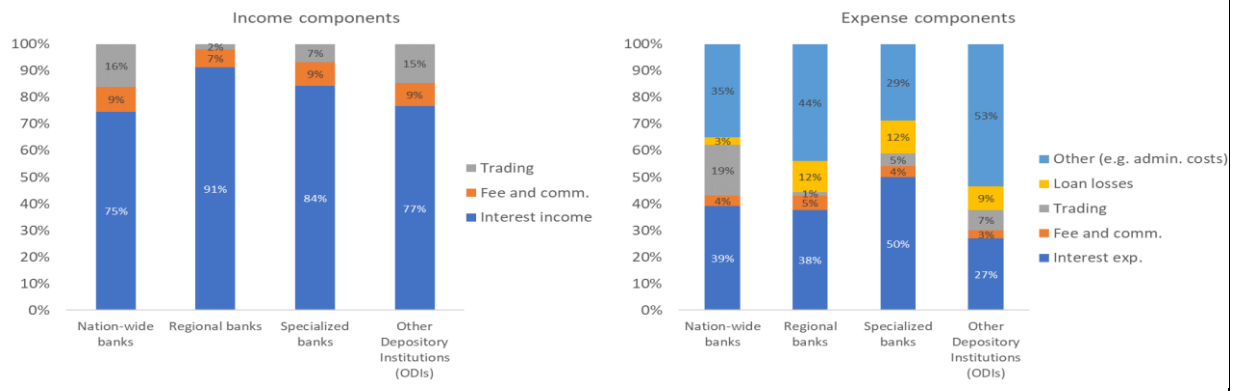
Korean banks' asset portfolio structure as of end-2018



Liability structure as of end-2018



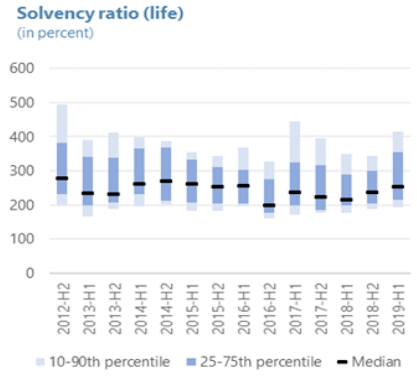
P&L as of 2018



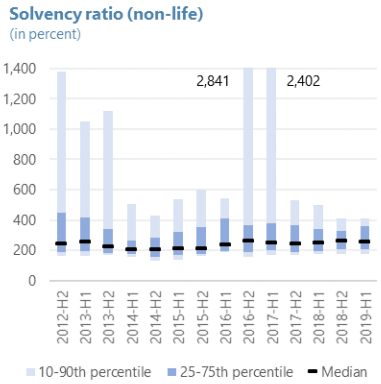
Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.
Notes: Based on data for underlying 8 nation-wide banks, 5 regional banks, 6 specialized banks, and 2,316 ODIs (888 Credit Unions, 79 Mutual Savings Banks, 1,122 Agricultural Cooperatives, 90 Fisheries Cooperatives, 137 Forestry Cooperatives).

Figure 7. Korea: Solvency and Profitability of the Insurance Sector

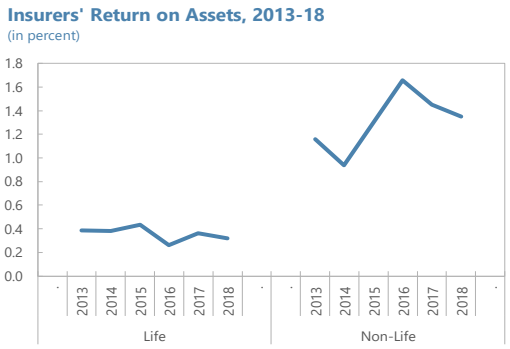
The life sector records a median solvency ratio of 239 percent, above the 100 percent minimum requirement.



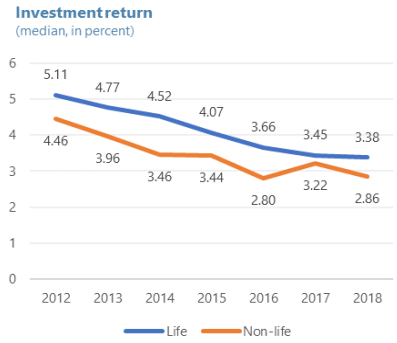
For the median non-life company, the solvency ratio stands at 263 percent, the highest ratio since 2012.



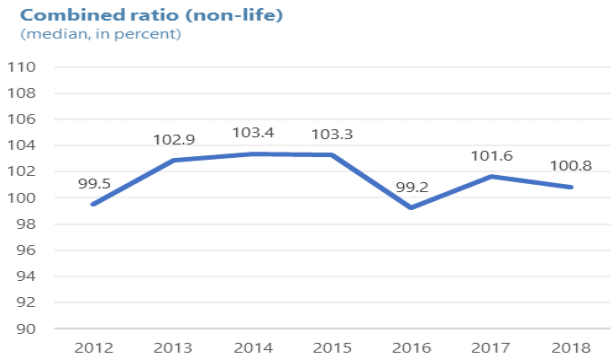
Profitability in life insurance is weak with returns on assets well below the non-life sector.



Investment returns have been steadily declining in recent years.



The combined ratio in non-life hovers above 100 percent, mainly driven by underwriting losses in health insurance.



Source: IMF staff calculations based on FSS data.

B. Macro-Financial Environment

12. Macro-financial stability in Korea remains vulnerable to external shocks. Korea's economy is very open and closely integrated with international supply chains. The export-oriented manufacturing sector, accounting for about a quarter of GDP, comprises Korea's steel, telecommunications equipment, electronics, auto, and shipping industries. Production is concentrated, with the top five conglomerates dominating the Korean stock index.

13. The macroeconomy has performed well since the last FSAP but faces headwinds. GDP growth was robust at around 3 percent in 2017 and 2018, reflecting strong export growth and business and construction investment. The semiconductor industry, a stable driver of South Korea's growth, has experienced a cyclical slowdown. Growth is expected to remain sluggish (Table 4) due to ongoing trade tensions and low business confidence, notwithstanding a boost from monetary and fiscal policy easing. Cross-border financial flows have been volatile, while the Korean won has depreciated partly on the back of trade tensions between the United States and China.

14. The financial cycle has reached an advanced phase with household debt among the highest for OECD countries (Figure 8). Financial conditions in mid-2019 were close to historical average after several years in easy territory, while the recent monetary policy loosening should counter the impact of rising market risks somewhat. The ratio of total non-financial private sector debt to GDP has reached an elevated level—standing close to 200 percent—and core debt (debt of the non-financial sector owed to banks) amounts to about 130 percent of GDP, which is high in international comparison. Although the trend has been upward, an accelerating trend is not evident. The credit-to-GDP gap is close to zero. After some deleveraging, corporate credit growth has picked up again, particularly to the SME sector driven by sole proprietors and often secured by lending against real estate.

15. The upward trend in house prices has moderated, but household leverage in real estate remains high (Figure 9). Housing supply has expanded over recent years and large sections of the financial sector are exposed to the housing market. Household lending growth, primarily related to housing, has slowed but remains above nominal GDP growth while household debt as a ratio of disposable income stands at about 180 percent, which is among the highest across the OECD countries.

16. Demographic shifts are posing a long-term challenge for the financial sector (Figure 10). By 2050 almost 40 percent of the population is expected to be older than 65, up from 13 percent now, while the working-age population will shrink significantly given Korea's low birth rate. One implication is that the proportion of debt held by older households will increase, also reflecting reverse mortgages promoted by the KFHC, and the DSTI may rise significantly. Adverse demographic developments are having an impact on capital flows as a rising share of growing retirement savings is invested abroad by pension funds, insurance firms, and asset management companies. This demographic shift, combined with competitive pressures from China, has raised concerns that Korea might be destined for a prolonged period of low growth and inflation with an erosion of its financial buffers. Structural changes and long-term implications that these demographic shifts are expected to exert on banks, insurers and other economic agents will be discussed later in this note.

17. The rapid rise in COVID-19 virus cases in South Korea since February 2020 likely implies a significant drag on economic activity, which is being tempered by a proactive policy response of Korea's government. The Korean authorities have taken bold steps to contain the COVID-19 outbreak and mitigate its impact on public health and the economy, including through large-scale testing of the population to rapidly identify, isolate, and treat infected patients. The Korean government is also using its fiscal space to mitigate the macroeconomic impact of the

outbreak, including through a proposed KRW 11.7trn (0.6 percent of GDP) supplementary budget that provides resources to step up disease control efforts, support small merchants and SMEs, provide transfers to sustain consumption and employment, and support local economies hit hardest by the spread of COVID-19[7].

C. Korean Housing Market Structure and Dynamics

18. House prices appear to have developed in line with fundamentals at the national level, but regional heterogeneity can be observed (Figure 9). Korean nominal house price growth has moderated since the GFC. Nation-wide median house price and apartment price to disposable income ratios have trended upward to an extent since 2014 (sub-figure 3 in Figure 9). Debt-to-income ratios have been rising steadily since 2010 for younger age cohorts (up to age 50), and also for people at 60 and above. A model-based valuation, based on regional data, points to overvaluations in the Seoul market and the larger capital region of 10 percent and 5 percent respectively. More rural areas have seen house prices increase less than fundamentals in relation to income and mortgage interest rates would have predicted[8].

19. The leasehold deposit market (Jeonse) is a unique feature of the Korean financial system and implies potential vulnerabilities for the Korean real estate market. Jeonse tenants give landlords a deposit equivalent to on average about 50-70 percent of the house price that is to be paid back to the tenant at the end of the two-year contract, if the lease contract is not extended[9]. To finance these deposits, tenants often turn to banks for Jeonse loans which doubled to KRW 72.2trn since 2014, while loan-to-deposit ratios have increased to 42 percent in 2018. In lieu of rental income, Jeonse landlords then rely on house price increases and return on any financial investments made using the Jeonse deposit. Given that landlords do not accrue a yield on Jeonse properties, in the cases where the Jeonse deposit is used to fund the property purchase, the total return on such an investment is entirely dependent on house price increases. Consequently, the investment in Jeonse properties is not sustainable in an environment in which house prices would fall over an extended period.

20. The rollover risk of Jeonse contracts could amplify negative shocks to house prices and the prices of financial assets. In a severe adverse scenario in which Jeonse deposit prices would fall, landlords may have to cover the resulting capital shortfall using their own funds. If this is done by selling financial assets, this would put pressure on asset prices. In an extreme case, landlords may need to sell their properties, which would further amplify the fall in house prices. An assessment conducted by the BOK shows that following a 20 percent fall in the Jeonse deposit price, about 78 percent of landlords could cover total leasehold deposits with their own financial assets, while a remaining 22 percent would need an additional loan[10].

[7] Assessment as of March 2020.
[8] For an additional assessment in terms of house price dynamics see the Korea 2019/20 Technical Note titled "Macroprudential Policy Framework and Tools".
[9] The Jeonse deposit price is determined by demand and supply conditions in the Jeonse market. Historically, the leasehold deposit to house price ratio has been relatively stable over time.
[10] The Bank of Korea, Financial Stability Report (June 2018), assumed a 20 percent fall in the Jeonse deposit price and a 13 percent house price fall. Financial assets were limited to accumulations and deposit-type savings with high liquidity, and mortgage loans to those on housing currently being resided in.

21. The authorities need to be vigilant on the following aspects of the Jeonse market structure: (i) who the ultimate holder of risk is and potential claims on the public exchequer; (ii) a rise in rollover risk of Jeonse contracts; and (iii) negative shocks to house prices and the economy more broadly could be amplified through adverse conditions in the Jeonse market. The potential vulnerability associated with household leverage with Jeonse leasing of their properties, possibly in addition to bank debt, could be mitigated by a policy tool that can consider and capture various factors, including the combined value of mortgage and Jeonse deposits, dynamics between house prices and Jeonse prices, and Jeonse loans held by tenants.

22. The public sector has a large footprint in the housing market. The Korean Housing-Finance Corporation (HF) offers a number of products with both a social function and a risk-sharing objective. The HF engages in direct funding of mortgages with funding from the Ministry of Land, Infrastructure and Transportation. It also offers subsidized mortgage loans to lower income households via banks, which are then securitized by the HF[11]. The HF securitizes non-subsidized long-term mortgages and total MBSs issued and guaranteed by the HF amounts to 116tr KRW, a large portion of which are held by insurance companies. The HF also guarantees other housing-related loans, including loans using Jeonse deposits as collateral and loans by landlords needed to cover falls in Jeonse deposit prices[12]. The HF offers reverse mortgages to the rapidly growing group of low-income pensioners. There is lack of transparency regarding the public sector's total contingent liabilities related to the housing market and whether the capital buffers held are adequate. While housing market subsidies and guarantees may have a social function, it is not clear to what extent these distort the market price of risk.

D. Scope of the Systemic Risk Analysis

23. The FSAP risk analysis covers the banking and insurance sector. The analysis as presented in this note was based on public and supervisory data for 24 banks, covering 95 percent of banking system assets at end-2018. Five banks of the 24 are sub-aggregates, forming the ODI category (Credit Unions, Mutual Savings Banks, credit cooperative banks). Table 5 lists the banks in-scope of the banking system stress test, including information about their D-SIB status.

24. Seven life and six non-life insurers were included in the insurance sector stress test. In terms of end-2018 balance sheet assets, the analysis covers 73 percent and 76 percent of the life and non-life sector, respectively. Table 6 presents the main characteristics of the insurance undertakings included in the analysis.

[11] These loans, known as Didimdol and Bogeumjari, are available to households meeting certain criteria regarding income, price of property, size of property, mortgage loan size and LTV.
[12] There are two additional housing market insurers, one private (Seoul Guarantee Insurance) and one public (Housing and Urban Guarantee Corporation).

Table 4. Korea: Selected Economic Indicators, 2017–24

			Projections					
	2017	2018	2019	2020	2021	2022	2023	2024
Real GDP (percent change)	3.2	2.7	2.0	2.2	2.7	2.9	2.9	2.9
Total domestic demand	5.6	1.7	2.0	1.8	2.9	3.1	3.1	3.1
Final domestic demand	5.2	1.5	1.2	3.0	2.9	3.1	3.1	3.1
Consumption	3.1	3.5	3.0	3.3	3.0	3.2	3.2	3.3
Gross fixed investment	9.8	-2.4	-2.6	2.3	2.7	2.8	2.8	2.8
Stock building 1/	0.4	0.2	0.7	-1.1	0.0	0.0	0.0	0.0
Net foreign balance 1/	-2.2	1.2	0.0	0.5	0.0	0.0	-0.1	-0.1
Output gap (percent of potential GDP)	-0.7	-0.7	-1.2	-1.5	-1.3	-0.9	-0.5	-0.1
Nominal GDP (in trillions of won)	1,836	1,893	1,922	1,966	2,043	2,136	2,238	2,350
Saving and investment (in percent of GDP)								
Gross national saving	36.9	35.8	34.9	33.8	33.6	33.3	33.0	32.8
Gross domestic investment	32.3	31.3	31.7	30.9	30.7	30.4	30.1	29.9
Current account balance	4.6	4.4	3.2	2.8	2.9	2.9	2.9	2.9
Prices (percent change)								
CPI inflation (end of period)	1.4	1.3	0.7	0.9	1.4	1.8	1.9	2.0
CPI inflation (average)	1.9	1.5	0.5	0.9	1.4	1.8	1.9	2.0
Core inflation (average)	1.5	1.2	...	...	...	...	...	...
GDP deflator	2.2	0.5	-0.4	0.1	1.1	1.6	1.8	2.0
Real effective exchange rate	3.1	0.9	...	...	...	...	...	...
Consolidated central government (in percent of GDP)								
Revenue	21.8	23.0	22.8	22.5	22.6	22.7	22.7	22.7
Expenditure	19.6	20.4	22.0	23.3	23.9	24.0	24.1	24.1
Net lending (+) / borrowing (-)	2.2	2.6	0.8	-0.7	-1.2	-1.3	-1.3	-1.3
Overall balance	1.3	1.6	-0.2	-1.8	-2.3	-2.4	-2.4	-2.4
Excluding Social Security Funds	-1.0	-0.6	-2.5	-4.0	-4.4	-4.4	-4.3	-4.2
Structural primary balance	1.4	1.8	0.1	-1.2	-1.7	-1.8	-1.9	-2.0
Fiscal impulse (+ expansionary)	-0.3	-0.4	1.6	1.3	0.5	0.1	0.1	0.1
General government debt	37.7	37.9	39.9	43.2	46.1	48.6	50.9	52.9
Money and credit (end of period)								
Overnight call rate	1.6	1.9	...	...	...	...	...	...
Three-year AA- corporate bond yield	2.7	2.3	...	...	...	...	...	...
Credit growth	6.3	6.1	5.9	5.9	5.9	5.9	5.9	6.9
M3 growth	6.6	7.2	...	...	...	...	...	...
Balance of payments (in billions of U.S. dollars)								
Exports, f.o.b.	580.3	625.4	578.0	570.1	592.2	619.6	648.1	681.6
Imports, f.o.b.	466.7	513.6	500.7	501.2	521.8	545.3	571.4	602.4
Oil imports	59.6	78.4	70.8	66.2	66.3	67.9	70.7	74.2
Current account balance	75.2	76.4	52.8	46.4	49.5	51.5	55.0	58.2
Export volumes (percent change)	5.3	6.1	-2.4	3.0	3.5	3.6	3.5	3.5
Import volumes (percent change)	8.6	1.6	-1.9	1.7	3.9	4.0	4.0	4.0
Gross international reserves (end of period) 2/	384.5	398.9	400.6	398.6	405.2	417.4	435.8	461.4
In percent of short-term debt (residual maturity)	227.2	226.8	220.9	213.3	209.8	209.3	212.2	218.3
External debt (in billions of U.S. dollars)								
Total external debt (end of period)	412.0	448.8	485.5	523.2	562.7	603.1	644.3	686.4
Of which: Short-term (end of period)	116.0	122.6	128.1	133.5	139.8	146.1	152.1	158.0
Total external debt (in percent of GDP)	25.4	26.1	29.7	32.0	32.9	33.5	34.1	34.4
Debt service ratio 3/	8.2	8.8	10.1	10.8	11.4	11.9	12.2	12.8

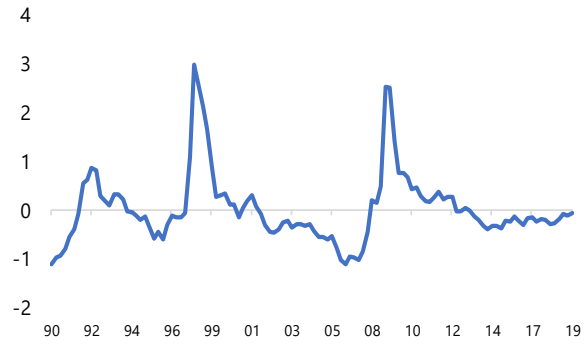
Sources: Korean authorities; and IMF staff estimates and projections.

1/ Contribution to GDP growth.
2/ Excludes gold.
3/ Debt service on medium- and long-term debt in percent of exports of goods and services.

Figure 8. Korea: Macrofinancial Environment

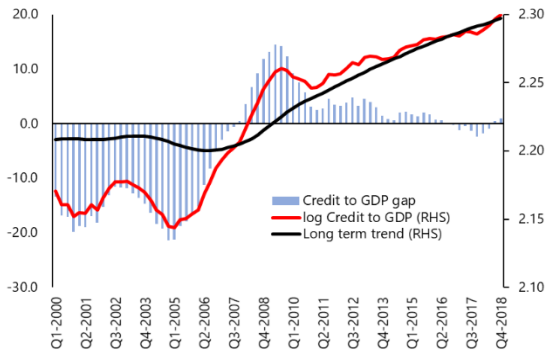
Financial conditions have slightly tightened…

Financial Conditions Index (IMF GFSR Methodology)



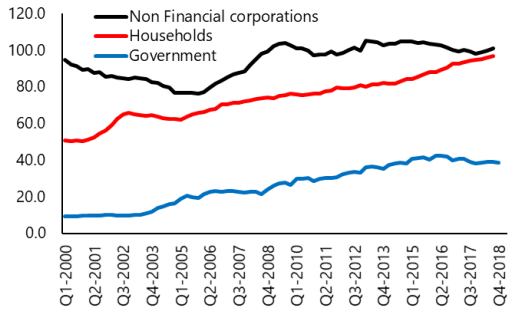
…while the credit gap has narrowed as the trend caught up

Credit Gap



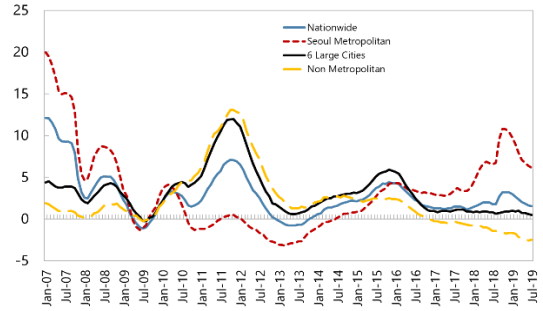
Leverage has increased significantly for households…

Leverage



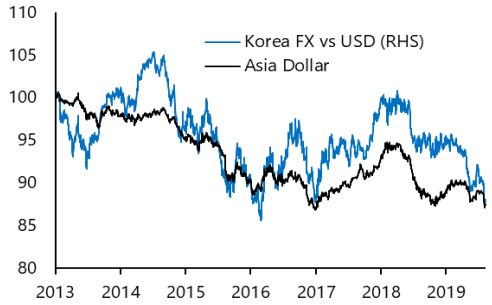
…on the back of a strong housing market.

Kookmin Bank House Price Indices



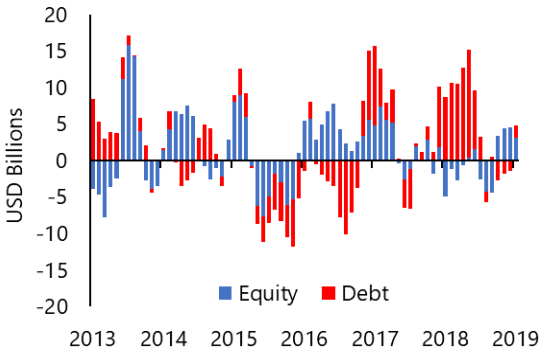
Korean Won has caught up with Asian peers…

Exchange Rates



…while portfolio flows have held up so far despite the recent global trade frictions and tech downturn

Portfolio Flows

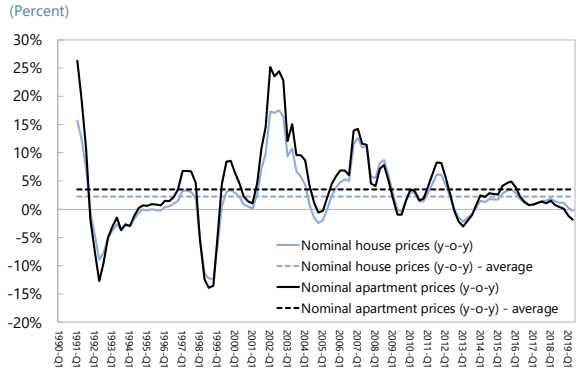


Sources: Bloomberg, IIF, BIS, Haver, IMF staff calculations.

Figure 9. Korea: Housing Market

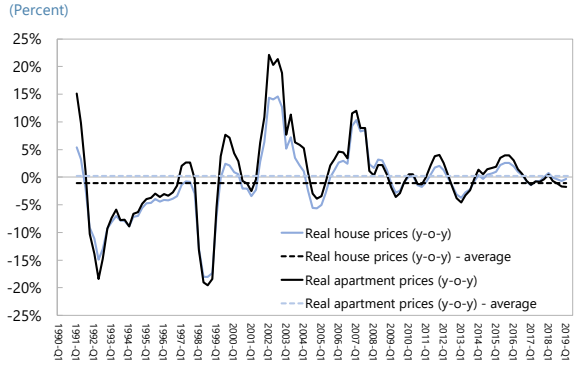
National house price growth has stabilized since the GFC

Figure 1. Korean nominal house and apartment prices y-o-y



Real house price growth at the national level has averaged close to zero percent in the past 30 years

Figure 2. Korean real house and apartment prices y-o-y

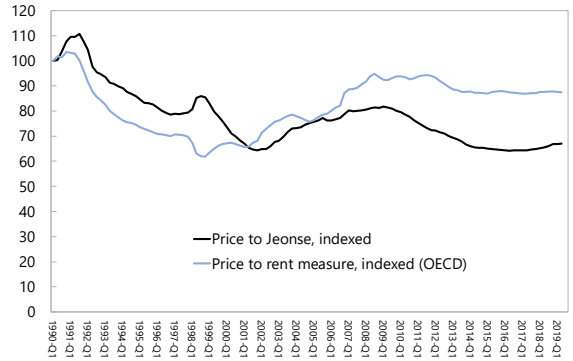


House prices and apartment prices relative to disposable income per household have trended up since 2014.

Figure 3. Median house and apartment prices to annual disposable income per household ratios

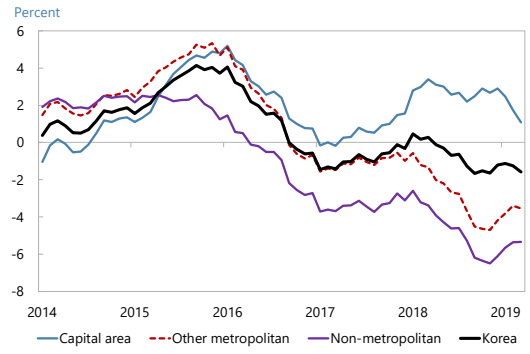
...and the yield on residential properties has been relatively stable in the past 5 years

Figure 4. Price to rent measures



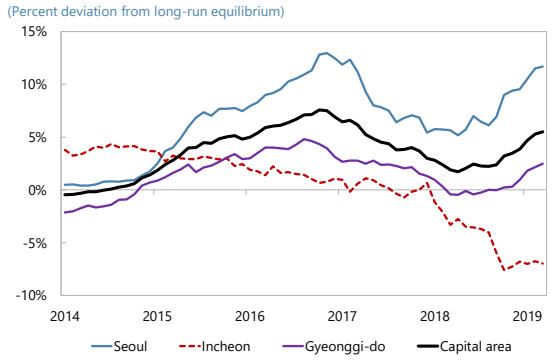
There are large regional variations in house price growth.

Figure 5. Real terms apartment price growth in Korean regions



...econometric analysis points to overvalued house prices in some areas, particularly in Seoul

Figure 6. Model-based valuation measure, capital area apartments



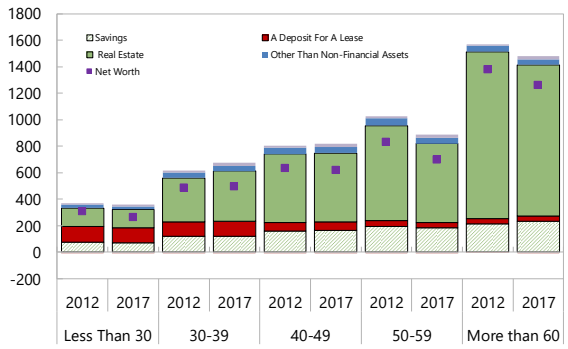
Sources: Haver, KOSIS, OECD, CEIC, and IMF staff calculations.

Notes: The disposable income series in the denominator of the median house price and apartment price to income ratios in sub-figure 3 are trailing 4-quarter sums of quarterly disposable income flows.

Figure 10. Korea: Demographics Shift and Household Debt

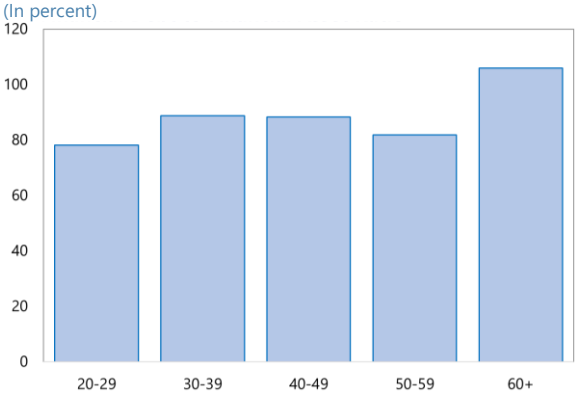
HH assets have risen since 2012 across all age groups.

Assets Holdings, By Age
(In percent of disposable income)



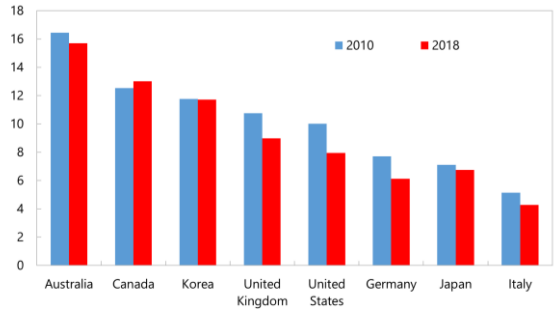
HH leverage tends to be more concentrated among the population of adults older than 60 years.

Financial Debt to Financial Asset Ratio
(In percent)



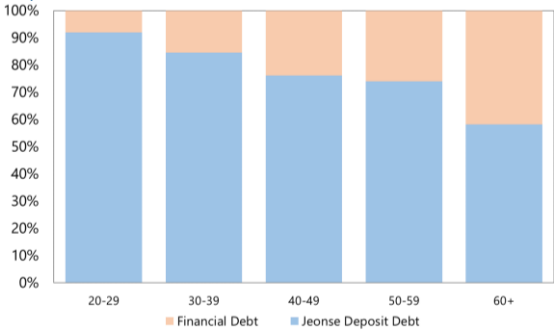
Households' debt service to income ratio has remained stable since 2010, though is relatively high compared to other advanced economies.

Debt Service to Income Ratio
(In percent)



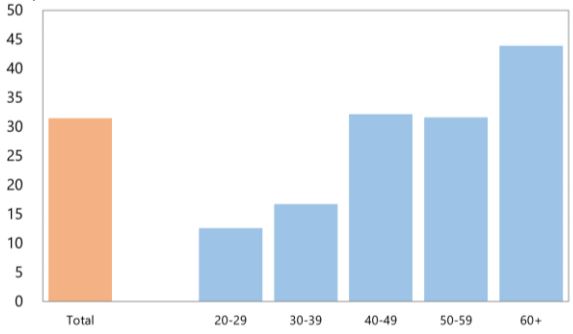
Older aged households are more likely to hold Jeonse deposit debt.

Household Debt Decomposition by Age Group
(In percent)



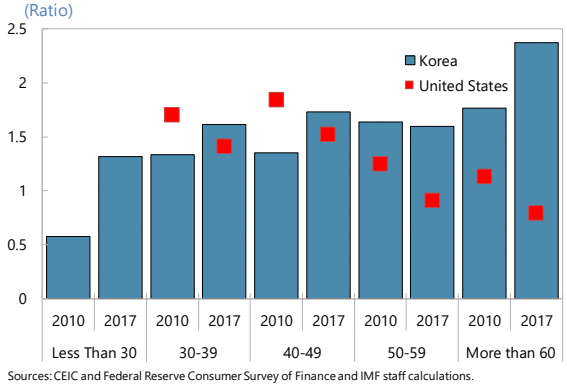
A significant share of household debt is secured against a second property, most of which is concentrated in older aged households.

Household Debt Secured by Second Property
(In percent)



Since 2012, household leverage in Korea (measured through DTI), has risen across younger age cohorts (up to age 50), but also for people aged 60 and above.

Debt-to-Income, by Age
(Ratio)



Sources: CEIC and Federal Reserve Consumer Survey of Finance and IMF staff calculations.

Sources: Haver, KOSIS, and IMF staff calculations.

Table 5. Korean Banks In-Scope of the Systemic Risk Analysis and Stress Test

FI	Full name	Category	TA end-2018	% in total	Legal basis for	Licensing	Prudential regulator	Prudential supervisor	Deposit insurer	Accounting regime	Reg. regime		CB funding	In-scope of		Active abroad	D-SIB in 2019/20	CCB and CCyB	LCR and NSFR	Loan to dep. reg.	FI
											STA	IRB		FSS/STARS	BOK/SAMP						
1	Kookmin Bank	Nationwide banks	356,959	11.9%	Banking Act	FSC	FSC	FSS	KDIC	IFRS 9	1	1	1	yes	yes	1	1	1	1	1	1
2	Shinhan Bank		348,524	11.6%							1	1	1			1	1	1	1	1	2
3	KEB Hana Bank		340,253	11.3%							1	1	1			1	1	1	1	1	3
4	Woori Bank		340,447	11.3%							1	1	1			1	1	1	1	1	4
5	Standard Chartered Korea (FSub)		65,015	2.2%							1	1	1					1	1	1	5
6	Citibank Korea (FSub)		45,115	1.5%							1		1					1	1	1	6
7	KakaoBank of Korea Corp. (IOB)		12,127	0.4%							1		1					1	1	1	7
8	K bank (IOB)		2,185	0.1%							1		1					1	1	1	8
9	Pusan Bank	Regional Banks	53,035	1.8%							1	1	1			1		1	1	1	9
10	Daegu Bank		49,785	1.7%							1	1	1			1		1	1	1	10
11	Kyoungnam Bank		37,937	1.3%							1	1	1					1	1	1	11
12	Kwangju Bank		23,042	0.8%							1	1	1					1	1	1	12
13	Jeonbuk Bank		18,242	0.6%							1		1			1		1	1	1	13
14	Jeju Bank		5,981	0.2%							1		1				1	1	1	1	14
15	Industrial Bank of Korea	Specialized Banks	289,509	9.6%	Individual legislation enacted by National Assembly			FSS and Board of Audit and Inspection			1	1	1			1		1	1		15
16	NongHyup Bank		283,251	9.4%							1	1	1			1	1				16
17	Korea Development Bank		226,373	7.5%							1	1	1			1		1	1		17
18	The Export-Import Bank of Korea		90,367	3.0%							1		1			1		1			18
19	Suhyup Bank		37,287	1.2%							1		1								19
20	Credit Unions (929 entities)	Other Depository Institutions (ODIs)	90,844	3.0%	CU Act			FSS & Fed.	Federation	K-GAAP											20
21	Mutual Savings Banks (79)		69,516	2.3%	MSB Act			FSS	KDIC	K-GAAP/IAS39	1										21
22	Agric. Cooperatives (1,122)		377,632	12.6%	ACoop Act	MoAFRA		FSS & Fed.	Federation	K-GAAP											22
23	Fisheries Cooperatives (90)		30,282	1.0%	FiCoop Act	MoOaF		FSS & Fed.	Federation	K-GAAP											23
24	Forestry Cooperatives (137)		7,195	0.2%	FoCoop Act	KFS		FSS & Fed.	Federation	K-GAAP											24
25	Community Credit Coop. (ca. 1,300)		162,735	5.4%	CCC Act	MoIS	MoIS in cons. w/ FSC +		Federation	-											25

Source: FSS and IMF staff.

Note: See Glossary for abbreviations used in this table. The last column (loan to deposit reg.) denotes whether the loan to deposit ratio-based regulatory constraints are relevant or not for a given bank (see FSS Handbook for details about the regulation). The FSS/STARS and BOK/SAMP models are the FSS' and BOK's top-down stress test model frameworks. All information provided in the table refers to end-2018.

Table 6. Korea: Insurance Firms Included in the Stress Test

	Sector	Total Assets (KRW trillion)	RBC Ratio
Hanwha Life	Life	114.3	212%
Kyobo Life	Life	101.5	312%
NongHyup Life	Life	64.7	195%
Orange Life	Life	32.7	425%
Samsung Life	Life	262.2	314%
Shinhan Life	Life	32.0	239%
Tongyang Life	Life	31.9	205%
DB Insurance	Non-life	39.8	216%
Hyundai Marine&Fire	Non-life	43.7	219%
KB Insurance	Non-life	33.7	187%
Korean Re	Non-life	10.7	211%
Meritz Fire&Marine	Non-life	20.4	211%
Samsung Fire	Non-life	79.0	334%

Source: FSS and company data, and IMF staff calculations.

RISKS, VULNERABILITIES, AND MACRO-FINANCIAL SCENARIOS

A. Risks, Vulnerabilities, and Macro-Financial Scenarios[13]

25. The risks to consider for the Korean economy stem primarily from escalating trade tensions. Adverse macro-financial developments may be triggered by escalating global trade tensions, involving the US, China, the EU, and Japan. Geopolitical risks could, moreover, unfold despite North Korea's stated commitment to denuclearization, with the related diplomatic process appearing to be repeatedly prone to breakdown; albeit the news related to North Korea have recently abated.

26. The structural macro-financial conditions against which such broad-based risks are judged to have an impact upon materialization include Korea's export orientation and notable Fintech developments. Relevant structural features include Korea's strong reliance on

[13] Definition of risks and vulnerabilities: By vulnerabilities we denote features of the macro-financial system that can be of cyclical or structural nature, which imply the potential for adverse macro-financial dynamics to unfold as a result of shocks. The notion of risk is equated to triggers, which set an adverse development in motion. The product of a probability of a risk to materialize (small) and "loss given materialization" of a risk (shall be large) in macroeconomic terms is to be material for the Korean economy, for the risk (trigger) to be considered as a basis for a scenario narrative. The probability (of a trigger) will remain subjective.

exports, its limited export diversification, its strongly intertwined network of interdependencies across firm conglomerates, rising competition from new financial firm types (Fintech), and adverse demographic developments. Fintech developments such as the Open Banking initiative that was launched in December 2019 as well as the growing popularity of e-money providers imply changing liquidity dynamics, with implications for solvency (through competition) and system-wide operational risks.

27. The adverse macro-financial scenario narrative is rooted in the escalation of global trade tensions. Upon it being triggered, the scenario is assumed to entail a broad-based, world-wide sell-off in equity markets, reflecting a general fall in investors' risk appetite. Korea would face significant capital outflows, coupled with strong currency depreciation, due to its close ties with China in terms of trade, and hence being close to the epicenter of the escalating trade tensions and very directly hit by a global slow-down in trade through falling export and import flows. [14,15]

28. The scenario would imply pressure on export-oriented Korean firms and adverse spillover effects to domestic demand through various channels (higher unemployment, drop in income, depressed confidence, etc.). The activities of large firm conglomerates in Korea would be significantly disrupted due to their cross-border supply-chain interconnectedness[16]. Firms' and households' expectations would turn adversely and imply for investment activity and private consumption to drop in anticipation of a slow-down of activity in the medium-term future, thereby further pressuring real activity in the short-term (expectation channel). Interest rate-based monetary policy would have less room to stimulate demand (through the credit channel) since interest rates are structurally lower at the outset of the scenario horizon, compared to the monetary policy stance ahead of the GFC.

29. Table 7 presents the baseline and adverse scenario calibration for a set of core macro-financial variables[17]**.** The baseline scenario is aligned with the IMF's October 2019 WEO. The adverse scenario was assumed to start unfolding from the first quarter of 2019 onward. The scenario horizon covers the 20-quarter period from 2019Q1-2023Q4[18]. A chart collection corresponding to the variables in Table 7 is presented in Figure 11. The adverse scenario has been calibrated such that

[14] China, the US and Japan constitute about 35, 15 and 7 percent of Korea's total export flows in 2018. Korea received about 25, 14, and 13 percent of its total imports from these three countries in 2018. These shares suggest a notable exposure to precisely those countries that are at the center of the trade dispute (US and China), and the more bilateral tensions with Japan in addition.

[15] Such capital outflows would distress banks' liquidity, particularly in FX, directly through funding and liquid asset valuation shocks and indirectly through NFCs export revenues given the importance of trade in the Korean economy. The channels through which Korean banks and NFCs access FX, including the importance of the interbank swap market and related high interconnectedness of banks, will also determine the extent of FX liquidity risk in such a scenario.

[16] For example, Korea and China are very much intertwined in terms of supply chains for semiconductors that China imports from Korea to produce smartphones and other electronics, which then are exported back to Korea.

[17] A regime-switching structural vector autoregressive model framework has been employed for the purpose of quantifying the external demand shock scenario deviations for Korea. The base variant of the model contains real GDP growth, GDP deflator inflation, house prices, interest rates, and the USD-KRW exchange rates. Numerous variants of the model were considered, considering the inclusion and exclusion of numerous variables, exploring different lag structures, etc., in order to assess the robustness of the resulting scenario trajectories.

[18] The solvency position of the financial institutions that are in-scope of the quantitative risk analysis will be assessed *along* the scenario horizon (i.e. not only at the end of the scenario horizon). Emphasis will be placed on the "low-point" (minimum capital ratios) for each bank along the scenario horizon.

the first year's real GDP growth matches an estimate implied by the Growth-at-Risk (GaR) framework that the IMF FSAP team has implemented for Korea. The GaR estimate corresponding to a 5 percent tail probability equals about -3.1 percent year-on-year for the year 2019. The real GDP shock severity corresponds to an approximate 2.1x standard deviation multiple (2-year cumulative) in historical perspective.

Table 7. Korea: Baseline and Adverse Macro-Financial Scenario—Main Features

		GDP			CPI infl. (annual av.)	CPI core infl. (annual av.)	URX (annual av.)	STN (annual av.)	LTN (annual av.)	Term spread (annual av.)	STN (end-year)	LTN (end-year)	Term spread (end-year)	ESX (a. av., 2018=100)	USDKRW (annual av.)	RPP (annual av., YoY)	MSCI World (end-year)	NFC credit (end-year, YoY)	HH credit (end-year, YoY)
		Real	Nominal	Defl. infl.															
2018		2.7%	3.0%	0.3%	1.5%	1.2%	3.8%	1.5%	2.5%	0.9pp	1.6%	2.2%	0.6pp	100.0	1100	2.2%	100.0	6.4%	6.1%
Baseline	2019	2.0%	1.6%	-0.4%	0.5%	0.7%	4.0%	1.8%	2.3%	0.5pp	1.9%	2.4%	0.5pp	90.4	1126	2.8%	106.4	4.3%	5.2%
	2020	2.2%	2.3%	0.1%	0.9%	0.5%	3.9%	2.0%	2.6%	0.6pp	2.1%	2.7%	0.6pp	90.4	1126	2.0%	112.6	4.6%	5.4%
	2021	2.7%	3.8%	1.1%	1.4%	0.9%	3.9%	2.1%	2.9%	0.7pp	2.2%	3.0%	0.8pp	90.4	1126	2.0%	119.1	5.1%	5.7%
	2022	2.9%	4.5%	1.6%	1.8%	1.0%	3.8%	2.3%	3.1%	0.8pp	2.4%	3.2%	0.9pp	90.4	1126	2.0%	126.1	5.1%	5.7%
	2023	2.9%	4.8%	1.8%	1.9%	1.1%	3.7%	2.4%	3.4%	1.0pp	2.5%	3.5%	1.0pp	90.4	1126	2.0%	133.4	5.2%	5.8%
Adverse	2019	-3.1%	0.2%	3.4%	4.4%	1.7%	4.8%	1.3%	4.5%	3.2pp	1.0%	4.5%	3.5pp	61.4	1432	-2.5%	72.0	1.8%	1.4%
	2020	-2.0%	-4.3%	-2.3%	-1.5%	0.3%	6.3%	0.3%	3.7%	3.4pp	0.2%	3.4%	3.2pp	55.8	1190	-8.8%	75.9	-1.8%	-1.7%
	2021	2.9%	-0.2%	-3.0%	-2.7%	-0.8%	4.1%	0.3%	3.1%	2.8pp	0.4%	3.0%	2.6pp	58.6	1181	-3.3%	80.3	-0.6%	0.6%
	2022	3.0%	4.6%	1.6%	1.8%	0.8%	3.8%	0.6%	3.1%	2.6pp	0.7%	3.2%	2.5pp	64.4	1180	2.2%	85.0	1.1%	2.3%
	2023	2.9%	4.7%	1.8%	1.9%	1.1%	3.7%	1.5%	3.4%	1.9pp	2.0%	3.5%	1.5pp	67.2	1180	2.0%	90.0	3.1%	3.7%
Deviation	2019	-5.1pp	-1.4pp	3.8pp	3.9pp	1.1pp	0.8pp	-0.5pp	2.2pp	2.7pp	-0.9pp	2.1pp	3.0pp	-32%	27%	-5.3pp	-32%	-2.5pp	-3.8pp
	2020	-4.2pp	-6.6pp	-2.4pp	-2.4pp	-0.2pp	2.5pp	-1.7pp	1.1pp	2.8pp	-1.9pp	0.8pp	2.6pp	-38%	6%	-10.8pp	-33%	-6.4pp	-7.1pp
	2021	0.2pp	-4.1pp	-4.1pp	-4.1pp	-1.7pp	0.2pp	-1.8pp	0.2pp	2.1pp	-1.9pp	0.0pp	1.9pp	-35%	5%	-5.3pp	-33%	-5.7pp	-5.1pp
	2022	0.1pp	0.1pp	0.0pp	0.0pp	-0.2pp	0.0pp	-1.7pp	0.0pp	1.7pp	-1.7pp	0.0pp	1.7pp	-29%	5%	0.1pp	-33%	-4.0pp	-3.4pp
	2023	0.0pp	0.0pp	0.0pp	0.0pp	0.0pp	0.0pp	-0.9pp	0.0pp	0.9pp	-0.5pp	0.0pp	0.5pp	-26%	5%	-0.1pp	-33%	-2.1pp	-2.1pp

Sources: IMF WEO and IMF staff calculations.

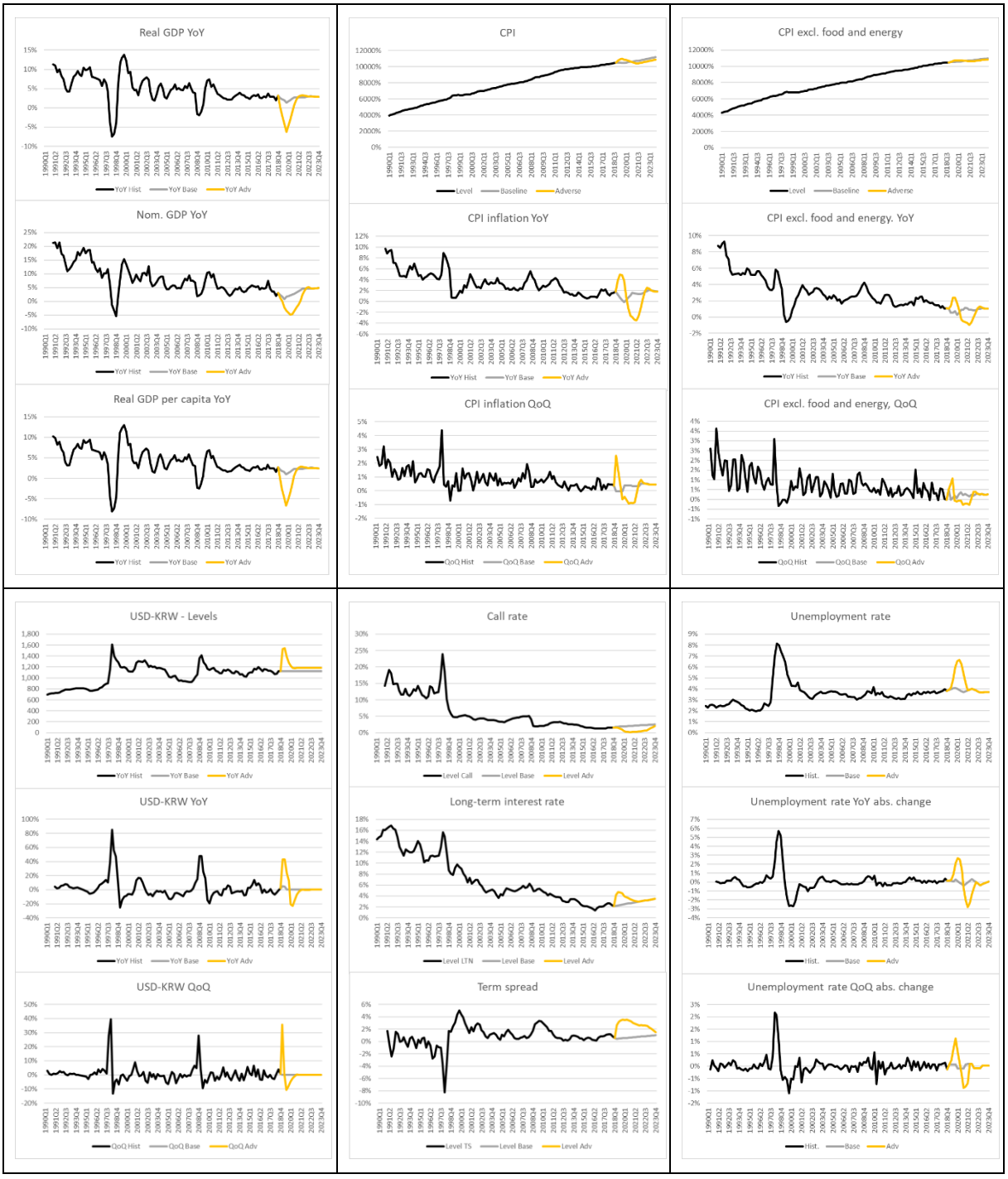
Note: URX = unemployment rate, STN = short-term money market rate (call rate), LTN = long-term interest rate (long-term sovereign bond yield), TS = term spread (LTN-STN), ESX = nominal stock prices, USDKRW = 1 USD in KRW (up means depreciation of KRW), RPP = residential property prices. MSCI World is the MSCI World Index. NFC credit = nonfinancial corporate credit stock. HH credit = household credit, including mortgages, Jeonse loans and consumer credit.

30. The IMF WEO as of April 2020 which reflects the expected impact of COVID-19 is less adverse than the adverse scenario profile considered for the FSAP. The April 2020 IMF WEO's baseline outlook for 2020 expects real GDP in 2020 to grow at -1.2 percent year-on-year, compared to a drop of -3.1 percent in the FSAP's adverse scenario. The unemployment rate is expected to move to 4.5 percent according to the April 2020 WEO, comparing to 4.8 percent in the FSAP's adverse scenario. Hence, the judgment is that the FSAP adverse scenario is sufficiently conservative conditional on the current information set as of end-April 2020 to encompass the adverse economic consequences of the COVID-19 pandemic.

31. Measures of inflation (deflator- and consumer price index-based) move up visibly in the first year of the adverse scenario. This reflects the impact of the depreciating currency through the implied rise in the costs of imports. After the value of the currency would be expected to normalize from 2020 onward, the inflation measures level off, moving temporarily into negative territory, before they recover throughout the second half of the scenario horizon.

32. Asset prices in Korea, including for real estate, would drop markedly. Asset prices would drop due to the slowdown in private sector demand for housing, inter alia for the assumed reason that loan interest rates would not fall sufficiently (to stimulate demand) because of banks being under solvency and liquidity stress and thereby implying for their funding costs to stretch to higher levels. Nation-wide nominal house prices would drop by -16 percent in cumulative terms between 2018Q4 and 2021Q2. Equity prices in Korea would drop by -39 percent from 2018Q4 to 2020Q2 (trough), before they start to recover.

Figure 11. Korea: Baseline and Adverse Macro-Financial Scenario



Sources: IMF WEO and IMF staff calculations.

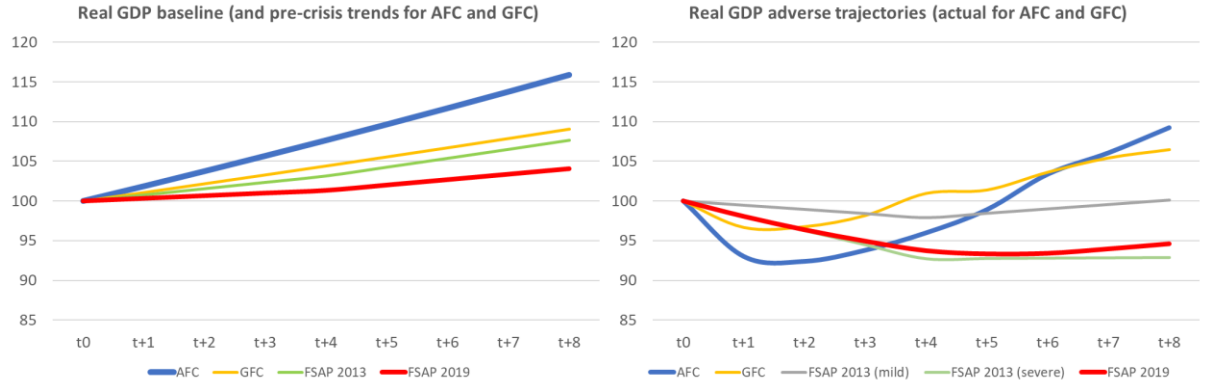
Note: The scenario is developed at quarterly frequency. The scenario horizon covers the 20-quarter period from 2019Q1-2023Q4.

33. Figure 12 shows the real GDP flow trajectories under the scenarios, along with their historical evolution during the AFC, the GFC, and the FSAP 2013 adverse scenarios. The baseline chart—involving the estimated pre-crisis trends for the AFC and GFC profiles in the figure—suggests that the FSAP 2019 baseline scenario is the weakest in comparison to the AFC, GFC pre-crisis trends as well as the FSAP 2013's baseline. The FSAP scenarios—both in 2013 and 2019—imply a more protracted path compared to the shape of the GDP flows as observed during the AFC and GFC (more frontloading and faster recovery). This shape has been considered for the sake of conservatism.

34. Figure 13 shows the cumulative real GDP deviations along different horizons, in historical perspective. The FSAP scenario's GDP losses relative to the baseline are less negative compared to the FSAP 2013 deviations. This deviation profile is judged to be justified against the background of the weaker baseline (resulting in comparable level trajectories under the adverse scenario, see Figure 12) as well as from the perspective of the GaR benchmark estimates that take account of the cyclical position of the Korean economy and its downside risks at a 5 percent probability level.

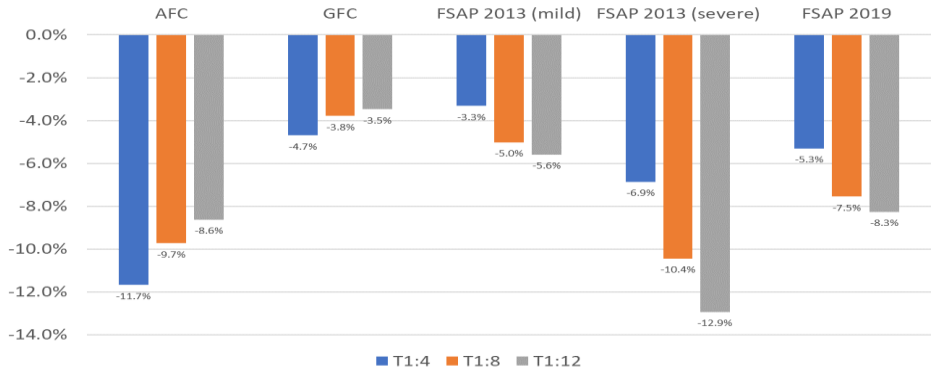
35. Real estate is 'pervasive' in the Korean economy, for the financial system's resilience to real estate price fluctuations therefore deserving emphasis. The assessment about the valuation of housing prices and their endogenous response in the scenario is surrounded by significant uncertainty, hence implying that sensitivity analyses around the adverse scenario with a special focus on house price shocks will be considered and presented later in this note.

Figure 12. Korea: Baseline and Adverse Scenario Paths for Real GDP in Historical Perspective



Sources: IMF WEO and IMF staff calculations. Note: AFC = Asian Financial Crisis (1997/38). GFC = Global Financial Crisis (2007-09). The origin, "t0", in the charts denote the years [1997Q4, 2008Q3, 2012Q4, 2018Q4] for the [AFC, GFC, FSAP 2013, FSAP 2019].

Figure 13. Korea: Cumulative Real GDP Deviations (Adverse Relative to Baseline)

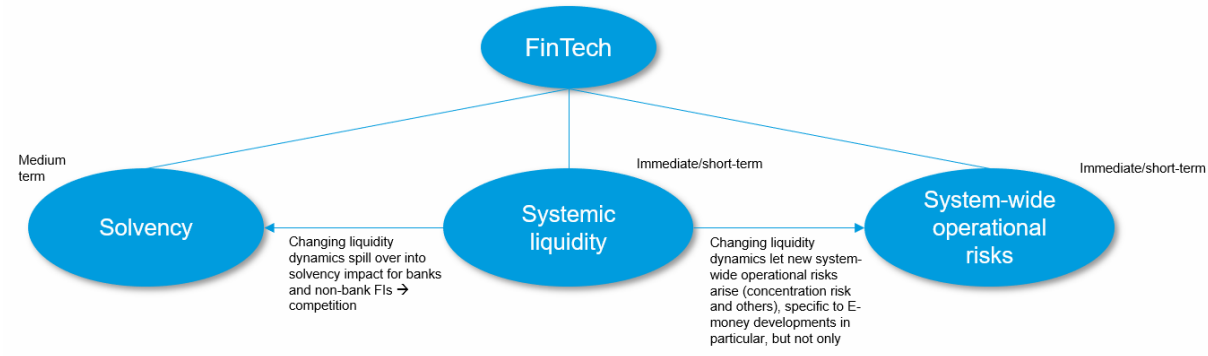


Sources: IMF WEO and staff calculations. Note: T1:X denotes the sum of quarterly GDP flows (real) over X=[4,8,12] quarters. The deviation measures are computed as the sum of adverse scenario's GDP flows minus the sum of baseline GDP flows, divided by the sum of baseline GDP flows; along 4, 8, and 12 quarters. For the AFC and GFC, the respective pre-crisis trends (average growth) over the preceding 24 quarters of the two recession episodes were used to project a 'baseline' that is assumed to have ensued if the AFC and GFC would not have happened. For the FSAP 2013 and FSAP 2019 calculations, the respective baseline scenarios were involved.

B. Fintech Developments in Korea

36. The possible implications of Fintech developments as observed in Korea can be seen in three dimensions. Both the Open Banking initiative and the e-money service provider developments imply changing liquidity dynamics in the retail payments and money market in Korea[19]. These have implications for solvency of financial institutions and system-wide operational risks (Figure 14).

Figure 14. Korea: Implications of Open Banking and E-Money Developments in Korea



Sources: IMF staff.

37. Notwithstanding its various expected positive implications, the Open Banking initiative could unfold its impact through rising competition and imply potential risks; in three dimensions. First, bank retail customers would be more inclined to swiftly transfer deposits

[19] For additional details on the Open Banking Initiative as well as e-money developments in Korea—in particular from a legal perspective—see the Technical Note titled "FinTech, Legal Frameworks, and Implications for Financial Stability".

across banks to where deposit rates are most competitive; using mobile phone applications that conveniently display them the pricing conditions across banks and allowing the transfer in the same place. This in turn may pressure banks' interest expense. Second, bank customers may learn to more actively seek the most competitive offers in terms of loan interest rates, as a result of being more open-minded to where to deposit their funds, which would pressure banks' interest income; third, rising financial literacy as a result of significant Fintech developments such as through Open Banking may enhance customers' willingness and ability to behave as outlined above.

38. The result of such changing customer behavior may be that banks with currently lower retail deposit rates may raise them, and those with currently higher loan interest rates may lower them. Such behavior is captured in the Fintech Overlay analysis which will be presented in the solvency analysis section of this note.

39. The growing popularity of e-money providers could in the future exacerbate such rising competition through at least two channels. First, they may compete with commercial bank deposits by offering remuneration resembling interest to attract customers[20], enabled by the Korean authorities' gradual de-regulation initiative; second, banks might offer more sizable deposit rates to the e-money providers to attract their—possibly sizable in the future—re-deposited customer funds. Both aspects could imply further upward pressure on banks' interest expense.

40. Open Banking and the growing popularity of e-money providers can in the future imply risks in terms of higher-frequency liquidity dynamics. First, the Open Banking system would imply that "stickiness" of bank deposits will be reduced. Bank customers could more likely react to 'bad news'—whether substantiated or not—by swiftly and sizably moving funds to other banks. This would represent an 'electronic deposit run' and could exacerbate a liquidity squeeze for banks beyond what would be justified by banks' fundamental solvency risk perception by the market[21]. Second, with e-money providers re-depositing customer funds in one or at most a few banks can imply concentration risk, i) from a system-wide operational risk viewpoint, and ii) in terms of a structural shortage of liquid funds (alongside reserves) for those banks with whom the service providers do not hold their funds.

41. Systemic liquidity risks may arise from e-money providers if their activities are not subject to adequate and formal regulation. Certain baseline requirements for e-money providers have been stipulated by EFTA (e.g., obligations to redeem the e-money they issue and to maintain dedicated accounts segregated for each line of business), but redemption risks may arise. E-money providers mitigate this risk in current practice by holding funds underlying their e-money on a 1:1 basis. Given the growing popularity of e-money, risk controls and mitigants would be strengthened by enshrining in law or regulation clear requirements as to a service providers' treatment of funds

[20] E-money service providers are currently not allowed to pay interest in the form of e-money on their customers' e-money holdings. They may, however, consider other remuneration or reward schemes, that is, purchases in e-money form may be offered with a discount, which would effectively be equivalent to interest payments from an economic perspective.

[21] Flow constraints are currently in place, for the Open Banking System to not allow more than KRW 10 million to be transferred, and no more than KRW 3 million through e-money service providers. Such constraints may not prevent a gradual outflow over a sequence of days to happen.

underlying their e-money, e.g., to avoid that e-money providers would in the future deviate from their 1:1 holding practice.

42. The FSAP recommends that the Korean oversight institutions conduct a detailed Fintech and competition-related impact assessment for the banking sector and other components of the financial system. As argued above, such an assessment would not only consider medium-term solvency implications through changing competition but focus as well (primarily) on systemic liquidity and system-wide operational risk implications (Figure 14).

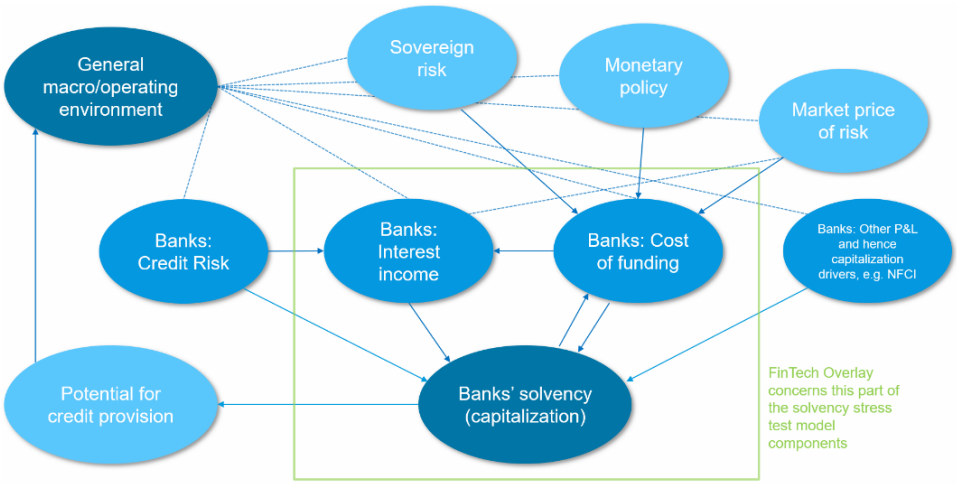
FORWARD-LOOKING BANK SOLVENCY ANALYSIS

A. Methodology

43. The schematic in Figure 15 illustrates selected elements of the modular Solvency Analysis Tool Suite for banks. It consists of several connected modules that have been set up for the Korea FSAP. The modules' inputs, functioning and outputs are described in this section.

44. Four defining features of the tool suite deserve emphasis. They include i) an account for IFRS 9 loan loss provision principles; ii) a nonlinear solvency-funding cost feedback mechanism; iii) dynamic balance sheets; and iv) a "Fintech Overlay". Figure 15 indicates which elements the Fintech Overlay relates to from a methodological perspective. Details will be explained later in this section. Figure 16 shows the P&L structure adopted for the Korea bank solvency analysis along with a summary of the model approach adopted for each line.

Figure 15. Korea: Dependencies Captured in Top-Down Solvency Model Suite for Korean Banks



Sources: IMF staff.

Figure 16. Korea: P&L Structure and Model Approaches Adopted for the Korea Solvency Analysis

#	P&L Item	Model Approach
1	Interest income and expense	Bank-panel econometric models for effective interest income and expense rates; transfer-pricing rationale reflected in expense and income equations; nonlinear solvency-to-funding cost feedback
2	Loan Losses (LL)	Structural credit risk model suite, Stage1-2-3-specific provisioning, using "hybrid Z-factor-PD-satellite" model approach
3	Net Trading Income (NTI)	Structural model, modified-duration-based for bonds and equity positions as function of relevant bond yield and equity index assumptions in the scenario
4	Net fee and commission income (NFCI)	Bank-panel econometric models to link NFCI to macro-financial conditions
5	Administrative expenses and other	Ratio of this expense flow in total relative to total assets gross of accounting loan loss provision stocks kept constant, hence absolute expense flow dynamic under dynamic bank balance sheet
6	Taxes	Tax rates kept constant at 2018 levels; zero tax expense in case net income (NI) is negative
7	Dividends	Dividend rates as of 2018 relative to NI after taxes held constant; dividends paid as long as NI after tax is positive

Sources: IMF staff.

Credit Risk (CR) Module

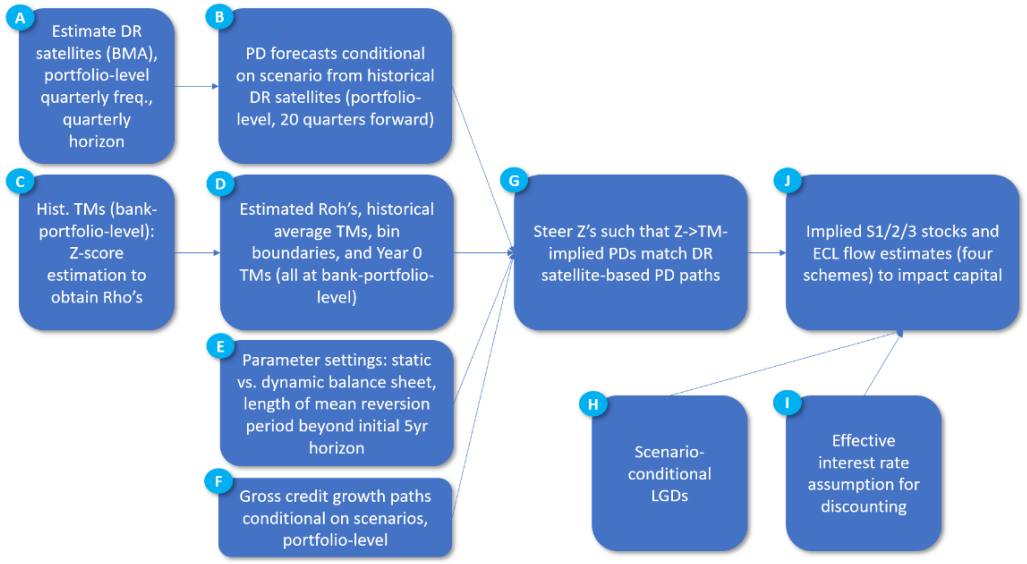
45. Figure 17 shows the structure of the CR module[22]. It summarizes the "hybrid" PD-satellite-Z-factor methodology developed for Korea, related to item 2 in Figure 16. Appendix IV shows a table which maps the line items from the banks' loan and trading books to their treatment under either the credit risk or market risk methodology.

46. Default rate satellite models were estimated based on confidential bank data provided by the FSS (Figure 17, Block A). They were structured and estimated based on a Bayesian Model Averaging (BMA) Methodology subject to sign constraints on the long-run multipliers of the equations[23]. The default rate models were developed for four portfolio segments: large nonfinancial corporates, SMEs, household mortgage loans (including Jeonse leasehold loans), and consumer credit. The default rate models were used to derive forecasts conditional on the baseline and the adverse scenario for Korea (Block B in Figure 17)[24,25]. The PDs at the outset of the scenario horizon and the maxima under the adverse scenario are shown in Figure 18. The model structure is sketched in Appendix V. Household mortgage portfolio PDs were found to be very reactive to the adverse scenario in terms of multiples to their starting points; the latter being very small in comparison to

[22] For a detailed treatment of various elements of the credit risk model methodology see Gross, Laliotis, Leika, Lukyantsau (2020), "Expected Credit Loss Modeling from a Macro-Financial System and Stress Testing Perspective," IMF Working Paper No. 20/111.
[23] See Gross, M. and Población, J. (2017), "Implications of model uncertainty for bank stress testing," Journal of Financial Services Research, Vol. 55, pp. 31-58.
[24] The default rate models and scenario-conditional forecasts are not presented here because this information is classified as confidential.
[25] The banking system-wide portfolio-specific default rate scenario paths are attached to the banks' portfolio-specific starting points using a distance-to-default transformation scheme.

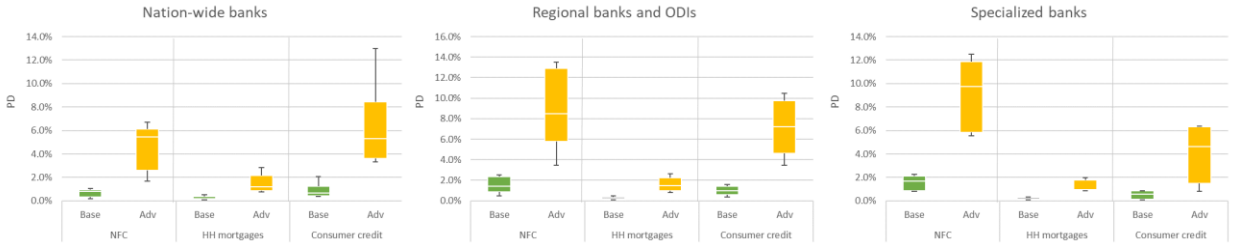
the other portfolios' PDs as of 2018. Their levels under the adverse scenario were deemed sufficiently conservative in historical perspective.

Figure 17. Korea: Credit Risk Module Structure



Sources: IMF staff. see Glossary for abbreviations.

Figure 18. Korea: Baseline and Adverse Scenario-Conditional PDs



Sources: Korean banks' and FSS data and IMF staff calculations. Annual horizon PDs. The NFC category comprises both large nonfinancial corporate exposures as well as SME exposures. The upper and lower ends of the boxes denote the 90th and 10th percentiles of the underlying distribution across banks. The error bars extending to the up- and downside denote the maxima and minima. White lines denote the median. Under the baseline (adverse) scenario, the distribution reflects the average (maximum) of the PDs along the 20-quarter scenario horizon.

47. Historical transition data in accordance with IFRS 9 classification criteria have been compiled by the FSS from the Korean banks, under FSAP guidance. The Korean regulatory asset classification scheme was mapped into the Stage 1-2-3 classification under IFRS 9: the prudential categories "normal" and "precautionary" were mapped to the accounting Stages 1 and 2, respectively. The prudential asset classes "substandard", "doubtful" and "loss" were jointly mapped to Stage 3. The historical *flows* across the resulting proxy accounting stages were sourced from the banks, including the additional flow categories for new business, repayment, write-offs and asset sales. They were collected at bank-level for three portfolio segments: nonfinancial corporate (large firms and SMEs combined), household mortgages, and consumer credit. Historical transition flow

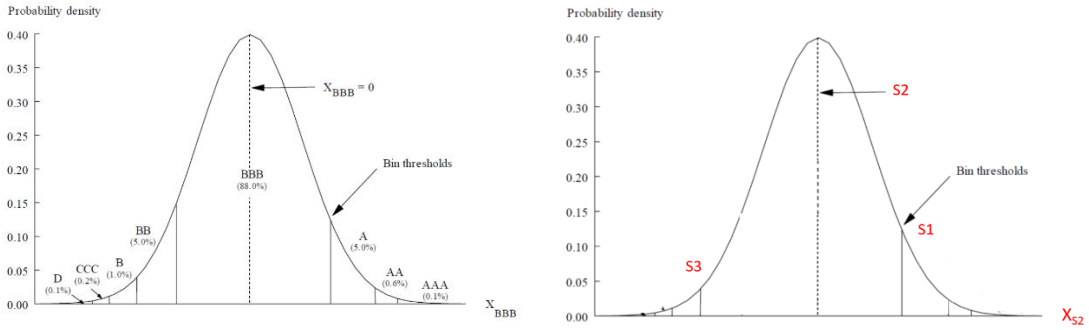
data with quarterly frequency were available from 2010Q1-2018Q4 for the majority of banks and portfolios.

48. Historical Z-factors and additional related parameters were estimated based on the historical bank-portfolio-specific transition flow data (Figure 17, Block C). The Z-factor methodology is summarized in Box 1.

Box 1. The Z-Score Methodology

The Z-score methodology (Belkin et al., 1998) aims to reduce the information contained in a time series of transition matrices down to one number per point in time. It was originally developed for rating transition matrices; involving letter-based grids of ratings spanning up to 10-15 classes (AAA-D). The methodology is applicable to matrices of any size and irrespective of the criteria set behind the classes in the matrix, and hence applicable to a time series of IFRS 9 transition matrices. Figure B1.1 combines Figure 1 from Belkin et al. (1998) (on the left, for an initial BBB exposure) with a modified version thereof that is based on an IFRS 9 staging structure (on the right, for an initial S2 exposure in this example). Both refer to a *long-term average* transition matrix.

Figure B1.1: Probability Density for BBB Rating (Left) vs. S2 Exposure Under IFRS 9 (Right)



The Z-score method builds on the assumption that the probability density X is a function of an idiosyncratic driver Y and a systematic economy-wide driver Z. Both are independent unit normal random variables by assumption. The parameter ρ captures the correlation between Z and X, with Z explaining a fraction ρ of the variance of X.

(1) $X_t = \sqrt{1-\rho}Y_t + \sqrt{\rho}Z_t$

The fitted transition probabilities, Δ_t, are expressed as:

(2) $\Delta_t\left(x_{g+1}^G, x_g^G, Z_t, \rho\right) = \Phi\left(\frac{x_{g+1}^G - \sqrt{\rho}Z_t}{\sqrt{1-\rho}}\right) - \Phi\left(\frac{x_g^G - \sqrt{\rho}Z_t}{\sqrt{1-\rho}}\right)$

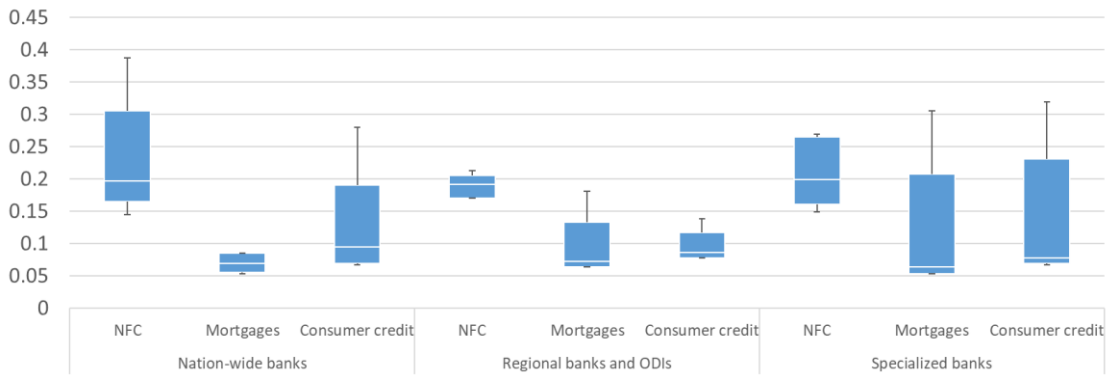
Φ is a standard normal cumulative distribution function. The terms x_g^G are the "bin boundaries" (referring to the vertical lines in Figure B1.1) which are computed based on an inverse of a standard normal cumulative distribution function, with reference to a long-term average transition matrix. The historical deviation between an observed and fitted transition matrix can be computed as:

Box 1. The Z-Score Methodology (concluded)

$$(3)\quad \min_{Z_t} \sum_G \sum_g w_{tg} \left(\underbrace{P_t(G,g)}_{\text{obs. transition rates}} - \underbrace{\Delta\left(x_{g+1}^G, x_g^G, Z_t, \rho\right)}_{\text{fitted transition rates}} \right)^2$$

where the two sums in this equation indicate a summation over all elements in a transition matrix. Conditional on a ρ and the bin boundaries from the long-term average transition matrix, a Z_t can be found for each point in time that minimizes eq. (3). The constant ρ and the time series Z_t were estimated jointly subject to the constraint that the variance of the resulting Z_t be equal one, for each bank-portfolio. A +1/-1 value for Z denotes a "1-standard deviation from normal (long-run average)" conditions. The estimated parameters ρ (bank-portfolio specific) for the Korean banks are depicted in Figure B1.2.

Figure B1.2: Estimated ρ for Korean Banks' Loan Portfolios



Note: The upper and lower ends of the boxes denote the 90th and 10th percentiles of the underlying distribution of estimated ρ across banks. The error bars extending to the up- and downside denote the maxima and minima. White lines denote the median. NFC abbreviates Nonfinancial corporate.

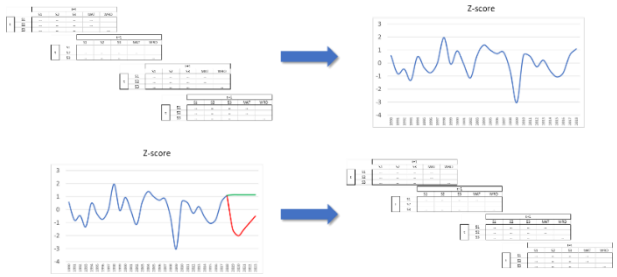
49. A "hybrid" PD-satellite-Z-factor methodology has been developed for Korea (Figure 17, Blocks A-G). In principle, one could use the estimated historical Z-factor times series at portfolio level—and either at bank- or aggregated banking-system level—to develop satellite models, to derive scenario-conditional paths of all Z's into the future, and in this case not requiring the separate estimation of default rate satellite models. Default rates would be part of the transition matrix and implied by the projected Z factor paths[26]. This approach was not chosen for Korea because the historical transition matrix data—albeit rich from a cross-bank-portfolio perspective—was still deemed too short from a time series perspective, not capturing a full economic cycle (as starting in 2010). Default rates were longer, starting at the end of the 1990s for most portfolios. The "hybrid" methodology is summarized in Box 2.

[26] TR1-3 and TR2-3, a weighted average of which can also be computed to obtain a performing loan stock-related PD.

Box 2. "Hybrid" PD-Satellite-Z-factor Methodology and Dynamic Balance Sheets

Figure B2.1 depicts how the previous step (Box 1, first row in Figure B2.1) compares to the translation of a Z-score path back to a transition matrix (this box, second row in Figure B2.1).

Figure B2.1: From Transition Matrices to the Z-Score and Vice-versa



To accomplish what is indicated in the second row of this figure, a transition matrix forecast can be obtained from a Z-score forecast path in the same way as historical fit is produced at the Z-estimation stage (Box 1). The formula required to that end has the same structure as eq. (2) in Box 1:

$$(4)\quad \Delta_t\left(x^G_{g+1}, x^G_g, Z_t, \rho\right) = \Phi\left(\frac{x^G_{g+1}-\sqrt{\rho}\widehat{Z_t}}{\sqrt{1-\rho}}\right) - \Phi\left(\frac{x^G_g-\sqrt{\rho}\widehat{Z_t}}{\sqrt{1-\rho}}\right)$$

The parameter ρ and the bin boundaries are given at this stage (previously estimated, Box 1) and do not change. Only Z is an input that varies conditional on different scenarios, now denoted as $\widehat{Z_t}$, implying the transition probabilities across the transition matrix and along the scenario horizon.

The formulas that were used to imply the S1, S2, and S3 *stocks* are the following:

$$(5)\quad S2_t = S2_{t-1} + \underbrace{TR^{12}_t S1_{t-1} + TR^{32}_t\ S3_{t-1}}_{\text{Inflows to S2}} - \underbrace{TR^{21}_t\ S2_{t-1} - TR^{23}_t\ S2_{t-1} - M^{S2}_t\ S2_{t-1}}_{\text{Outflows away from S2}}$$

$$S3_t = S3_{t-1} + \underbrace{TR^{13}_t S1_{t-1} + TR^{23}_t\ S2_{t-1}}_{\text{Inflows to S3}} - \underbrace{TR^{31}_t\ S3_{t-1} - TR^{32}_t\ S3_{t-1} - WRO_t S3_{t-1}}_{\text{Outflows away from S3}}$$

$$S_t = S1_t + S2_t + S3_t = (1+g_t)S_{t-1}$$

$$S1_t = \max\left(0, S_t - S2_t - S3_t\right)$$

The portfolio-specific gross loan growth is under explicit control (g_t), pre-determined by the scenario. The repayment percentage for S2 exposures as well as the write-off/asset-sale parameter (M^{S2}_t and WRO_t) were held constant at observed end-sample position for all portfolios and banks.

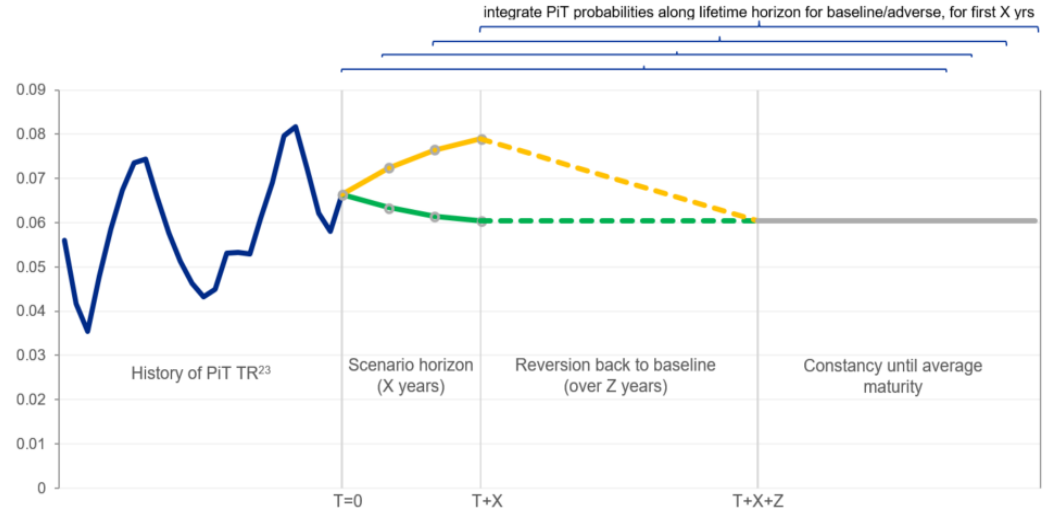
Based on the above set of equations, the "hybrid Z-score-PD-Satellite" methodology was designed as follows: the bank-portfolio-specific Z path for a given bank-portfolio along the 20-quarter forward horizon was set such that the exposure-weighted PD would match a path implied by the PD satellite models. The PD paths from the PD satellite models were attached to bank-portfolio-specific PD starting points using a distance-to-default transformation. The exposure-weighted PDs based on the transition matrices were computed, period by period, as follows:

$$(6)\quad PD^{PiT}_{t+1|t} = \frac{S1_t \times TR13_{t+1|t} + S2_t \times TR23_{t+1|t}}{S1_t + S2_t}$$

50. A "perfect foresight" assumption was employed (Figure 17, Block E). "Perfect foresight" means that the multiple probability-weighted scenario requirement as stipulated under IFRS 9 for accounting provision purposes is ignored for what concerns the solvency stress test analysis. Two concrete scenarios are instead considered, with 100 percent weight set for each of them separately (baseline, adverse).

51. ECL provisioning under IFRS 9 requires forming an expectation as to how the underlying risk parameters behave until the end of the lifetime of the relevant financial assets. This horizon extends beyond the 5-year horizon of the FSAP scenarios for portfolios with residual maturities larger than 5 years; that is, in particular for mortgage portfolios. The baseline risk parameters (PDs, LGDs) as of the last quarter of year 5 (2023Q4) were held constant; the adverse scenario's parameters at 2023Q4 were assumed to decay back to baseline over an 8-year period (Figure 19)[27].

Figure 19. Korea: Perfect Foresight and Risk Parameter Behavior after Initial 5-Year Horizon



Sources: IMF staff. X is 5 years. Z is 8 years.

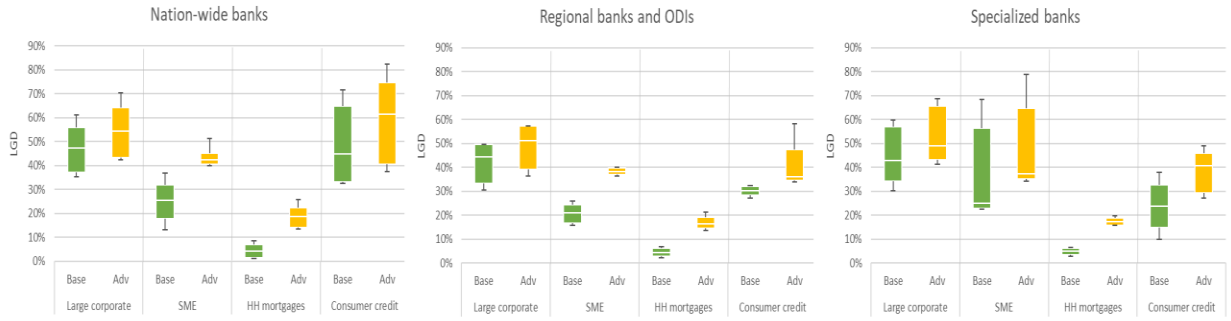
52. The solvency analysis was conducted based on a dynamic bank balance sheet assumption (Figure 17 Blocks E/F and Box 3). Gross credit growth paths for the banks' corporate and household loan portfolios were set as part of the scenario design process, consistent with the assumed macro-financial developments in the baseline and adverse scenario, at economy-wide level. The portfolio-specific growth paths were assumed to be equal across banks. Write-offs and asset sales were allowed to be positive, which is important in Korea since banks make active use of NPL management firms for them to take care of the workout, seizure of collateral, etc. The relevant

[27] A sensitivity analysis was conducted with respect to the length of this mean reversion period. The solvency stress test results are not very sensitive to varying this assumption between a 5-12-year range, which is partially due to the fact that longer-duration mortgage portfolios are not overly sizable and, moreover, subject to mortgage insurance in non-negligible shares, hence rendering their risk parameters (LGDs in particular) low.

equations to account for write-offs and asset sales were shown in Box 2 in relation to the hybrid Z-factor methodologies.

53. A simple structural LGD model was employed to link housing-collateralized portfolios' LGDs to the house price paths in the scenarios (Figure 17, Block H). The structural LGD model captures the dependence of the LGDs on the underlying housing collateral value[28,29]. For all other portfolios, LGDs were kept constant in the baseline and scaled by a factor of 1.15 under the adverse scenario. On top, for all portfolios in-scope of the CR Module, a conservative overlay has been applied, by taking the maximum of the model-implied (structural model or simple factor) LGDs and the bank-reported regulatory downturn LGDs[30]. Figure 20 shows the resulting distribution of LGDs for different portfolios under the baseline and adverse scenario.

Figure 20. Korea: Baseline and Adverse Scenario-Conditional LGDs



Sources: Korean Banks' and FSS data and IMF staff calculations. The upper and lower ends of the boxes denote the 90th and 10th percentiles of the underlying LGD distribution across banks. The error bars extending to the up- and downside denote the maxima and minima. White lines denote the median.

54. Effective interest rate assumptions are required for discounting purposes when computing ECLs (Figure 17, Block I). The effective interest rates as of end-2018 were sourced from the banks at bank-portfolio level (Figure 21) and held constant for the purpose of discounting (Box 3 documents how).

55. An IFRS 9-compatible ECL scheme was employed (Figure 17, Block J). Box 3 summarizes the methodology for computing 12-month ECLs for Stage 1 exposures, lifetime ECLs for Stage 2 and 3 exposures, as well as for implying the provision stocks and flows.

56. RWs for credit exposures were treated differently for STA and IRB portfolios. RWs for STA exposures were kept constant at their end-2018 levels. RWs for IRB exposures were allowed to move dynamically as a function of the underlying changes in regulatory TTC-PDs. Downturn LGDs were kept constant as deemed sufficiently conservative. The TTC PDs at bank-portfolio level were

[28] Applied for residential real estate portfolios including Jeonse leasehold loans for the Korean banks. Data for commercial real estate portfolios were not separately available and part of the nonfinancial corporate portfolios (either SME or large corporates).
[29] For details see Gross et al. (2020, forthcoming), "Expected Credit Loss Modeling from a Macro-Financial System and Stress Testing Perspective".
[30] This conservative overlay was used because the choice of a simple scaling factor for LGDs of uncollateralized portfolios is rather ad hoc; and the various caveats apply to the structural model for real estate-collateralized portfolios as well (e.g., it could not be back-tested on Korean bank data because historical data for LGDs was not available).

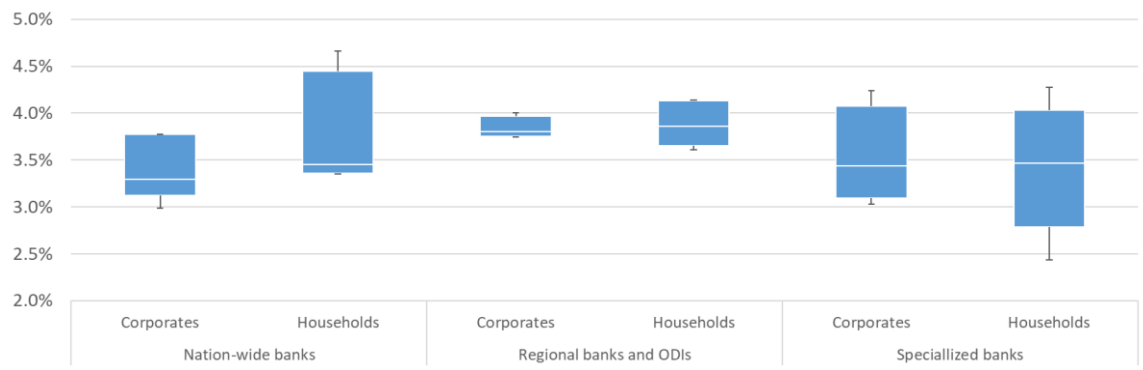
made a smooth function of PiT-PDs as used for accounting provisioning, using the formula $\mathrm{PD}_{t+1|t}^{\mathrm{TTC}} = \phi^{-1}\left(\phi\left(\mathrm{PD}_{t|t-1}^{\mathrm{TTC}}\right) + \alpha \times \Delta\phi\left(\mathrm{PD}_{t+1|t}^{\mathrm{PiT}}\right)\right)$. The smoothing parameter α was set to 0.5 for the base set of results. A sensitivity analysis related to α will be presented in the result section. Under both the STA and IRB approach, the RWA evolution in volume-terms also reflects the allowance for dynamic balance sheets[31].

Interest Income and Expense, incl. Nonlinear Solvency-funding Cost Feedback, Feedback from Credit Risk to Interest Income, and Fintech Overlay

57. The interest income and expense module—capturing interest rate risk in the banking book—is based on cross-bank panel econometric models. The banks' historical effective interest income and interest expense rates form the basis for these models (Figure 22). The corresponding panel models were estimated for the groups of nation-wide banks, regional banks, and specialized banks separately. The regional banks' models were employed for the group of ODIs (credit unions, credit cooperatives and mutual savings banks). The interest income and expense panel model equations are documented in Appendix V.

58. The interest expense model contains a feedback link from banks' solvency position to their funding cost (Appendix V). From an economic perspective, this estimated feedback was deemed material enough to warrant its inclusion in the model for the Korean banks. From a methodological perspective, including that link meant that a sequential, iterative link from the end-period (quarter) capital ratios resulting from the overall stress test model suite to banks' funding cost in any subsequent quarter was built in.

Figure 21. Korea: Effective Interest Rates for ECL Discounting Purposes



Sources: FSS and IMF staff calculations. The upper and lower ends of the boxes denote the 90th and 10th percentiles of the underlying distribution across banks. The error bars extending to the up- and downside denote the maxima and minima. White lines denote the median.

[31] Capital floors for banks with IRB portfolios (see Detailed Regulations on Supervision of Banking Business, Appendix 3), as relevant for four banks in the Korean bank stress test sample, were not accounted for.

Box 3. Lifetime (LT-) ECL and Provision Stock and Flow Calculations

The LT-ECL formula employed for the Korea solvency analysis has been structured as follows:

(6) $\mathrm{ECL}_t^{\mathrm{LT,S2}} = \sum_{s=t+1}^{M} \frac{\mathrm{TR}_s^{2-3,*} \times \mathrm{LGD}_s \times \mathrm{S2}_{s-1}}{(1+r)^s}$

with *M* denoting the average residual maturity of a portfolio. The lifetime ECL is here measured in monetary units. The right hand-side includes a point-in-time LGD and the relevant exposure, which is the S2 stock. The denominator of the formula involves an effective loan interest rate for discounting the ECL along the lifetime of a loan portfolio. The formula for the incremental PD in the numerator, denoted $\mathrm{TR}_s^{2-3,*}$, is:

(7) $\mathrm{TR}_s^{2-3,*} = \mathrm{TR}_s^{2-3} \times \underbrace{\prod_{t=1}^{s-1} \overbrace{(1-\mathrm{TR}_t^{2-3})}^{\text{PiT survival probability}}}_{\text{cumulative survival probability}}$

The term TR_s^{2-3} is the unconditional transition probability for S2 stocks which links to the outcome of the transition matrix forecast path (Box 2). While this unconditional PD (TR^{2-3}) moves over the lifetime of a loan portfolio in an 'unrestricted' manner and in relation to macro-financial conditions, the incremental PD measures the probability of default in period *s* conditional on not having defaulted up to period *s-1* and approaches zero over time[1]. The exposure term in eq. (6), i.e. the S2 stock, is projected for simplicity using a linear principal repayment scheme[2].

For S1 exposures under IFRS 9, the provision stocks are to equal the 12-month expected credit loss, i.e.:

(8) $\mathrm{PROV}_{t,S1} = \mathrm{ECL}_{t,S1} = \mathrm{TR}_{t+1|t}^{13} \times \mathrm{LGD}_{t+H|t} \times \mathrm{S1}_t$

Any change in the underlying risk parameters implies a provision flow and hence an impact on capital through the P&L. The term $\mathrm{TR}_{t+1|t}^{13}$ is the expected default rate for S1 exposures conditional on end of period-t information for the following year. The $\mathrm{LGD}_{t+H|t}$ term has a t+H to denote the fact that the LGD is meant to be forward-looking beyond a 1-year horizon if the expected time until collateral can be sold is more than 1 year. For S2, exposures, the lifetime ECL formula becomes relevant (eq. 1), with its provision stock is supposed to equal, that is, $\mathrm{PROV}_{t,S2} = \mathrm{ECL}_t^{\mathrm{LT,S2}}$. For S3 exposures, provision stocks are to cover the portion of the defaulted loan exposures that will likely not be recoverable, that is:

(9) $\mathrm{PROV}_{t,S3} = \mathrm{ECL}_{t,S3} = \mathrm{LGD}_{t+H|t} \times \mathrm{S3}_t$

The total provision stock is to the sum of the stage-specific provision stocks:

(10) $\mathrm{PROV}_t = \mathrm{PROV}_{t,S1} + \mathrm{PROV}_{t,S2} + \mathrm{PROV}_{t,S3}$

The loan loss provision flow is then the change in the stock, adjusted for write-offs and asset sales:

(11) $\mathrm{PROVFLOW}_t = \Delta\mathrm{PROV}_t + \mathrm{WRO}_t \times \mathrm{LGD}_t \times \mathrm{S3}_{t-1}$

The adjustment term related to the write-offs in eq. (11) accounts for the fact that exposures that are written off or sold to asset managers, whose provision stock is falling for that reason, and which should be residual net-equity neutral. The way the adjustment is designed involves the assumption that the LGD estimate

Box 3. Lifetime (LT-) ECL and Provision Stock and Flow Calculations (concluded)

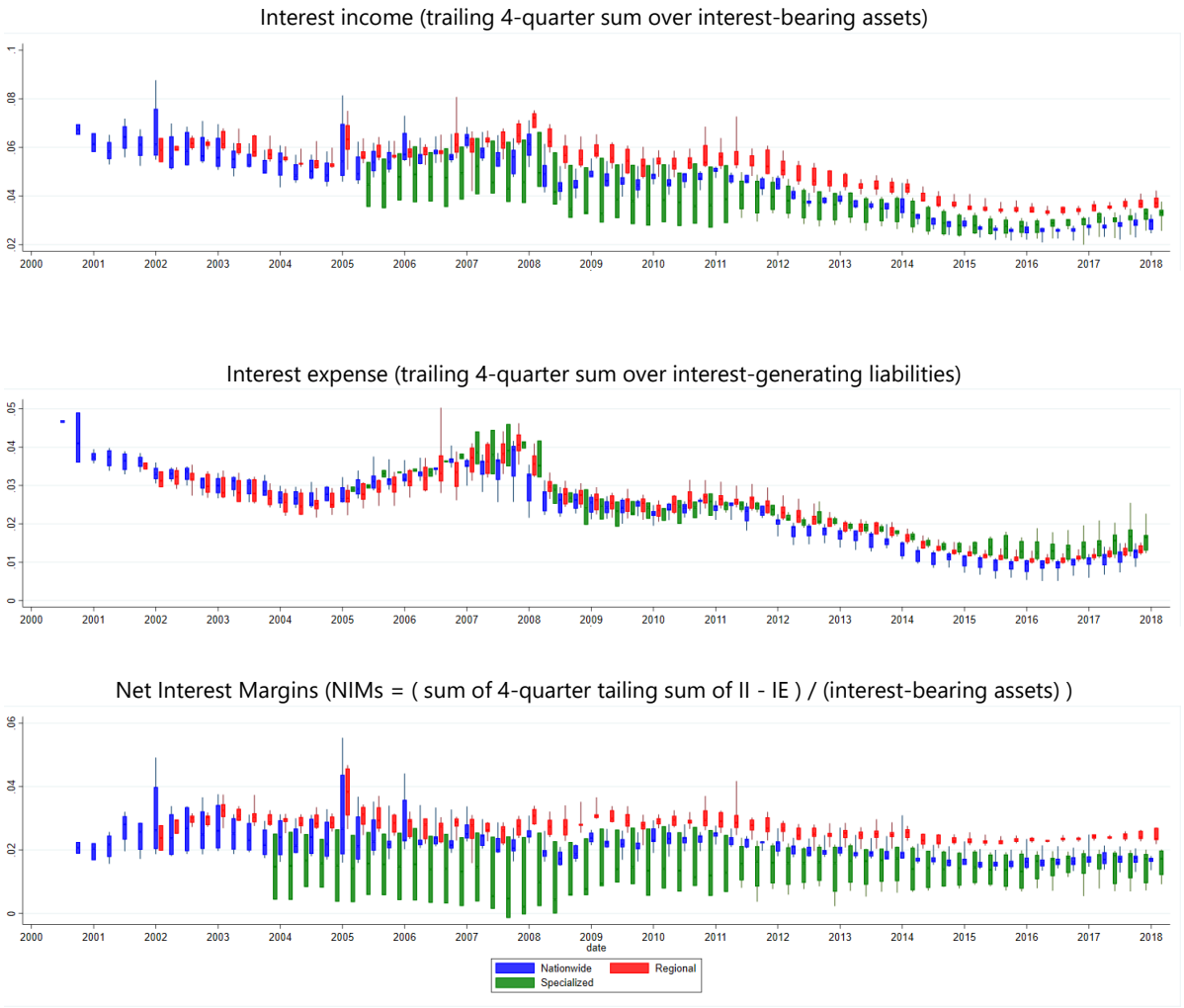
based on which a provision stock had been set just before the write-off or asset sales equals the realized LGD upon the collateral sale for the exposures that are written off or sold.

---

[1] If the maturity parameter M in eq. (6) would be set to one, then the lifetime ECL would be a 12-month ECL. In this case, the incremental PD would yet equal the unconditional PD according to eq. (7). If one may ignore in this case the discount factor in the denominator of eq. (6), then the ECL formula would attain the standard "PDxLGDxEAD" structure.

[2] Alternatively, it could be projected into the future based on a nonlinear repayment schedule of fixed or variable rate loans. If a nonlinear repayment schedule was employed, for variable rate loan portfolios specifically, then an expectation about the loan interest rate would have to be considered as well. For portfolios that are "mixed", i.e. contain fixed and variable loans, two corresponding repayment schedules could be considered which could then be added together for the two portfolio components. Modelling prepayments explicitly is an option as well. All of these model options were not deemed necessary for the Korea FSAP, as they would have added undue complexity that was not warranted given the target level of detail for the analysis.

Figure 22. Korea: Banks' Historical Effective Interest Rate Evolution for Korean Banks

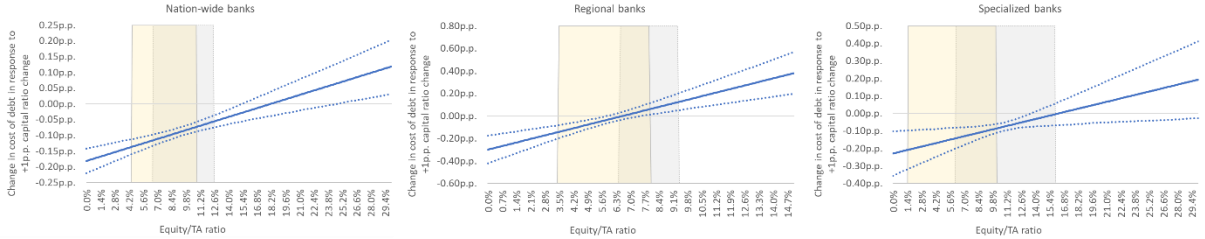


Sources: IMF staff.
Notes: The bars show the distribution of the underlying individual-bank samples at a quarterly frequency since the beginning of the 2000s.

59. In addition to being included as such, the solvency-funding cost feedback was allowed to be *nonlinear*. A notable nonlinearity has been found (Figure 23). The shape of the nonlinear relation implies that at low initial capital ratio levels of a bank, an increase in that ratio would compress its funding cost, while at higher initial capital ratios, a further rising capital ratio may increase its funding cost[32]. Loan interest rates in turn depend on banks' funding cost, for the solvency feedback to funding costs to effectively also influence lending rates at the bank level (Appendix V) [33].

[32] For a discussion as to the rationale and theoretical background to such nonlinearity see Gross, Hansen, and Kok (2020, forthcoming), "Break-Even Capital Ratios".
[33] Even a rather linear relationship would already imply a nonlinear feedback effect; which is even more nonlinear if the relationship at this level is found to be nonlinear.

Figure 23. Korea: Nonlinear Solvency-to-Funding Cost Feedback for Korean Banks



Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations. The estimated feedback from solvency to the banks' cost of debt is significantly negative on average over the capital ratio range observed for the banks. The light grey (yellow) shaded area indicate the 5th-95th percentile range of the banks' shareholder equity/TA ratios under the baseline (adverse) scenario across banks and the scenario horizon. Solid lines (dashed lines) depict the mean (10th and 90th percentiles) of the derivative of the cost of debt to the initial capital ratio. The interpretation for example for the regional banks: a 1p.p. shift to the capital ratio starting at 1 percent (4 percent) would induce a -0.25 p.p. (-0.1 p.p.) response of their cost of debt.

60. An additional feedback mechanism from materializing credit risk to interest income is captured. It is the structural link from the CR Module—as a result of which initially performing exposures (Stage 1 and 2) move to nonperforming status (Stage 3)—which implies no interest income by assumption in Stage 3. This is depicted by the connecting line between credit risk and interest income in Figure 15.

61. The interest income and expense models were used to implement a "Fintech Overlay" analysis. The methodology (Box 4) is embedded in the stress test model suite, implying that it can be used in "scenario-conditional" mode, and hence be set as an overlay to both the baseline and the adverse scenario. The Fintech Overlay concerns only one of the three dimensions (Fig. 14)—the medium-term *solvency* impact on banks—under the assumption of "no business model change".

Market Risk (MR) Module

62. The methodologies applied to exposures subject to MtM revaluation depend on their exposure type (bonds, equity). For sovereign, nonfinancial and financial bond exposures under the FVOCI and FVPL category, a modified-duration formula was employed to revalue the exposures as a function of their reported residual duration and the relevant bond yield assumptions under the scenarios[34].

63. Domestic and foreign equity exposures were revalued using a direct link to the assumed equity index paths under the scenarios. The KOSPI and the MSCI World index were used to revalue Korean banks' domestic and foreign equity exposures under the FVPL category.

64. Korean banks' domestic NFC exposures in the FVOCI category were subject to both the MR and CR Module. In line with the accounting standard, the CR revaluation component was

[34] Sovereign and financial bonds under the AC accounting category were also subject to the MR Module. Such AC exposures should actually be subject to the CR Module, but due to their missing information as to the Year 0 transition matrices, they were treated under the MR Module instead. Korean banks' foreign bond exposures were excluded from the scope of the MR Module because they were deemed sufficiently insignificant in terms of exposure size.

reflected in the P&L (tax non-neutral), while the FVOCI differential beyond the CR impact was reflected through the OCI account (tax neutral).

Box 4. Fintech Overlay – Methodology

The Fintech Overlay methodology is anchored in the bank-level panel econometric models for interest income and expenses (Appendix V) and focused on the medium-term solvency impact of rising competition. The panel models have bank-specific intercepts. These intercepts will be adjusted based on the following methodology.

A Fintech Overlay "strength" parameter is defined as α which can range between zero and one. The share of household loans in total loans of a bank is denoted as h_b^L; the share of household deposits in total liabilities as h_b^D. The initial bank-specific intercepts for the interest income rate (IIR) and interest expense rate (IER) models are denoted as c_b^L and c_b^D. The cross-bank percentiles over the initial intercepts are defined as:

(1) $\hat{c}^L = \text{perc}((c_{b=1}^L, \dots, c_{b=B}^L), 1-\alpha)$ and $\hat{c}^D = \text{perc}((c_{b=1}^D, \dots, c_{b=B}^D), \alpha)$

where α determines the percentile. The adjustment to the IIR models' intercepts, denoted as $\tilde{c}_b^L$, is then done as follows:

(2) $\tilde{c}_b^L = \min\left(c_b^L, \hat{c}^L(\alpha) + (1-h_b^L)(c_b^L - \hat{c}^L(\alpha))\right)$

For the IER models, the intercepts are adjusted as:

(3) $\tilde{c}_b^D = \max\left(c_b^D, \hat{c}^D(\alpha) + (1-h_b^D)(c_b^D - \hat{c}^D(\alpha))\right)$

The underlying idea is that an adjustment of an intercept in, say, the IIR model, downward to a lower cross-bank percentile would be scaled by the share of household loans in total loans; likewise, the upward adjustment of an expense rate model's intercept by the share of household deposits in total liabilities. Banks that do not have any household deposits (as for example some selected specialized banks) would not face any change in their funding cost, by assumption. The max and min operators in eqs. (2) and (3) imply that banks whose intercept would already stand below/above the required target intercept would not change.

Two additional assumptions are embedded in the methodology: first, a "no business model change" assumption, as fees and other sources of income are not modified; second, there is no consideration and account of caps on transactions fees which the Open Banking initiative in Korea implies, due to insufficient data in this respect.

The methodology is simplistic, yet useful for the purpose of deriving an approximate impact of heightened competition, in a scenario-conditional mode of the overall integrated stress test model suite. It can be further developed and refined in numerous dimensions; for example, by the Korean oversight institutions.

Regulatory Capital Ratio Thresholds

65. Regulatory capital thresholds are employed for nation-wide, regional, and specialized banks. Inclusive of the CCB (2.5 percent), the threshold for non-DSIBs amounts to 7 percent, 8.5 percent and 10.5 percent for CET1/RWA, Tier1/RWA and total capital (Tier 1 + Tier 2)/RWA ratios, respectively. For DSIBs, these three thresholds are 1 percentage point higher[35].

B. Results

Headline Bank Solvency Stress Test Results

66. The Korean banking system appears resilient under the FSAP adverse macro-financial scenario. A few regional, specialized banks and ODIs face the most sizable capital losses across banks. Credit risk losses and diminished net interest income would be the most pronounced source of pressure on banks' capital ratios (Figure 24). Specialized banks would experience a notable change in their capital ratios in both absolute and relative terms (Figure 25). The cross-bank heterogeneity in terms of capital responses is most visible in the ODI category.

67. The system-wide capital depletion from the starting point amounts to about 22 percent of initial capital levels (Figure 26). This represents about 2.9 percent of GDP as of 2018.[36] All banks' capital ratios would stay above regulatory minima when allowing the consumption of the capital conservation buffer (CCB).[37] A subset of the specialized banks would consume between 0.3 and 1.4 percentage points of their CCB under the adverse scenario.

68. The banks' asset exposure shares and their portfolio-loss-in-total-loss shares are not fully proportional, i.e. some portfolios are more sensitive under the adverse scenario than others. Consumer credit losses are about aligned with their portfolio shares while nonfinancial corporate loss shares are higher and household mortgage-related loss shares—including from Jeonse loans—lower relative to their portfolio shares (Figure 27). The latter finding reflects the widespread use of mortgage insurance schemes in Korea which protect the banks' capital and provide relief in terms of risk weight densities for such portfolios under both the baseline and the adverse scenario[38].

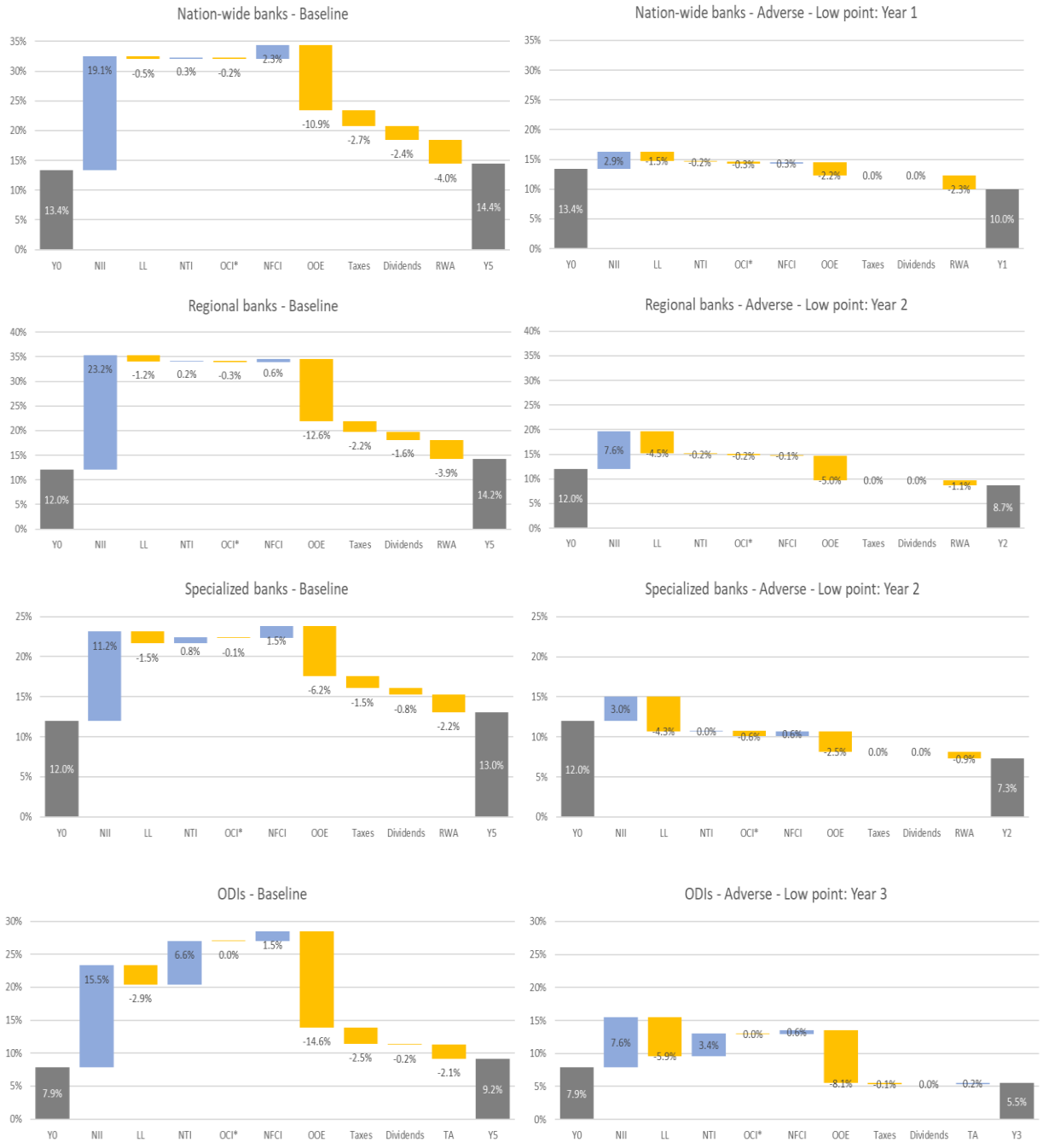
[35] For ODIs, capital thresholds were employed only in an indicative manner, when examining the bank-level results jointly with the Korean authorities during the second FSAP mission in December 2019. The reason for not referring to capital shortfalls for ODIs, should there be any, was that the data quality for ODIs was deemed to be insufficient to an extent. The analyses related to ODIs as presented in the result subsection of this note was deemed sufficiently robust, however.

[36] For nation-wide, regional, and specialized banks, 'capital' refers to CET1 in the following, unless otherwise stated. For ODIs, capital is expressed in accounting terms, net of loan loss provision stocks.

[37] Currently, there are no Pillar 2-related capital requirement add-ons in place for the Korean banks.

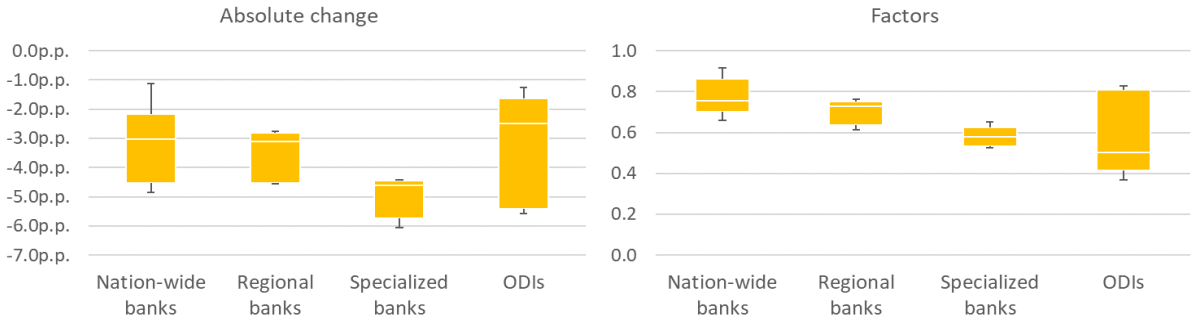
[38] The insured portion of the mortgage portfolios amounts to 26 percent, 45 percent, and 27 percent for nation-wide, regional, and specialized banks respectively (exposure-weighted averages) at end-2018. The shares were assumed to stay constant along the horizon under both the baseline and the adverse scenario.

Figure 24. Korea: Solvency Stress Test Results: CET1 Ratios, Sub-Sector Aggregates



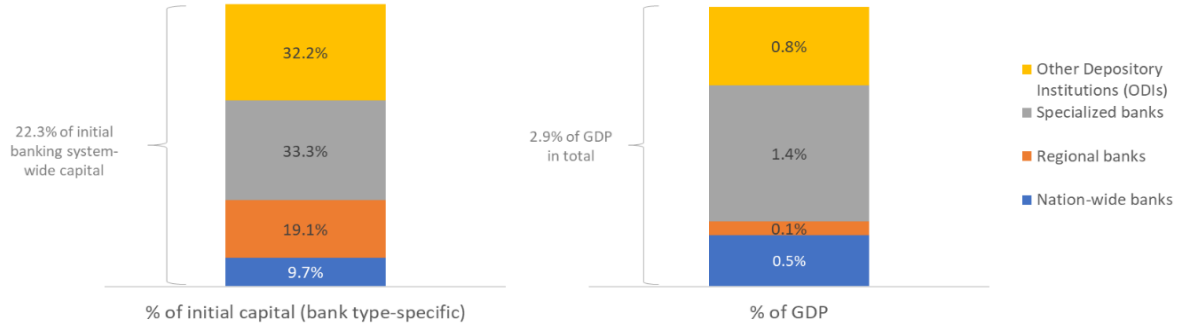
Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.
Notes: The forecasts conditional on the baseline scenario are displayed in cumulative terms up until Year 5 (end-2023). The adverse scenario results are reported in cumulative terms up to the low point, as indicated in the title of the Figures (year 1-5 correspond to 2019-23). The capital ratios are defined as CET1/RWA for nation-wide, regional and specialized banks. For ODIs, the ratios are defined as accounting equity (net of loan loss provision stocks) over total assets. OCI carries an asterisk to indicate that its impact is not measured before tax but after tax, despite in the figures being positioned to the left of the tax impact.

Figure 25. Korea: Changes in CET1 Capital Ratios from Starting Point to Low Point Under the Adverse Scenario



Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.
Notes: The upper and lower ends of the boxes denote the 90th and 10th percentiles of the underlying distribution across banks. The error bars extending to the up- and downside denote the maxima and minima. White lines denote the median. "Factors" are defined as the capital ratio at the banks' respective low points divided by their initial capital ratios at end-2018.

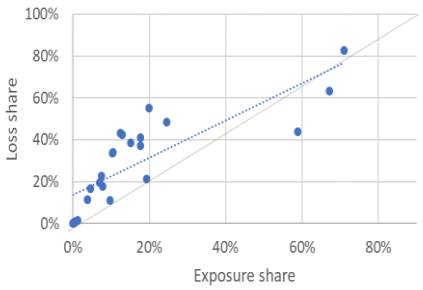
Figure 26. Korea: Capital Depletion Under the Adverse Scenario



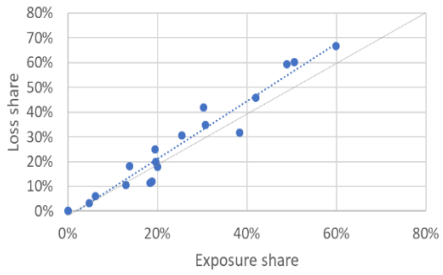
Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.

Figure 27. Korea: Asset Exposure Shares vs. Credit and Market Loss Shares Under the Adverse Scenario

Large nonfinancial corporate loan portfolio



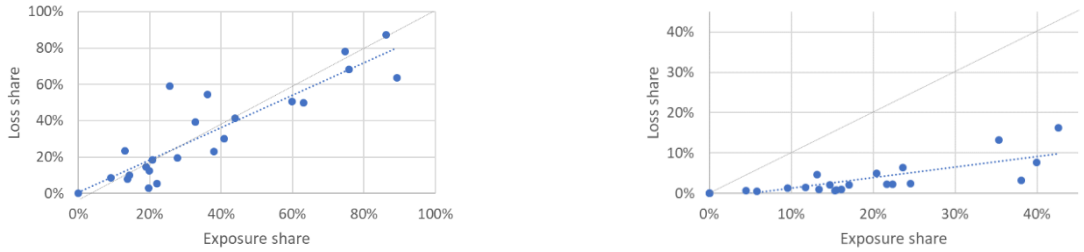
SME lending portfolio



Consumer credit portfolio

Household mortgage loan portfolio

Figure 27. Korea: Asset Exposure Shares vs. Credit and Market Loss Shares Under the Adverse Scenario (concluded)



Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.
Notes: Each dot (24) is a bank (including five ODI aggregates). The "loss share" is based on the maximum cumulative loan loss per bank-portfolio from along the adverse scenario horizon (2019-23). The "exposure share" is measured as of end-2018.

Fintech Overlay

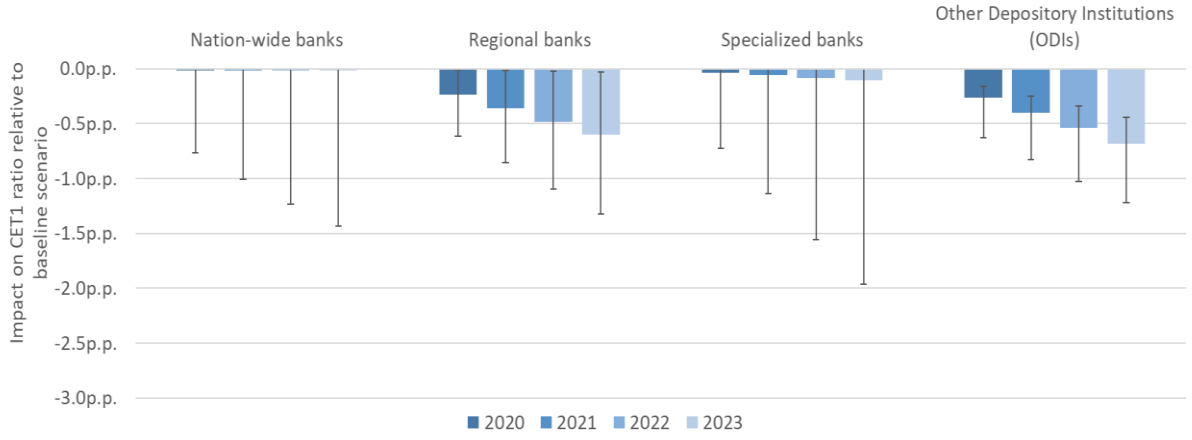
69. The pressure on capital ratios may grow if Fintech-induced competition would intensify. The "Fintech Overlay" has been used to gauge the effect of intensifying competition due to the "Open Banking" initiative as well as Fintech developments in the retail payment sector, suggesting potentially notable impacts on regional banks, ODIs and selected specialized banks. The analysis assumes that Open Banking and e-money may put upward pressure on retail deposit rates, coupled with downward pressure on loan interest rates, and not allowing banks to adjust their business models, e.g. by raising fees. The aim was to thereby examine how Open Banking may impact the solvency conditions of banks under some conservative assumptions (related system-wide liquidity aspects are discussed later in this note).

70. Under the baseline scenario, regional banks' capital ratios may fall by 0.6 to 1.3 percentage points by the end of the five-year horizon under the Fintech Overlay. For nation-wide and specialized banks, the effects are "nonlinear" in the sense that only once the strength of the overlay is set to high levels, the impact on the banks' capital ratios would become notable. When activating the Fintech Overlay, the system-wide capital depletion would rise to 4 percent, from 3 percent without the overlay. In this case, several regional and specialized banks' as well as ODIs' capital ratios would be further stretched. In aggregate, nation-wide, regional, and specialized banks would consume about 0.4, 0.7, and 2.2 percentage points of their CCBs. Figure 28 shows the impact in terms of capital ratios and capital depletion from Year 0. Figure 29 shows the impact on NIMs, which are the main underlying channel through which stronger competition would influence the capital ratios. This effect is not a baseline forecast, as banks will likely change their business model to counteract such possible losses in income.

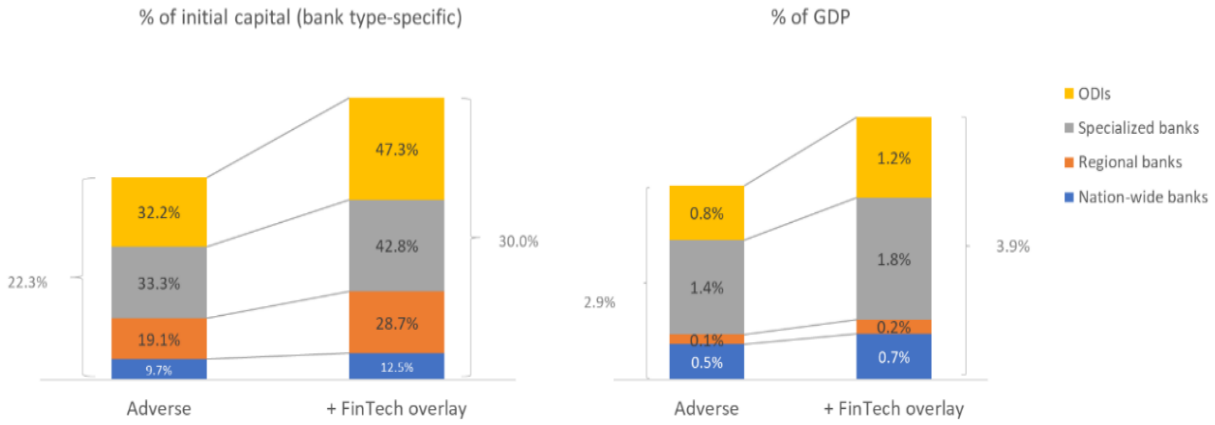
71. The Fintech Overlay analysis suggests that various regional banks, a subset of the specialized banks and MSBs might be affected the strongest. MSBs, however, offer loans to customers which are deemed to be structurally riskier, for their loan interest rate spreads over MSBs' funding cost to be structurally higher. Such spreads may not necessarily fall as much as a result of rising competition, hence lessoning a bit the effects for MSBs relative to other banks in Korea.

Figure 28. Korea: Fintech Overlay—Impact on Banks' Capitalization Under Conservative Assumptions

The impact of rising competition (e.g. due to the Open Banking initiative) on baseline capital ratios may be sizable…

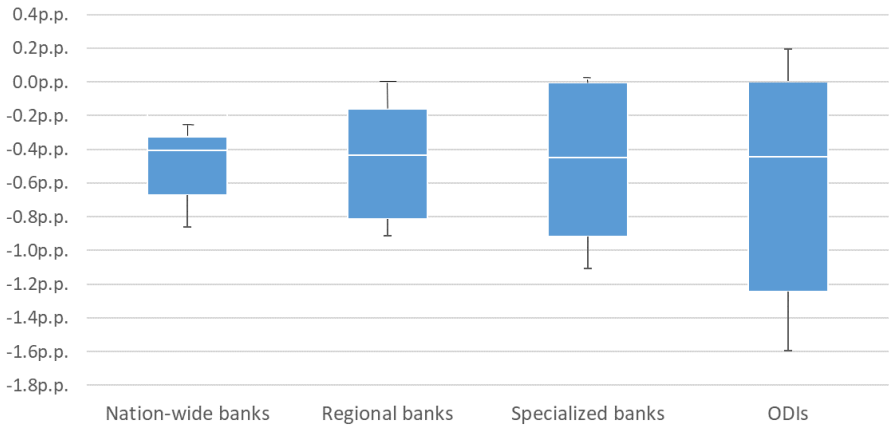


Capital depletion with and without FinTech Overlay, as percentage of initial capital and relative to nominal GDP (2018)



Source: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.

Figure 29. Korea: Fintech Overlay—Impact on NIMs

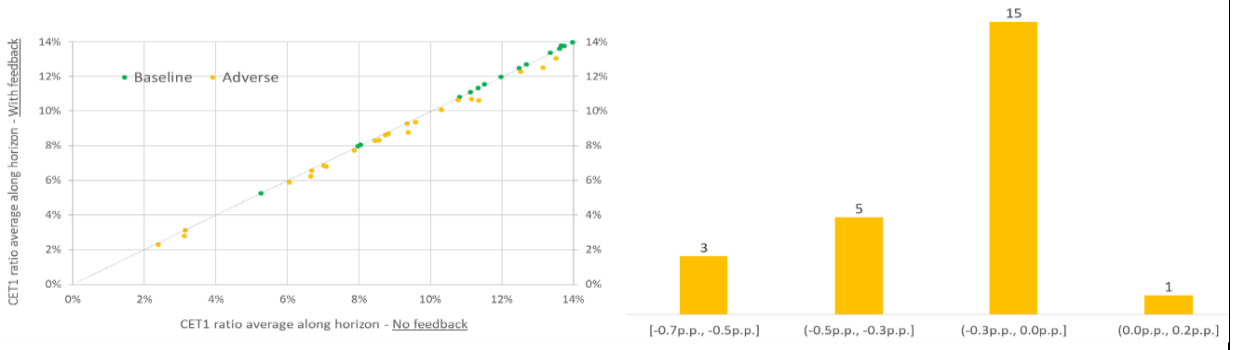


Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.
Notes: The figure shows the difference in NIMs compared to baseline scenario, on average per annum, in percentage points. The upper and lower ends of the boxes denote the 90th and 10th percentiles of the underlying distribution across banks. The error bars extending to the up- and downside denote the maxima and minima. White lines denote the median.

Bank Solvency-Funding Cost Feedback

72. The solvency-liquidity cost feedback is notable. Under the adverse scenario, for eight of the banks the additional feedback explains between -0.3 and -0.7 percentage points in the fall of their regulatory capital ratios (Figure 30).

Figure 30. Korea: Solvency-Liquidity Cost Feedback



Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.

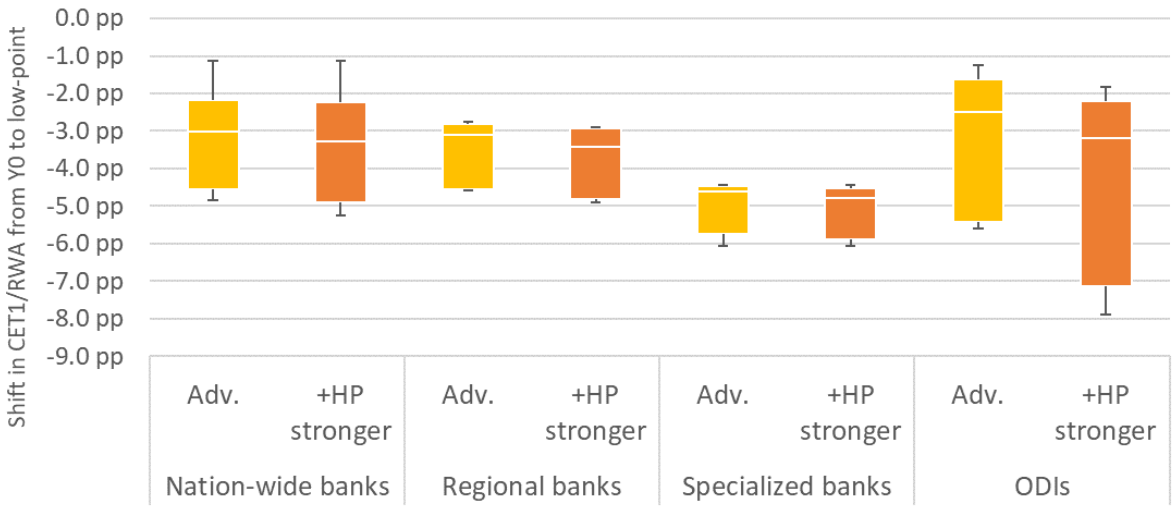
House Price Sensitivity Analysis

73. The rationale for conducting a house price sensitivity analysis stems from the special housing market structure in Korea. The housing market in Korea is of notable centrality and uniqueness, in terms of its leasehold rent system and the use of insurance in relation to leasehold and mortgage loans by state-run institutions. Over the past decades, Korea has not experienced any significant housing market downturn, except for its endogenous, yet limited, response in terms of

price falls during the AFC and GFC. The adverse scenario reflects this past endogenous response of about -16 percent peak-to-trough.

74. The Korean banking system appears resilient to a hypothetical more severe house price decline of -40 percent, coupled with the adverse scenario. The additional burden on banks' capital ratios appears limited (Figure 31). A caveat to this analysis is that it captured the impact of falling house prices on only the banks' mortgage portfolios, i.e., not capturing commercial real estate portfolios[39]. The analysis was conducted in a way that affects only the mortgage portfolios' LGDs, under the assumption that house price movements in isolation would not materially affect mortgage PDs. This is a reasonable assumption in jurisdictions such as Korea—a full recourse system—in which households have no notable incentives for strategic default in response specifically to falling house prices when they would face "negative equity".

Figure 31. Korea: Capital Ratios' Sensitivity to Stronger House Price Shock for Residential Mortgage Portfolios



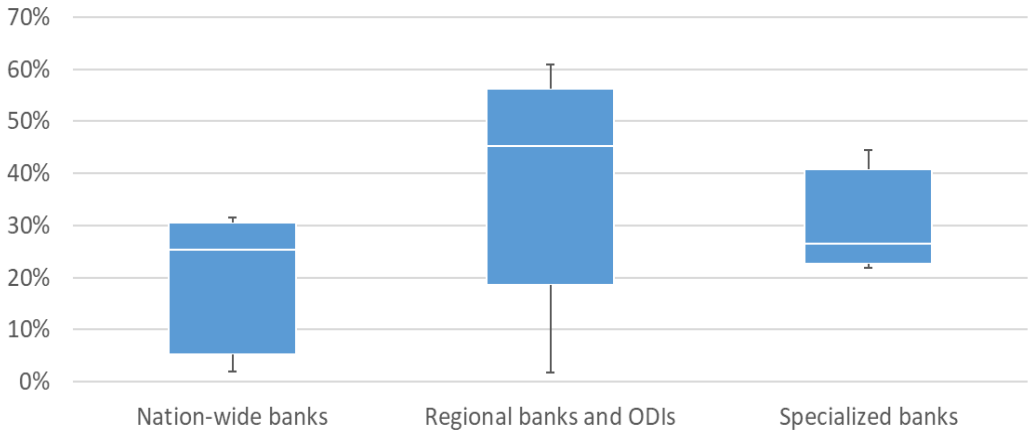
Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.
Notes: The upper and lower ends of the boxes denote the 90th and 10th percentiles of the underlying distribution across banks. The error bars extending to the up- and downside denote the maxima and minima. White lines denote the median.

Mortgage Insurance

75. Mortgage insurance schemes are used to a significant extent in Korea. They imply a shield to banks' capital and relief in terms of risk weight densities for such portfolios. The insured portion of the mortgage portfolios amount to 25 percent, 45 percent, and 27 percent for nation-wide, regional, and specialized banks respectively (medians) at end-2018 (Figure 32). The shares were assumed to stay constant along the horizon under both the baseline and the adverse scenario[40].

[39] Data for commercial real estate portfolios were not separately available, i.e. they were part of the nonfinancial corporate portfolio aggregate.
[40] They were held constant for both the derivation of the "headline" solvency stress test results as well as the sensitivity analysis presented here.

Figure 32. Korea: Mortgage Insurance Shares Across Korean Banks



Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.

Notes: The upper and lower ends of the boxes denote the 90th and 10th percentiles of the underlying distribution across banks. The error bars extending to the up- and downside denote the maxima and minima. White lines denote the median.

76. To quantify the impact of switching the insurance off, three effects need to be accounted for. They include the accounting provision stock difference at the end-sample position, the provision flow difference conditional on the scenario along the 5-year scenario horizon (focus on the adverse scenario), and the relief in terms of risk weights.

77. The effect of shifting the insured mortgage share to zero percent on RWAs has been captured based on an auxiliary regression relating mortgage risk weight densities to their drivers. The equation had the following structure: $RWD_b = \alpha + \beta PD_b^{TTC} + \gamma(1 - w_b^I)LGD_b^I$. RWD_b is the bank-specific risk weight density for the IRB mortgage portfolio of all banks for which this share is non-zero. PD_b^{TTC} is the IRB mortgage portfolios' TTC-PD, w_b^I is the share of the mortgage portfolio that is insured, and LGD_b^I is the regulatory downturn LGD estimated for the insured portion of the portfolio, computed as $LGD_b^I = LGD_b/(1 - w_b^I)$, where LGD_b is the weighted average DT-LGD for the portfolio. The equation structure assumes that the TTC-PD is the same for the insured and uninsured portion of the portfolio and that the LGD for the insured portion is zero percent. All variables are measured as of 2018. The equation has an R-square of 89 percent and both β and γ were found to be economically significant positive coefficients[41].

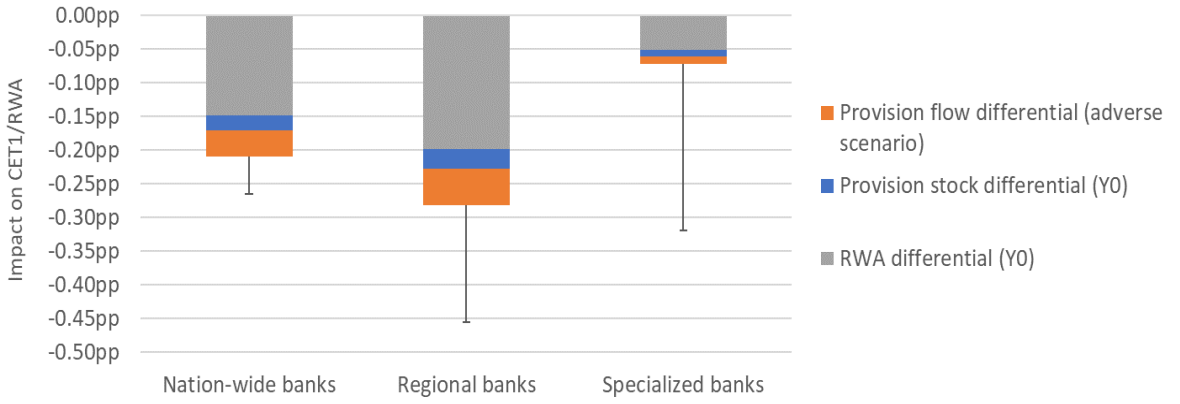
78. The counterfactual calculation suggests a sizable role for risk weighted assets among the three drivers on capital ratios (Figure 33)[42]. For nation-wide, regional, and specialized banks, the weighted average impact per group of banks amounts to a combined 21, 28, and 7 basis points,

[41] Upon its estimation, the equation has been used to set the insured mortgage share to zero percent to imply a fitted RWD on the assumption that the whole portfolio was uninsured, along with the fitted risk weight densities at 2018Q4. The difference in the resulting two fitted RWDs for each bank were then multiplied with the initial risk-unweighted mortgage portfolios to obtain the change in the risk-weighted mortgage exposures. The R-square (89 percent) was deemed sufficiently high to not consider a nonlinear equation structure which in principle might be warranted due to the nonlinear nature of the Basel risk weight formulas.

[42] ODIs have been excluded from this counterfactual analysis because mortgage insurance shares were not available for them; the average across the regional banks was employed for them.

respectively. About 70 percent of these impacts stem from the risk weighted asset effect. For selected banks in the three categories, the overall impact reaches a non-negligible 26, 46, and 32 basis points, respectively. The fact that regional banks are most sensitive to the presence of the insurance squares with them having the highest insurance shares in the banking system (Figure 32).

Figure 33. Korea: Impact on Accounting Provision Stocks, Flows, and Risk Weights when Assuming that Mortgage Insurance was Absent



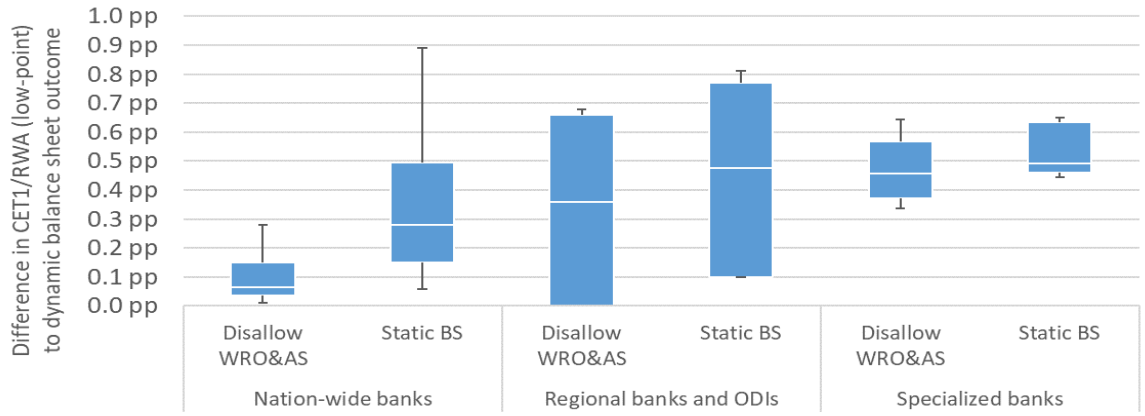
Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.

Notes: The bars reflect the RWA-weighted impact on CET1/RWA ratios of the underlying individual banks in each category. The bar extending to the downside denotes the maximal impact for one bank in the respective category.

Static vs. Dynamic Bank Balance Sheets

79. Assuming static instead of dynamic balance sheets would make the bank-solvency results more benign. The banks' capital ratios would be higher than they are under the dynamic balance sheet assumption if write-offs and asset sales were disallowed (Figure 34), while otherwise still operating under a dynamic balance sheet mode. Gross loan growth and hence overall balance sheet growth would equal the dynamic balance sheet growth; yet, prohibiting write-offs and asset sales implies that less new business enters the loan portfolios (by design of that counterfactual simulation), which would generate more income as these loans are performing, and carry less sizable risk weights. The move to a full static balance sheet (zero gross loan growth, no write-offs and asset sales) would render the solvency ratios even more benign. The median difference to the full DBS outcome would amount to 28, 46, and 50 basis points for nation-wide banks, regional banks and ODIs, and specialized banks, respectively. For some selected nation-wide banks, the difference would equal a material 90 basis points.

Figure 34. Korea: Capital Ratio Differentials under Different Static and Dynamic Balance Sheet Variants (Adverse Scenario)

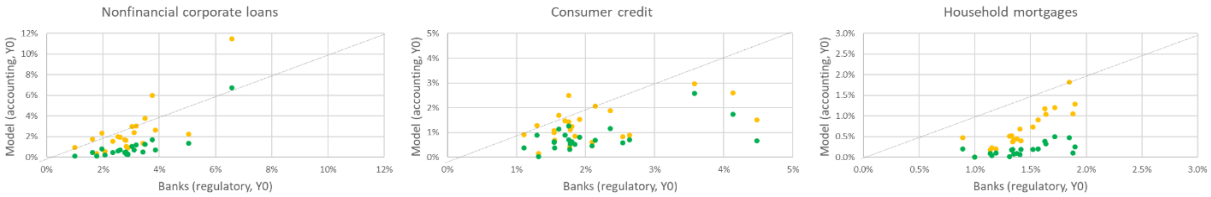


Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations. WRO = write-offs. AS = assets sales. BS = balance sheet. The upper and lower ends of the boxes denote the 90th and 10th percentiles of the underlying distribution across banks. The error bars extending to the up- and downside denote the maxima and minima. White lines denote the median.

Regulatory Loan Loss Provision Overlay

80. The regulatory provision coverage ratios across banks and portfolios tend to exceed the top-down accounting model-implied starting point coverage ratios based on the adverse scenario. Unlike an unbiased accounting provisioning, regulatory loan loss coverage ratios are expected to be set in a prudent, downturn scenario-conditional manner, akin to what an accounting-based loan loss estimates under an *adverse scenario* may suggest. The Korean banks' regulatory coverage ratios indeed largely exceed the Year 0 adverse scenario-based accounting model-implied coverage ratios (Figure 35, focus on orange dots for the adverse scenario)[43]. If the regulatory provision scheme was switched off, the capital depletion of the banks would rise from the "headline" impact of 2.9 percent of GDP (Figure 26) to 3.7 percent (Figure 36).

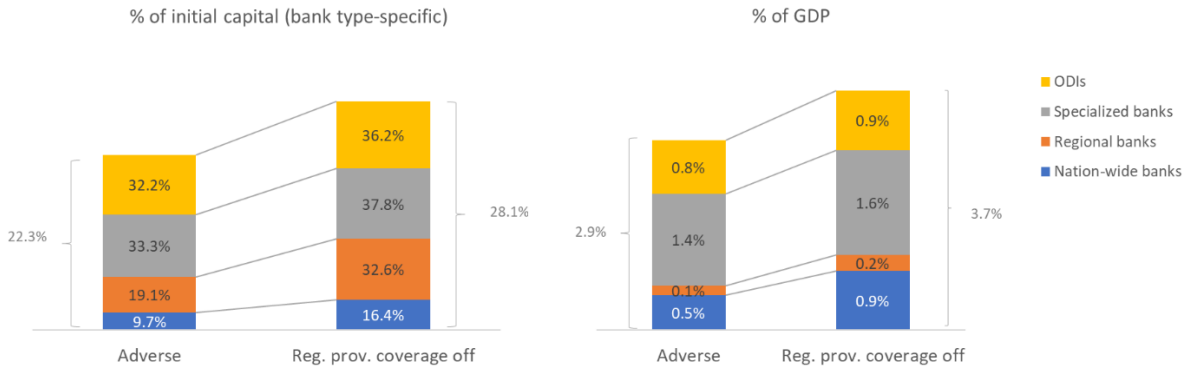
Figure 35. Korea: Loan Loss Coverage as of End-2018, Regulatory Provision-based vs. Top-down Model-based (Adverse Scenario)



Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations. The scatter plots (each dot is a bank) show loan loss coverage ratios (provision stock for S1/2/3 over gross exposure in S1/2/3) for different portfolios.

[43] A differential, if one would arise, would concern largely Stage 1 and Stage 2 stocks, because Stage 3 exposures are provisioned, from a regulatory perspective, based on net-of-expected-recovery exposures, hence rendering them effectively similar to accounting provisions.

Figure 36. Korea: Impact of Regulatory Loan Loss Coverage on Capital Ratios and Depletion



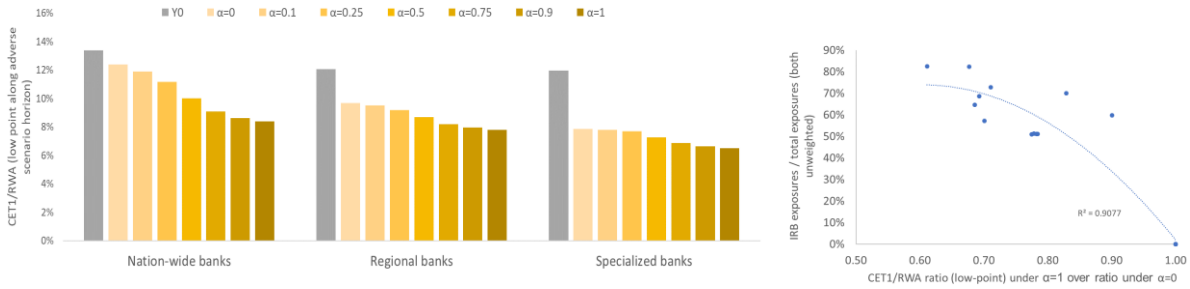
Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations.

RWA Pass-Through Strength

81. The pass-through parameter that links changes in PiT-PDs to TTC-PDs to obtain RW changes for IRB portfolios is subject to uncertainty and hence deserves a sensitivity analysis. The "headline" results presented before (Figures 24-26) were based on a pass-through strength of 0.5. Varying this pass-through parameter on a range from zero to one implies a notable range for the resulting CET1/RWA ratios under the adverse scenario (Figure 37, left). Under the strongest pass-through of 100 percent (arguably a too conservative assumption), still all nation-wide, regional and specialized banks would not fall short of their regulatory minima. Next to the specialized banks, two nation-wide banks would start consuming their CCB under this conservative assumption.

82. The higher sensitivity of nation-wide banks' solvency results on the RWA pass-through strength stems from their higher IRB portfolio shares. Naturally, the impact of the pass-through relates to the IRB portfolio shares (Figure 37, right).

Figure 37. Korea: Sensitivity of Capital Ratios to RWA Pass-Through Strength under the Adverse Scenario



Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations. "Y0" refers to 2018Q4. The bars are the risk-weighted asset weighted average across the underlying banks. The parameter α (right figure) denotes the RWA pass-through strength. The scatter and the fitted polynomial/trend-line on the right were based on the subset of 19 banks (nation-wide, regional, specialized banks) who do or may employ the IRB approach.

C. Recommendations

83. The top-down stress test frameworks by the FSS and BOK are well developed. They serve the purpose of conducting top-down risk assessments for the Korean banking system well. They also were instrumental for informing the very detailed bank-by-bank deep-dive analyses conducted during the 2019 FSAP.[44]

84. Fintech developments are significant in Korea and require a thorough risk analysis. As outlined earlier in this note, Fintech developments such as the Open Banking initiative and the e-money providers deserve special emphasis. A risk analysis should be conducted in particular in the area of systemic liquidity implications and system-wide operational risks, to then derive policy recommendations to help shield the Korean financial system from potential risks.

85. It is recommended that the FSS and BOK consider developing a lifetime ECL and hence IFRS 9-compatible credit risk model. This development is important to make sure that a top-down scenario analysis performs well in accurately predicting how banks' capitalization behaves under hypothetical downturn scenarios, whose impact is more frontloaded than under an incurred loss accounting regime. It is also important to enable the supervisory authority to gauge whether banks' provision stock coverage (portfolio-specific) is adequate—as observed at a point in time, and conditional on a baseline scenario.

86. It is recommended that the Korean authorities invest resources in back-testing various of their top-down model components. This recommendation concerns in particular the structural model components such as the authorities' LGD models. Documented back-test results are instrumental for enhancing certainty and confidence with the models that the authorities' risk analysis is based upon.

87. It is recommended that the authorities invest more resources into developing a dynamic balance sheet feature in general, and accounting for asset sales and write-offs in their models specifically. Allowing for realistic dynamic balance sheet dynamics instead of hypothetical static balance sheets is important and understanding and capturing the specific market structures in terms of the continuous and swift sale of banks' nonperforming assets to an active NPL market is essential; in particular since the NPL market is so active in Korea. The FSS' willingness to modify their stress test model to account for write-offs is positively acknowledged.

88. The stress test models for credit guarantee institutions (HF, SGI, HUG, others) should be further developed. The BOK already conducted some first risk assessments for guarantors, which is a positive development. The framework should be further developed for example in terms of linking to a common scenario, which would require developing satellite model systems of

[44] The BOK has developed its Systemic Risk Assessment Model (SAMP) since 2012; and its Non-bank Financial Institution Stress Test Model since 2019, which covers insurance companies, credit cooperatives, savings banks, securities firms, and credit-specialized finance firms (BOK Financial Stability Report, June 2018, p. 85-97). The BOK's Extensive Stress Test Model (2019) integrates banks and non-banks (BOK Financial Stability Report, December 2018, p. 95-102). The One distinguishing feature of the BOK model suite is its integrated contagion module. The FSS developed its Stress Test for Assessing Resilience and Stability of the Financial System (STARS) framework since 2017, to support its macroprudential supervision tasks. STARS include a suite of models that capture contagion and macro-feedback effects that were developed jointly with the BOK. Results from the BOK stress tests are published in the FSR.

different kinds for the guarantors (currently the BOK's approach is to stress the guarantors' subrogation rates by self-set multiples of standard deviations, not linking to historical data nor scenarios). The stress test of the guarantors should ideally be integrated with those of banks and other non-bank FIs to account for the likely significantly nonlinear system behavior due to the presence of guarantors. The BOK and FSS are recommended to work jointly on such model developments going forward, in the interest of maximizing the synergies of pooling the specific expertise of both authorities.

89. Korea's ODI sector is systemically relevant—constituting about 20 percent of the banking system—and related risk analyses should be kept under the header of the 'banking system'. Financial institutions under the ODI category are banks, not non-banks, as suggested in various documents that the Korean oversight institutions publish on a regular basis. Placing the ODI's in separate chapters under a non-bank FI category implies the risk of misleading an inference about risks in the banking system.

FORWARD-LOOKING BANK LIQUIDITY ANALYSIS

A. Overview

90. The FSAP conducted a top-down liquidity stress test based on 2018Q4 regulatory data. The analysis included 18 banks: six nation-wide commercial banks, two internet-only banks (KRW currency exposures only), six regional banks, and four specialized banks. In addition, foreign bank branches are included (KRW only). These correspond to approximately 90 percent of the banking system as of 2018Q4 in terms of total assets. In addition to the liquidity stress test, the FSAP also analyzed liability characteristics, liquidity buffers, and asset–liability–matching.

B. Current Liquidity Conditions and Banks' Liquidity Profiles

91. Banks' Liquidity Coverage Ratios (LCR) stand above the recently introduced requirement of 100 percent. The LCR requirements have been gradually introduced to levels of 100 percent for all currency (60 percent for foreign bank branches) and 80 percent for FX in 2019. Most banks already met these requirements in 2018 (Figure 38).

92. The Net Stable Funding Ratios (NSFR) suggest that banks can meet funding requirement over a 12-month horizon. All banks subject to the NSFR met the 100 percent minimum regulatory threshold in 2019Q1.

93. Banks' funding mix is diversified, and the FX funding structure has become more stable. Short-term FX funding now mostly comprises FX deposits by domestic nonfinancial corporations. Retail deposits still represent most KRW funding. The NSFR funding structure appears more diversified with funding from retail and SME deposits, corporates, other financial institutions and sovereigns being more balanced. Maturities of assets and liabilities are generally well matched, despite some short-term maturity mismatch being measured for selected regional banks and internet-only banks in KRW.

94. Contractual maturities of assets and liabilities appear well matched. The cumulative funding gap is measured as the sum of the net funding gaps for different maturity buckets, between

3 months and 10 years, expressed as a percentage of total assets[45]. There appears to be some short-term maturity mismatch for regional banks and internet-only banks in KRW. The maturity gaps are close to -8 percent for both bank categories for assets and liabilities maturing within 6 months. For other categories of banks, contractual maturities are well matched, and the FX funding gap is positive for all bank categories.

C. Methodology

95. The liquidity stress test (LST) assesses banks' ability to withstand net-cash outflows amid shocks to asset prices, retail funding and wholesale funding. Four scenarios were considered, one for each of the three shocks and a more extreme scenario in which all the three shocks occur simultaneously (Appendix 3). For each scenario, the assessment was conducted for KRW currency only, FX only, and both combined. The hurdle rate was set to 100 percent, even in the cases where the regulatory LCR requirement is less than 100 percent to assess banks' capacity to withstand the shocks outlined in the adverse scenarios.[46]

96. The liquidity shocks applied in the LST were more severe than the historical experience of Korea[47]. Since liquidity crises (including bank runs) are exceedingly rare, there is little in terms of historical precedents (even globally) from which to calibrate extreme shocks (tail risks); history-based calibrations would therefore fall increasingly short of the severe yet plausible criterion for scenario design. The preference for calibrating severe shocks (more severe than implied by history) is also driven by the notable Fintech developments in Korea, as well as the increased cross-border interconnectedness. Korea's Open Banking structure implies that bank customers can in the future even more swiftly channel their deposits across banks; rendering deposits notably less sticky and increasing customers' reactiveness to bad news, possibly triggering electronic deposit runs.

97. Liquidity shortfalls are calculated as a percentage of the banks' counterbalancing capacity for different scenario severities. In total, 20 scenarios with increasingly severe shocks were considered for retail and wholesale funding (Appendix 3). Liquidity shortfalls are identified for all currencies, KRW and FX both in terms of type of shock and type of bank.

D. Results

98. Banks' liquidity buffers appear to be adequate against significant drops in financial asset prices (Figure 39). Asset price shocks consistent with the bank solvency stress test would have little effect on liquidity with liquidity coverage decreasing from 121 percent to 120 percent. The shock has a similarly small impact on all categories of banks for both KRW and FX liquidity and results from banks' HQLAs being mainly central bank reserves withdrawable in stress (15 percent) and securities with 0 percent risk-weight (73 percent).

[45] Based on 2018Q4 data.
[46] For example, commercial banks faced a minimum FC LCR requirement of 70 percent in 2018 and 80 percent in 2019.
[47] For example, the LCR assumes 40 percent of runoff rate on unsecured non-operating deposits, whereas the LST assumes 50 percent. These assumptions are both more severe than what occurred during the Asian Financial Crisis or the Global Financial Crisis.

99. Banks appear resilient to retail funding shocks. These would impact KRW liquidity, with the average liquidity coverage of nation-wide banks falling to 98 percent, implying a marginal liquidity shortfall. FX liquidity coverage would remain above 100 percent. Regional and specialized banks would carry sufficient FX liquidity to cover their implied shortfalls in KRW. The liquidity buffers in KRW of internet-only banks and foreign bank branches would cover the run-off in deposits. However, given the heavy reliance of internet-only banks on retail deposits, their coverage ratio would fall from 284 percent to 140 percent.

100. FX liquidity is sensitive to wholesale funding shocks. The banking system is likely to maintain liquidity following a wholesale funding shock. However, specialized banks' reliance on unsecured wholesale funding would lead to a fall in FX liquidity coverage from 112 percent to 85 percent.

101. The liquidity shortfall is largest for nation-wide banks. Using gradually more severe scenarios for the retail and wholesale funding shocks illustrates the resilience of the Korean banking system. The overall system shortfall in KRW would reach 2 percent of the initial counterbalancing capacity. But while foreign bank branches would have excess liquidity of approximately 8 percent of the banking systems counterbalancing capacity, nation-wide banks would face a shortfall of close to 9 percent. The banking system's FX liquidity shortfall resulting from FX funding shocks would reach 4 percent of FX counterbalancing capacity, where nation-wide banks would have an 8 percent liquidity shortfall. Regional and specialized banks would have combined liquidity buffers of 4 percent.

102. The BOK has ample space to provide liquidity in extreme stress scenarios. Both KRW and FX liquidity could be provided through standard facilities or unconventional policy measures. In an extreme scenario where banks with liquidity shortfalls had no access to liquidity from banks with surpluses, the aggregate shortfalls would reach KRW 43tr in domestic currency and USD 3.5bn in FX. The latter is equivalent to less than 1 percent of the BOK's FX reserves.

E. Recommendations

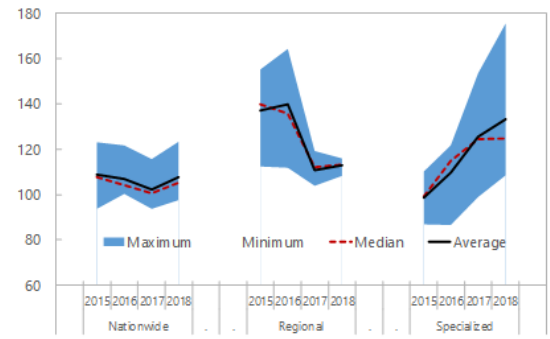
103. Measures have been taken to strengthen the liquidity of the Korean banking system. Several regulatory requirements have been introduced, including the liquidity coverage ratios and stable funding ratios for both domestic and foreign currency, loan to deposit ratios and limits on open FX positions. The authorities are monitoring FX liquidity closely with both the BOK and the FSS carrying out FX liquidity stress tests separately, in addition to having a joint working group responsible for monitoring liquidity. While efforts are being made to stress test KRW liquidity, this seems to be lagging behind the recent developments in the FX liquidity stress test.

104. The authorities shall continue to improve the bank LST for domestic currency and develop the FX LST by major currencies. It would also be useful to expand the methodology of the joint BoK and FSS FX liquidity stress test to include FX LCRs, add an NDF stress scenario in different types of stress tests; and periodically survey the resident NDF FX market participants for any potential macroprudential effects as global shifts take place in currency and interest rate markets.

Figure 38. Korea: Liquidity and Stable Funding

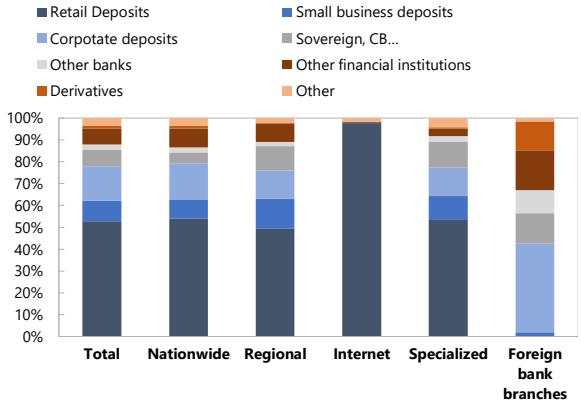
Banks' LCRs remain above the recently introduced requirement of 100 percent

Liquidity Coverage Ratio (LCR) in KRW



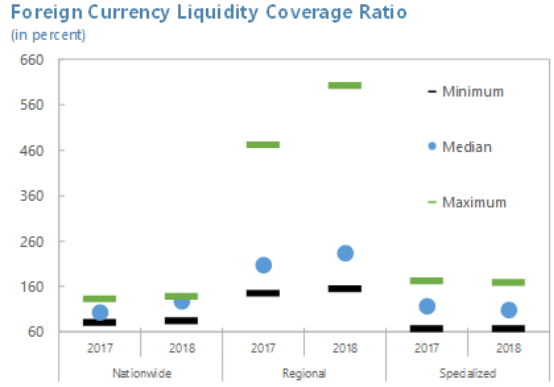
Domestic banks' KRW funding is mainly from retail deposits, while foreign bank branches rely on corporate deposits

LCR KRW Funding Structure



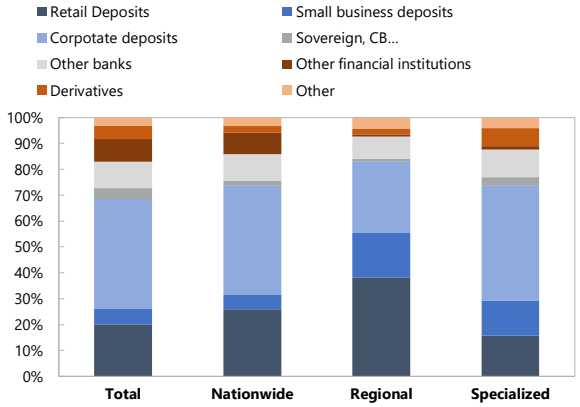
Most banks have FX LCRs above the 80 percent minimum requirement introduced in 2019

Liquidity Coverage Ratio (LCR) in FX



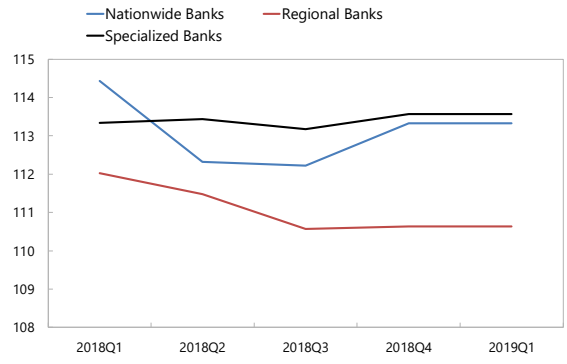
Korean banks largely rely on the deposits of domestic corporates for FX funding

LCR FX Funding Structure



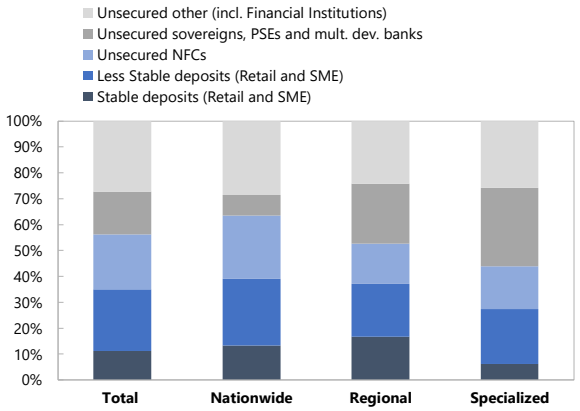
The NSFR suggests that banks will have buffers to meet the funding requirements for the next 12 months

Net Stable Funding Ratio (NSFR)



The NSFR funding structure is well diversified.

NSFR Funding Structure

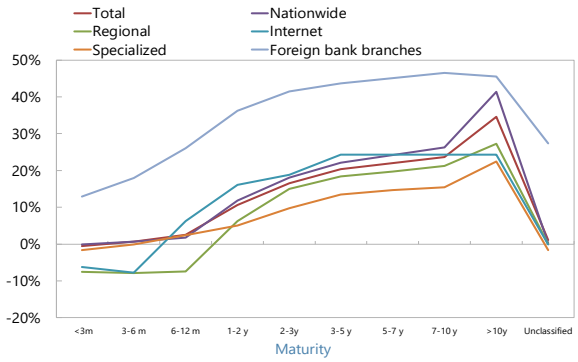


Sources: FSS and IMF staff calculations.

Figure 39. Korea: Liquidity Stress Test

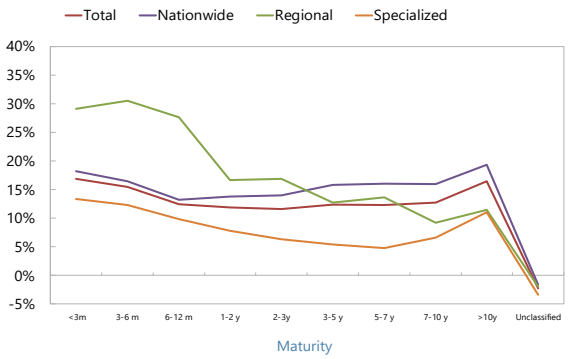
Regional and internet banks have negative funding gaps over the next 6 months

KRW Cumulative Funding Gaps



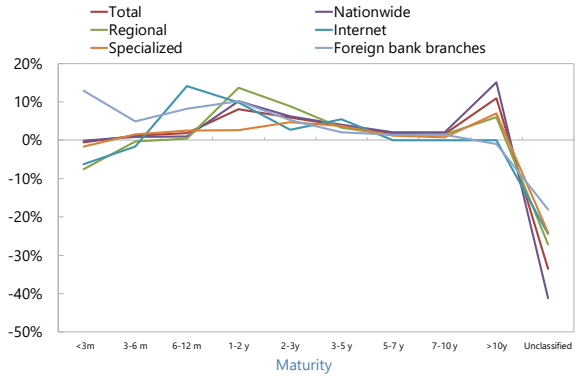
The maturity of FX assets and liabilities are well matched

FX Cumulative Funding Gaps



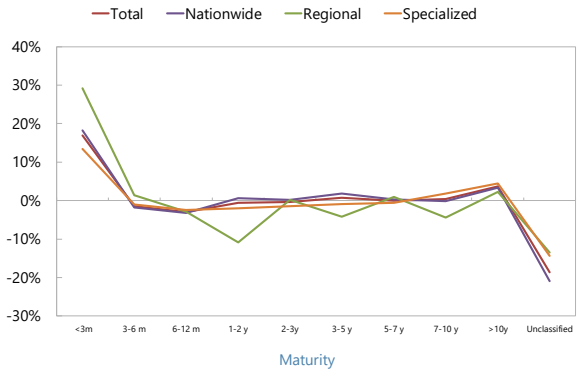
Regional and internet banks have negative funding gaps over the next 6 months

KRW Funding Gaps by Maturity



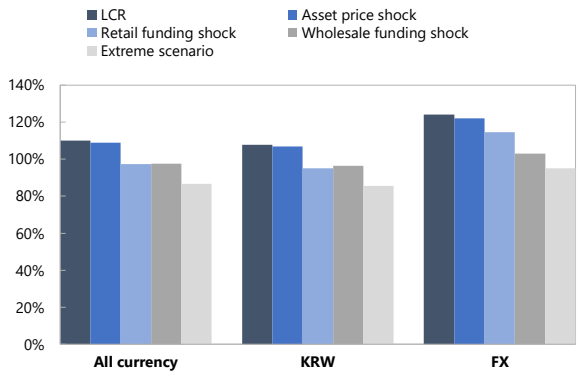
The maturity of FX assets and liabilities are well matched

FX Funding Gaps by Maturity



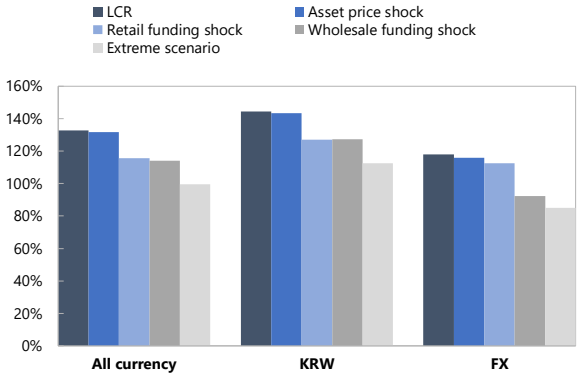
D-SIBs are resilient to liquidity shocks and have ample FX liquidity buffers

D-SIBs- LCR and Stress Test Results



Non-DSIBs are more sensitive to FX wholesale funding shocks

Non-D-SIBs

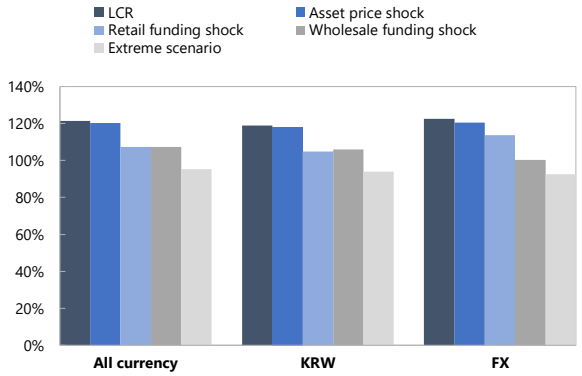


Source: FSS and IMF staff calculations

Figure 39. Korea: Liquidity Stress Test (continued)

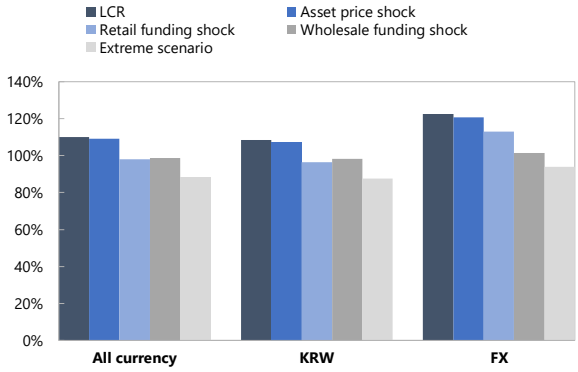
The LST results suggests that the banking sector is resilient to asset price falls and funding shocks

All Banks- LCR and Stress Test Results



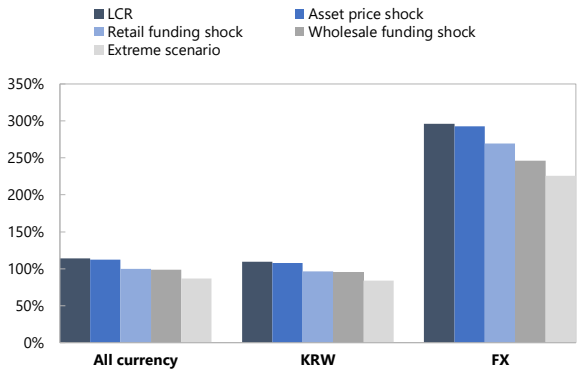
Nationwide banks are most sensitive to run-offs in KRW retail deposits

Nationwide Banks- LCR and Stress Test Results



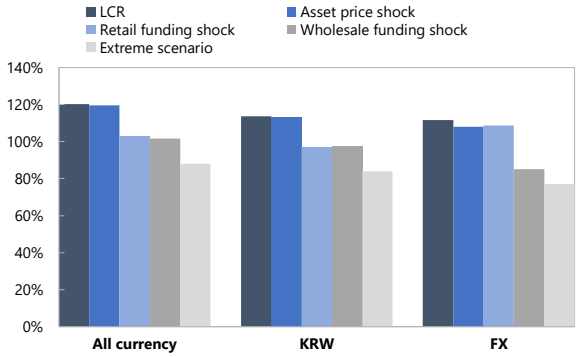
Regional banks have ample FX liquidity buffers but are somewhat sensitive to run-offs in KRW wholesale funding

Regional Banks- LCR and Stress Test Results



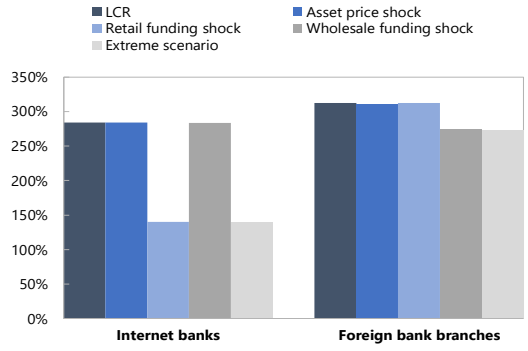
Specialized banks have lower FX LCR requirements and are sensitive to FX wholesale funding shocks

Specialized Banks- LCR and Stress Test Results



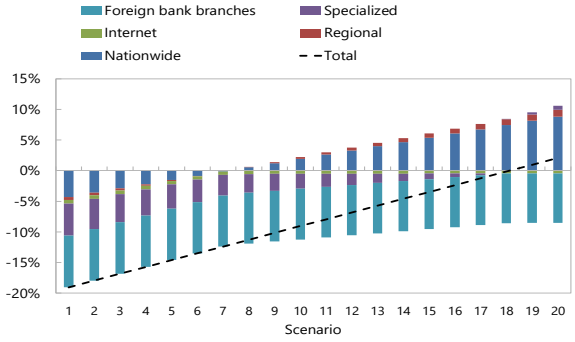
Internet banks are sensitive to KRW retail deposit shocks, but currently have ample liquidity to withstands such shocks

Internet Banks and Foreign Bank Branches- LCR and Stress Test Results (KRW)



Sum of liquidity shortfalls from retail and wholesale funding shocks as percentage of counterbalancing capacity

Liquidity shortfalls for different scenario severity as percentage of counterbalancing capacity (KRW)

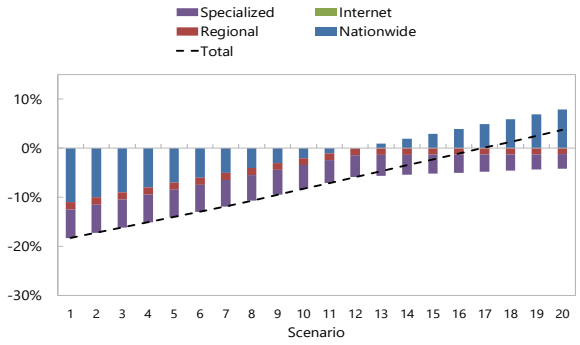


Source: FSS and IMF staff calculations

Figure 39. Korea: Liquidity Stress Test (concluded)

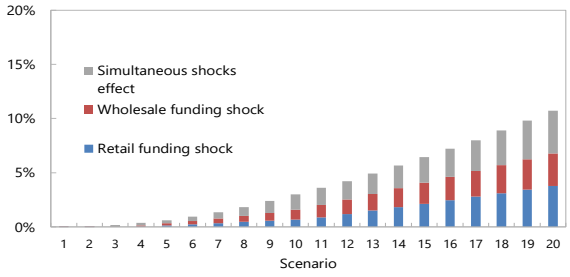
FX liquidity shortfall of nationwide banks exceed surplus of regional and specialized banks

Liquidity shortfalls for different scenario severity as percentage of counterbalancing capacity (FX)



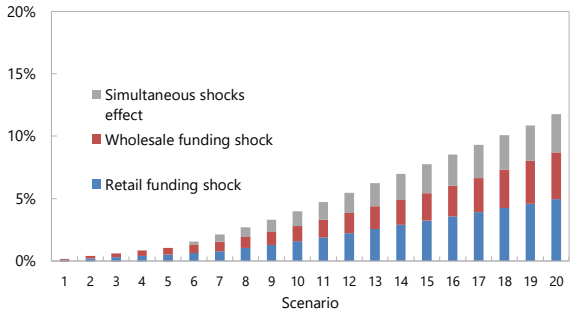
Retail and wholesale funding shocks have similar effects on banking liquidity

Liquidity shortfalls (excl. surplus banks) as percentage of counterbalancing capacity (KRW)



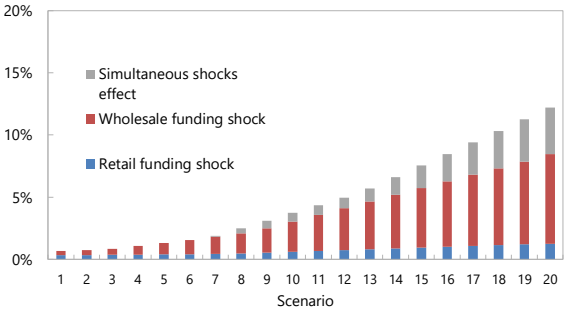
Liquidity shortfalls in KRW liquidity are sensitive to retail deposit shocks

Liquidity Cash Flow Analysis for different severity levels (KRW)



Reliance on FX deposits of domestic corporates makes banks sensitive to shocks in FX wholesale funding

Liquidity Cash Flow Analysis for different severity levels (FX)



Source: FSS and IMF staff calculations

RISK ANALYSIS FOR THE INSURANCE AND PENSION FUND SECTOR

A. Insurance Sector

105. The FSAP conducted a top-down solvency stress test for seven life and six non-life insurance firms covering about 75 percent of the sector's assets. The stress test was conducted on a solo entity basis, using public and supervisory data as of end-2018. See Figures 40 and 41, and the Insurance Stress Test Matrix in Appendix II for more details. An additional analysis of profitability trends was used to explore the ability of the insurance sector to re-capitalize after the adverse stress scenario.

106. The adverse scenario as employed for the bank stress test was slightly adjusted and more focused on market shocks; but is comparable in terms of severity and narrative of the banking solvency stress test (Table 8). It included shocks to sovereign bond yields (up to +250 bps), equity prices (up to -39 percent), corporate credit spreads and defaults, as well as FX rates. The shock applied to mutual funds (-12.5 percent) reflects the rather conservative nature of indirect investments which are mostly fixed-income or alternative investments including infrastructure. No explicit shock was used for real estate, as direct holdings in real estate are only allowed for own use, but not for investments. All shocks were assumed to occur instantaneously and modelled as haircuts to the asset values. The value of liabilities was only marginally affected by the stress scenario as discount rates are based on historic cost accounting.

107. The current asset valuation regime mitigates the impact of the market price shocks. Under the current accounting regime, held-to-maturity designation is still allowed—and widely used among life insurers, but also by a few non-life insurers for large shares of their assets. Hence, around 23 percent of the sample's investment assets were shielded from market price changes.

108. The impact in terms of RBC coverage is the main output of the stress test. Under the current risk-based solvency regime, reductions in the asset base will typically reduce the available capital. In the stress test model, the required capital was assumed to decline very marginally by 2 percent, as two opposing effects are likely to broadly cancel each other out: With a reduced asset base, less capital is required; e.g., for equity risk, while rating downgrades would result in higher capital requirements for credit risks.

109. In the stress scenario, life insurers' available capital declines substantially while non-life insurers are marginally affected. All companies stay above regulatory thresholds (Figures 41 and 42). Starting from an RBC coverage of 239 percent, the median life company drops to 169 percent, and two insurers would see their coverage ratio slightly below the recommended level of 150 percent, though still well above the 100 percent regulatory threshold. The overall reduction in available capital amounts to KRW 27.4 trillion, corresponding to a 38.7 decline, or 4.3 percent of total assets. Non-life insurers, of which most in the sample follow a very similar business model, reveal a narrow range of RBC ratios before stress which narrows even further after stress. The RBC coverage of the median non-life company declines from 214 to 158 percent. Only for one company in the sample, the RBC coverage falls below the recommended level. Available capital of the six non-life insurers is reduced by KRW 8.9 trillion (-27.8 percent, or -3.9 percent of assets).

110. The shocks on corporate bond yields and equity prices cause the largest reduction in available capital (Figure 42). In the life insurance sector, 35 percent of the KRW 27.4 trn reduction in available capital stems from the equity shock, another 30 percent from the corporate bond shock. The sovereign yield shock and the mutual fund shock, too, have a notable impact (18 and 15 percent, respectively). In the non-life sector, the relative importance of the corporate bond shock is even more pronounced as it contributes 50 percent of the overall reduction in available capital. In both sectors, the FX shock affects only a minority of companies as most are almost fully hedged using currency swaps and forwards.

111. In the stress scenario, life insurers would experience an accelerated decline in profitability forcing, perhaps, further liability restructuring to regain profitability (Figure 43).

Underwriting results of life companies have been under pressure for some years, mostly as a result of declining premium income, and have turned negative in 2018. While this downward trend was largely compensated by a slightly increasing investment income, the top-down stress test model assumes no recovery of asset prices after the materialization of the instantaneous shock. Consequently, investment income would be largely composed of interest, dividends and rental income, but exclude any gains on the sale of investment assets. Compared to 2018, investment income in 2019 would be 12 percent (KRW 2.2 trillion) lower. Net income before tax would drop to 2.3 trn (-42 percent) in 2019, the first year of the projection horizon, recovering afterwards mainly on the back of positive investment results. Still, the projected underwriting results remain muted which exemplifies the urgency with which life companies should restructure their business to increase underwriting profitability, shifting further from guaranteed savings products into lower guarantees and protection business.

Table 8. Korea: Insurance Stress Test Scenario

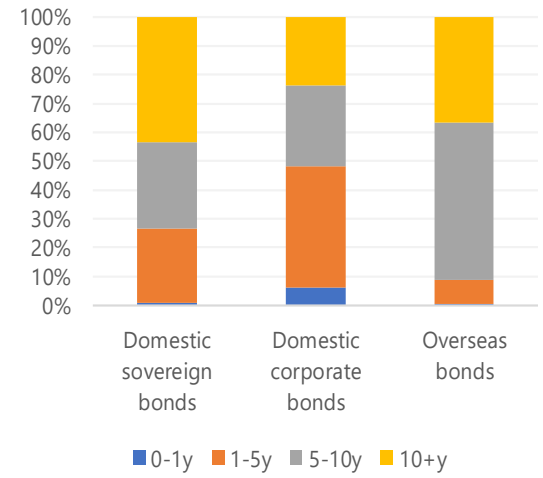
Domestic sovereign bond yield	0-1Y		-20bps
	1-5Y		+50bps
	5-10Y		+140bps
	10Y+		+250bps
Stocks	domestic		-39%
	foreign		-35%
Corporate bond yields	domestic	AAA	+120bps
		AA	+160bps
		A	+210bps
		BBB	+300bps
		BB and lower	+400bps
	foreign	AAA	+70bps
		AA	+90bps
		A	+120bps
		BBB	+180bps
		BB and lower	+300bps
Unsecured loans			-1.5%
Sub-standard loans			-30%
Exchange rate	KRW/USD		-37%

Sources: IMF staff.

Figure 40. Korea: Insurance Stress Test Sample—Fixed-Income Portfolio

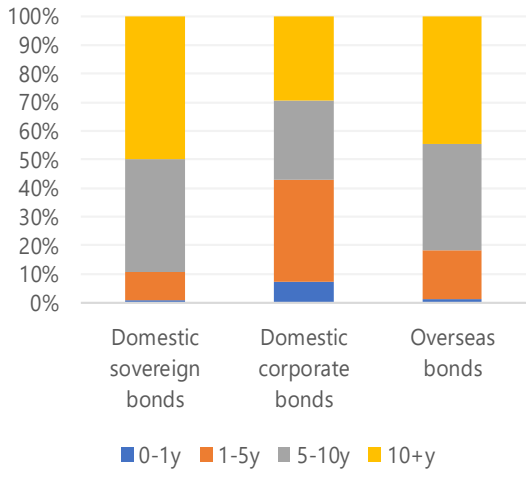
Bond maturities of life insurers are very long-term, with more than one third maturing only after ten years.

Life - Bond maturities



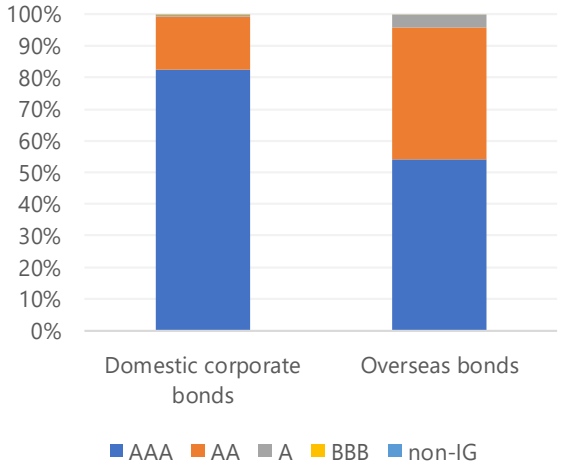
Unlike other peers, also Korean non-life insurers hold large amounts of long-term assets to match their liabilities.

Non-life - Bond maturities



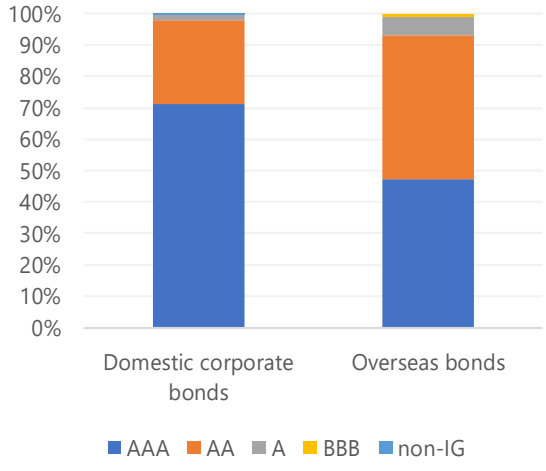
Life insurers take only little credit risk in the bond holdings….

Life - Bond ratings



… and also, in the non-life sector most bonds are rated AAA or AA.

Non-life - Bond ratings



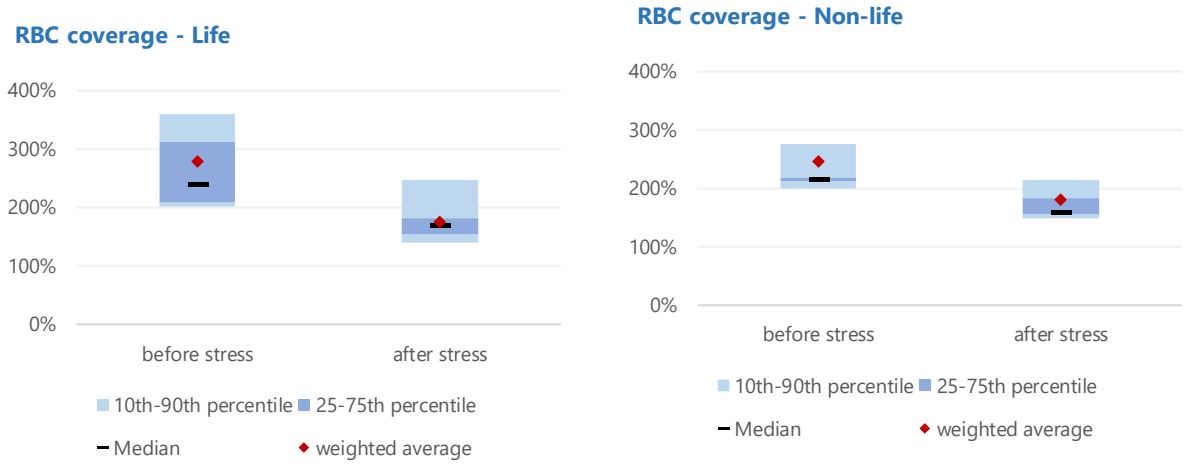
Sources: IMF staff calculations based on FSS and company data.

Notes: Breakdowns only include bonds designated as held for trading or fair value through profit and loss.

Figure 41. Korea: Insurance Stress Test—RBC Coverage

For the median life company, the RBC coverage declines from 239 to 169 percent.

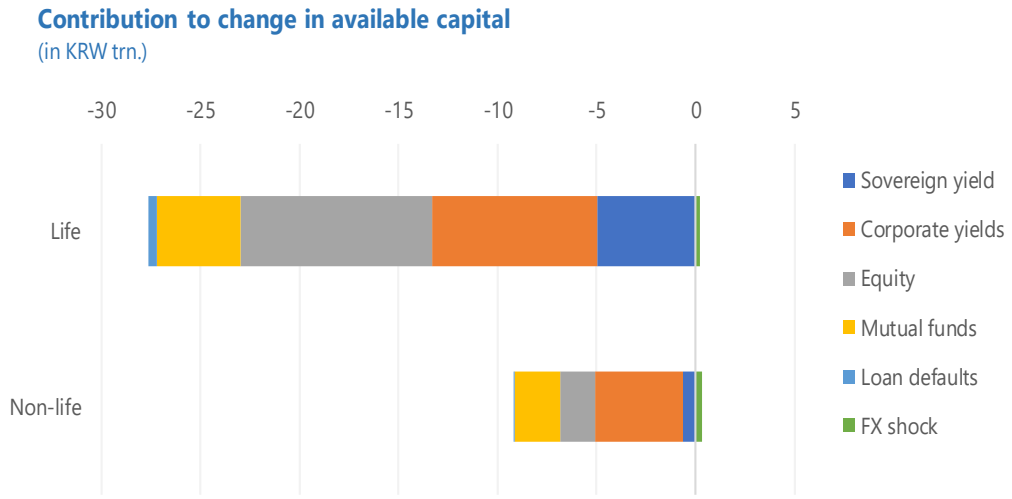
In the non-life sector, companies' solvency ratios are more homogenous both before and after stress. The scenario results in a decline in the RBC coverage of 56 percentage points.



Sources: IMF staff calculations based on FSS and company data.

Figure 42. Korea: Insurance Stress Test—Contribution of Individual Shocks

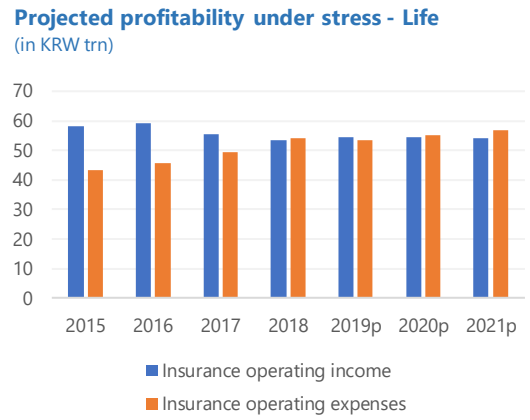
The largest impact on available capital stems from the shocks on equity prices and corporate bond yields.



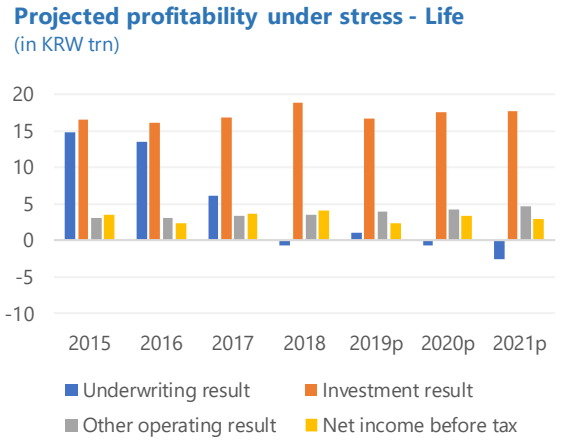
Sources: IMF staff calculations based on FSS and company data.

Figure 43. Korea: Insurance Profitability Projections After Stress

Assuming no recovery after the instantaneous stress in financial markets, life insurers' underwriting results remain muted...



...while positive investment returns and other operating results contribute to positive net income before tax.



Sources: IMF staff calculations based on FSS and company data.

B. Pension Fund Sector

112. The Korean pension system faces heterogenous challenges in all three pillars. While the first pillar still provides very decent returns as of now, its long-term sustainability over the next decades will depend on reforms of its contribution and benefit parameters. In the meantime, strengthening the second and third pillar as complementing mechanisms is urgently needed.

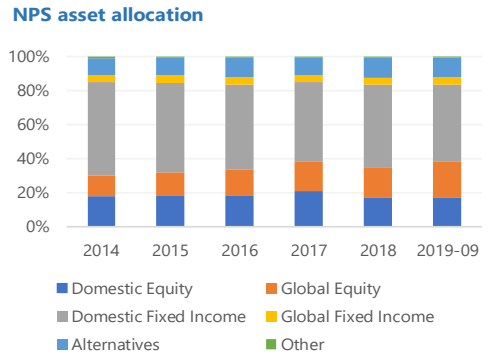
113. The National Pension Service (NPS) faces challenges from the combination of low interest rates and adverse demographics, but also in its day-to-day operations. NPS is still in an accumulation phase and expected to grow from currently KRW 700 trn to 1,778 trn in 2041 when benefit payments will start exceeding contributions. Leaving parameters unchanged, the fund will be depleted by 2057. Options to cope with these long-term sustainability concerns include reducing benefits, increasing the contribution rate, increasing the retirement age, and increasing the target for investment returns. Operational challenges result from recent staff fluctuation, especially among investment and risk managers, which has surged after having moved the headquarter out of Seoul—as a public entity, NPS is increasingly competing with the private sector for talent.

114. NPS is striving for a more globally diversified investment portfolio, while currently still more than 60 percent are invested in domestic assets (Figure 44). In the domestic market, NPS holds more than 7 percent of the stock market's capitalization, in addition to 18 percent of Korean sovereign bonds. In particular, the domestic equity portfolio is heavily weighted towards electrical and electronic equipment (30 percent), while overseas assets are more evenly spread across economic sectors. Alternative investments, accounting for 12 percent of total assets, are almost equally split in real estate (37 percent), private equity (32 percent) and infrastructure (30 percent), with the remaining 2 percent invested in hedge funds. Both asset classes, overseas and alternative investments, have contributed to shielding the fund from more volatility in 2018 when the return

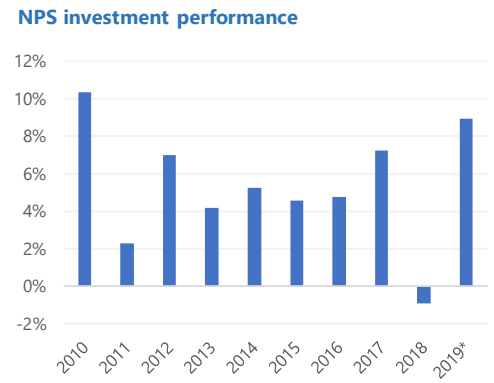
was negative for the first time since 2008, at -0.9 percent—since its inception in 1988, the average annual performance was 5.6 percent. As more foreign assets are included in the portfolio, the NPS will be exposed to higher currency risk—which are currently largely unhedged—and will have to develop its risk management capacity accordingly. In the past however, the KRW/USD exchange rate tended to co-vary negatively with foreign asset prices, especially in the long term.

Figure 44. Korea: The National Pension Fund

NPS is still mostly invested in domestic assets (60 percent), but gradually expanding its overseas portfolio.



After a negative performance in 2018, NPS has recorded an almost double-digit return in the first three quarters of 2019.



Notes: */ 2019 performance is for the first nine months only.

Source: IMF staff calculations based on NPS data.

115. In the second pillar, risks to pension scheme members and beneficiaries are largely contained due to a conservative asset management process, which limits long-term performance, however. Products in the second pillar, the retirement pension, such as bank deposits, guaranteed investment contracts (financial products with principal and interest guaranteed) or funds (financial products whose earnings depend on their performance) are currently offered by around 50 pension service providers, incl. banks, insurers and securities firms. Assets managed by these pension service providers reached KRW 190 trillion at end-2018, of which banks managed 51 percent, followed by life insurers with 23 percent, investment firms with 19 percent, and non-life insurers with 6 percent. Around 90 percent of retirement pension funds were being invested in principal-protected products, and the remainder in funds. In 2018, the return averaged at 1.0 percent, below the average deposit rate; the principal-protected product yielded 1.6 percent, while the performance-based type was negative at -3.8 percent. Still, pension participants and sponsors have recently been showing more interest in diversified fund vehicles with better yields and actively seeking products without guarantees. As of now, retirement pensions cannot exploit their full potential yet, as necessary reforms are stuck in the parliamentary process. In particular, the possibility to offer pooled pension funds, covering multiple employers, has been discussed for several years. Such multi-employer schemes require a careful monitoring to ensure fair treatment of all cohorts and scheme members.

116. Private pensions of the third pillar are also offered by most financial sectors—certain products suffer from their inherent design, limiting the long-term performance. The third pillar includes savings-based annuities (the largest proportion with 78 percent), pension savings trust, and

pension savings funds, all of which offer tax deduction benefits to investors. Pension savings trusts offered by banks have traditionally been showing a relatively weak performance. These can typically be redeemed annually without full market value adjustments, so that guaranteed amounts are effectively locked in every year, instead of providing the guarantee at retirement age. Accordingly, investments are to a large degree in sovereign bonds and highly rated corporate bonds. As a drawback, the performance of such products is not incentivizing potential customers to join those pension plans.

C. Recommendations

117. The FSS shall further develop its insurance stress tests and include adverse macro-financial scenarios, based on a medium-term risk outlook. Currently the FSS uses single-factor sensitivity analyses which potentially underestimate the effect of a widespread financial crisis on the balance sheets and solvency ratios of insurers. Combining risk factors in a consistent adverse scenario should consider the dependence across risk factors and could be used both for top-down and bottom-up stress tests. After the implementation of the new insurance capital standard (K-ICS), stress test results could inform about the need for potential capital add-ons, and should, as a minimum, determine the level of supervisory intensity.

NETWORK AND CONTAGION ANALYSIS

A. Analysis

118. Korea's financial institutions are linked through significant direct balance sheet and interbank market exposures, as well as their significant exposures to the real estate sector. The FSAP's analysis employed a network approach based on cross-exposures for 64 large financial institutions across financial sectors (banks, insurance, investment firms, and credit-specialized firms). A network visualization based on raw exposure data as well as based on the outcome of a default simulation[48] confirm the significant balance sheet interlinkages (Figure 45). Figure 46 shows the results in terms of capital depletion across sectors[49].

119. The network and default simulations reveal that specialized banks are about as systemic as nationwide banks, which is confirmed as well by network centrality metrics (Figures 46 and 47). Nationwide banks are net lenders to specialized banks, and hence are more vulnerable to specialized banks than the other way around. Life and non-life insurance firms are not as systemic, but vulnerable to stress in specialized banks and nation-wide banks. Insurers are net lenders to all other subsegments of the Korean financial system.

120. The banks and insurance firms that face the hardest hit on capital under the adverse scenario in the solvency stress test are not tightly linked with the rest of the financial system. The spillover potential from such firms appears sufficiently contained at the current juncture. The assessment should be treated cautiously, however, because confidence effects can imply spillover

[48] The default simulation follows closely the methodology developed by Espinosa-Vega and Solé (2010).
[49] Firm-level results in terms of impact and vulnerability across the system have been developed and discussed in detail with the Korean authorities. They are not presented here because the information is deemed confidential.

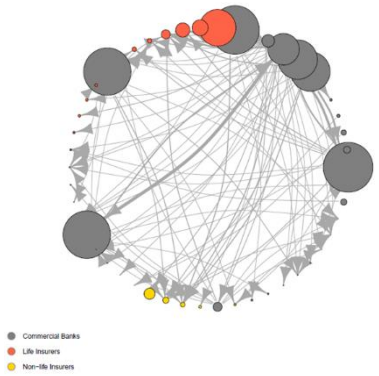
effects beyond the direct financial linkages between firms that the default simulation methodology captures.

B. Recommendations

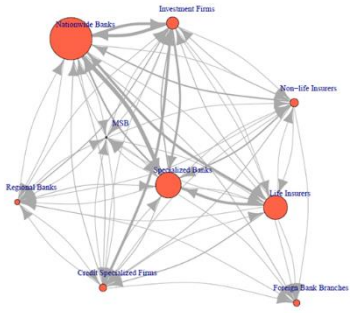
121. The bilateral exposure data set compiled by the FSS for conducting the FSAP network and contagion analysis is highly valuable. The Korean authorities are recommended to keep maintaining this database, and further expanding the cross-section of financial sector firms where possible. Collecting the exposure data on a regular and frequent basis in the future, for example with a quarterly frequency, will be instrumental for supporting the network and contagion analysis for the Korean financial system. Dynamic network model methodologies can be developed to aid the analysis of such time varying exposure data in the future.

Figure 45. Korea: Financial System Network Structure

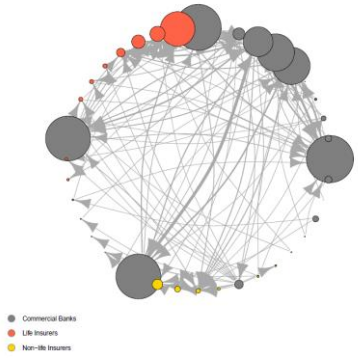
Firm-level interconnectedness, raw debt exposure data-based



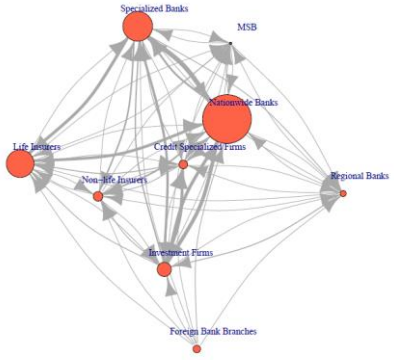
Sector-level interconnectedness, raw debt exposure data-based



Firm-level interconnectedness, default simulation-based



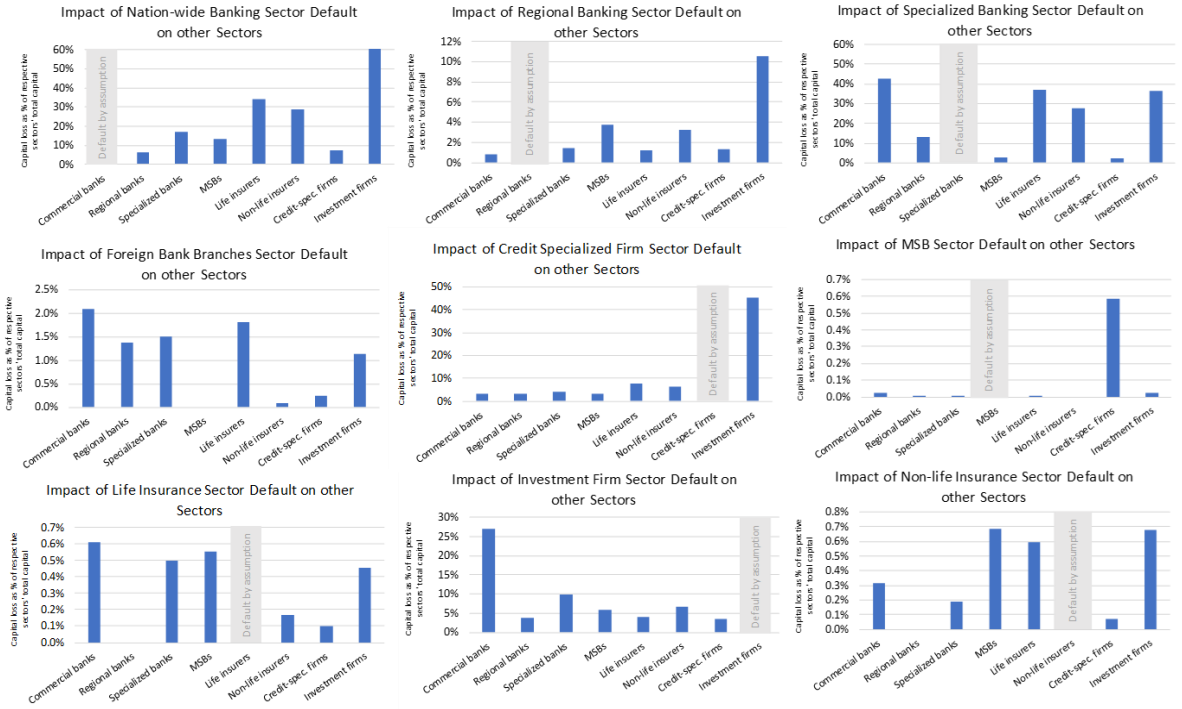
Sector-level interconnectedness, default simulation-based



Sources: FSS supervisory exposure data and IMF staff calculations.

Notes: The sample includes 21 banks, 25 life insurers, 29 non-life insurers, foreign bank branches as a block (38 underlying entities), Mutual Savings Banks as a block (79 entities), credit-specialized firms (102 entities), and investment firms (485 firms). The size of the bubbles is proportional to the size of the assets of an institution, or institution type. At the top: The width of a connecting line and arrow from A to B is proportional to the size of the exposure of A (asset side) to B (liability side). At the bottom: A line connects A to B if the default of A induces a positive capital depletion for B. The width of the connecting line and arrow is proportional to the capital impact of B expressed relative to the initial capital stock of B. The underlying multi-round simulation engine is adopted from Espinosa-Vega & Sole (2010), with an assumed LGD equal 100 percent.

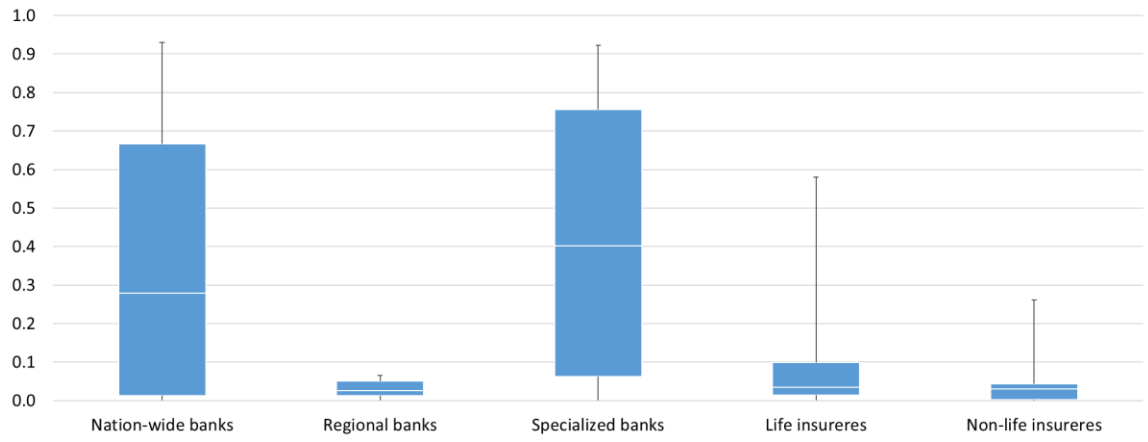
Figure 46. Korea: Sector-Level Default Simulation: Capital Depletion



Sources: FSS supervisory exposure data and IMF staff calculations.

Notes: The sample includes 21 banks, 25 life insurers, 29 non-life insurers, foreign bank branches as a block (38 underlying entities), Mutual Savings Banks as a block (79 entities), credit-specialized firms (102 entities), and investment firms (485 firms). The underlying multi-round simulation engine is adopted from Espinosa-Vega & Sole (2010), with an assumed LGD equal 100 percent.

Figure 47. Korea: Network Centrality (Eigenvector Centrality)



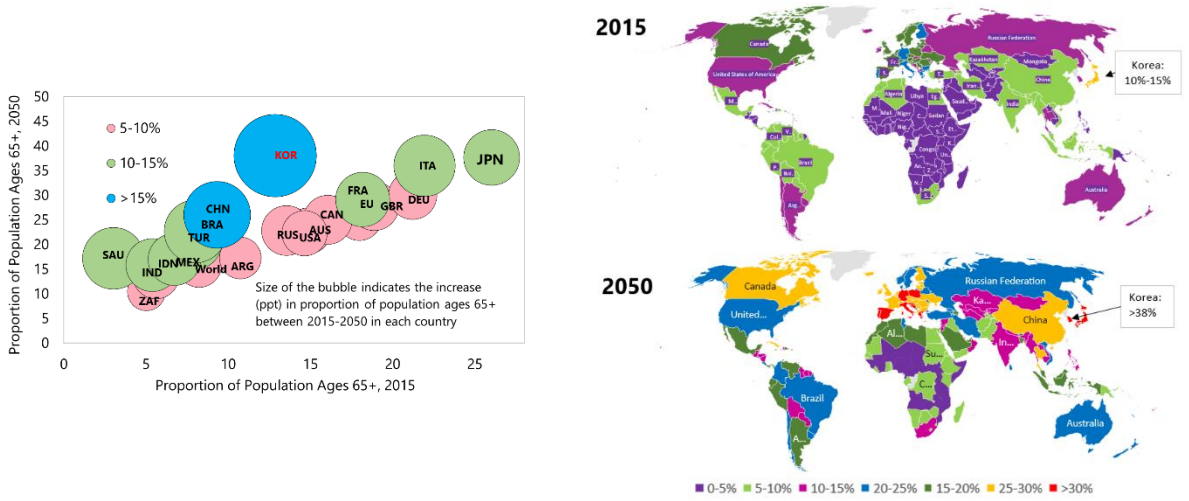
Sources: FSS supervisory exposure data and IMF staff calculations.

Notes: The upper and lower ends of the boxes denote the 90th and 10th percentiles of the underlying distribution across banks. The bars extending to the up- and downside denote the maxima and minima. White lines denote the median. Eigenvector Centrality measures a node's importance based on the number of links it possesses to other nodes in the network, while also taking account of extended indirect connections.

DEMOGRAPHIC DEVELOPMENTS IN KOREA

122. Demographic developments in Korea have shifted adversely over the past decades and are expected to keep rotating adversely, in terms of both stagnating population growth and rising dependency ratios. The trends point to a stagnating and soon shrinking population over the coming decades, coupled with the related shift in the age distribution from the young to the old. Figure 48 shows that the demographic rotation as materializing in Korea is one of the most adverse world-wide[50]. At the same time, old-age poverty in Korea is highest among OECD countries, affecting almost 44 percent of those aged 66 or older, while the OECD average is only 14 percent (Figure 49).

Figure 48. Korea: Demographic Developments Proportion of Population Ages 65+



Sources: UNDESA Population Division, World Population Prospects, 2019.

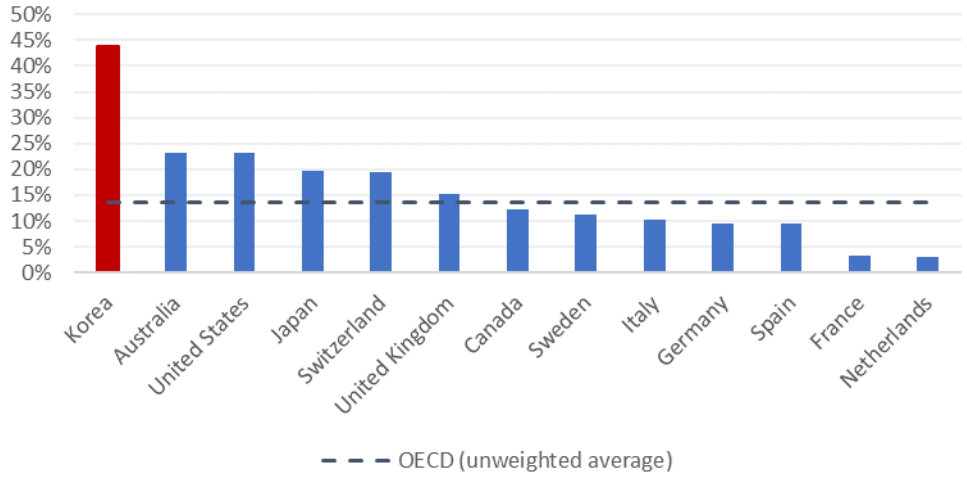
123. Demographic shifts of the materiality observed in Korea will imply a longer-term structural drag on natural interest rates and inflation, reflecting in turn a continuous drag in demand. Demographic developments constitute one of a number of causes that have been related to the notion of "secular stagnation" which is a characteristic assigned to numerous countries around the world in the aftermath of the Great Recession of 2007-09.[51] A comprehensive analysis as to the consequences of aging in Korea has been developed by the Bank of Korea[52].

124. The extent to which demand would slow down as a result of adverse demographic trends is surrounded by sizable uncertainty. The investment component of output may slow down in selected industries, reflecting entrepreneurs' acting on an expected fall in future

[50] A useful descriptive analysis involving data from the United Nations can be found in Moody's (2018), "Governments of Japan and Korea: Demographics will weigh on long-term economic and fiscal strength, despite offsets from technology and labor participation". Investor Report.
[51] See, for example, Summers, L. (2014): "U.S. economic prospects: Secular stagnation, hysteresis, and the zero-lower bound". *Business Economics*; Eggertsson, G. and N. Mehrotra (2014): "A model of secular stagnation", NBER Working Paper; and Ferrero, G., Gross, M. and S. Neri (2017): "On secular stagnation and low interest rates: demography matters", *International Finance*.
[52] Bank of Korea (September 2017), "Population Aging: Impacts and Policy Imperatives".

consumption. However, some specific industries might benefit from demographic changes (e.g. health care, medical science, etc.). The elderly portion of the population can be expected to spend their savings, with consumptive expenditures implying a sustained velocity of money and contribution to GDP flows.

Figure 49. Korea: Old Age Poverty Across OECD Countries



Sources: OECD and IMF staff calculations.

125. The demographic developments are expected to have a notable impact on housing market dynamics in Korea. The impact would stem from falling demand for housing, implying downward pressure on house and rent prices, which would be exacerbated by the leasehold rent system (Jeonse) which builds on the premise of rising house prices in the future (see Section 1.C. for a related discussion).

126. Next to demand side-oriented concerns rooted in demographics, supply side factors in Korea matter. Public and private investment in technology is instrumental to sustain productivity growth, amid a downward trend in potential output growth which may be due to a shrinking working age population which might not be avoided. Korea's Ministry of Science appears to put forward meaningful and significant policies under its "Fourth Industrial Revolution" plan, aiming to boost productivity growth and innovation, foster female participation, devote larger budgets to childcare and elderly care, etc. Boosts in productivity may counteract an otherwise stronger upward pressure on real wages due to a shrinking working age population.

127. Public and private pension funds in Korea will experience the consequence of demographic shifts most directly and hence deserve special attention. The pension system will need to balance a shrinking contributing population with rising pension outflows. The contribution share of the working-age population will need to rise in absolute and in relative, per contributor terms, thereby reducing disposable income of the young population cohorts, and in turn implying an additional drag on demand and feedback to yet lower interest rates. In the long term, rising fund outflows from a pension fund perspective may imply a visible pullback of funds from corporate and sovereign bond markets which would let their prices fall (yields rise) and in turn imply some upward pressure on corporate and sovereign funding costs. The Korean sovereign may consider borrowing

from banks instead (whose credit business to the private sector would meanwhile likely shrink; see below).

128. Korea's National Pension Service (NPS), the first pension pillar, is still in an accumulation phase and expected to double its assets until 2040 when payouts will start exceeding inflows. Managing close to KRW 700 trillion, NPS is one of the largest pension funds globally. With 22.1 million members and 4.7 million beneficiaries, net inflows are still positive and contribute to steadily growing assets over the next 20 years. The second pension pillar ("retirement pensions") is currently undergoing reforms aiming for a more extensive coverage—as of 2018, only half of the employees are covered by such a pension scheme, resulting in a sector size of around KRW 190 trillion. Necessary reforms, however, have been stalled in the parliamentary process for more than four year already.

129. The impact of demographic change specifically on banks goes through numerous channels whose net effect for the banking system would likely point to consolidation, business model restructuring in general, and a rotation to non-interest income sources specifically. The impact on banks would stem from lower interest rates, a flatter yield curve respectively, hence structural downward pressure on net interest income and in turn a lower potential to retain profits and hence capital accumulation. Demand for long duration loans (e.g. mortgages) would fall because of a shrinking young population cohort, keeping interest income low. In order for banks to maintain sizable enough capital buffers, they may need to consider i) shrinking in terms of branch structure to reduce staff costs, ii) shifting to non-interest income sources, to offset falling interest income with higher fee and commission income, iii) fostering innovation to remain competitive in view of the strongly rising non-bank sectors, one aspect of which is to conduct non-bank pure intermediary business for instance (e.g. peer-to-peer lending) next to loan granting (money creation). The dis-saving process of the elderly population will meanwhile mean more spending flows between households and firms, which may leave the liquidity position of banks in terms of a deposit base rather unchanged, however. Figure 50 summarizes the channels through which aging can affect the financial system and its components. It lists the potential mitigating strategies and effects at the bottom, including, inter alia, overseas expansion for banks and other financial firms to seek higher returns, cost cutting and consolidation domestically, and digitalization and Fintech developments.

130. Life insurance companies are venturing into protection products and health insurance to compensate the lower demand for traditional savings products. Health insurance includes coverage for dread diseases including cancer and dementia, and life insurers also aim to provide health management services.[53] The shift in product design also implies targeting a different age cohort—savings products are typically bought by 30 to 40-year olds, while health insurance is mostly demanded after an age of 50. As of now, improvements in longevity have not materialized in the form of lower underwriting profits for life insurers and longevity risks are—as of now—contained. Many savings products are lapsed by policyholders and hence do not reach the contractual maturity date; the benefits are typically paid out as lump-sums or term annuities (usually 10 years). As financial literacy increases and policyholders increasingly understand the risks of old-

[53] Medical services are, however, strictly regulated in Korea, and can only be offered by medical doctors.

age poverty, their behavior might likely change, and whole-life annuities will be more appreciated and sought after, exposing life companies to heightened longevity risks.

Figure 50. Korea: Channels through which Demographic Developments May Impact the Financial System

Population growth stagnating and dependency ratios rising

Continuous drag on demand (incl. on investment in anticipation of lower consumption in future), hence lower interest rates and inflation as long as demographic rotation takes place

	Banks	Insurance	Pension funds	Asset management	Government
Demand for financial products	Demand for loans shrinking or growing less intensely as working age population stagnates (less demand for mortgages, less firm loans for investment)	Declining demand for traditional savings products (given rather low guaranteed rates); increasing demand for health insurance (incl. dread disease)	2nd and 3rd pillar becoming more important as NPS faces asset depletion by 2057	Potentially higher demand for more risky assets amid low interest rate environment	-
P&L flows	Declining profitability due to less net (interest) income, hence less upward trend potential for capital ratios; rotation toward fee-based income to compensate for stagnating net interest income; need for cost cutting will naturally call for consolidation	Declining profitability due to lower investment returns, hence less upward trend potential for capital ratios	Risks increasingly shifted to households through DC schemes (2nd pillar)	Potentially higher margins when customers demand riskier assets	Expenses (health care, public pensions, etc.) to rise, while tax income from working age population may shrink relative to that; hence less sizeable surplus or even deficits in flow terms, hence implying upward pressure on debt stocks
Balance sheet size and structure	Balance sheets would shrink or grow less intensely due to less credit provision and hence money/deposit creation; consolidation in terms of branch structure and bank population more widely	Increasing liabilities when longevity estimates were too low		Increasing (and potentially more volatile) balance sheet	Rising leverage

Potential mitigating strategies:
- Overseas expansion (search for yield)
- Cost-cutting, consolidation (financial system)
- Digitalization, FinTech
- Some industries may benefit (health care, medical services, etc.)
- KOR's Fourth Industrial Revolution: boost productivity growth, foster female participation, devote budget to childcare and elderly care

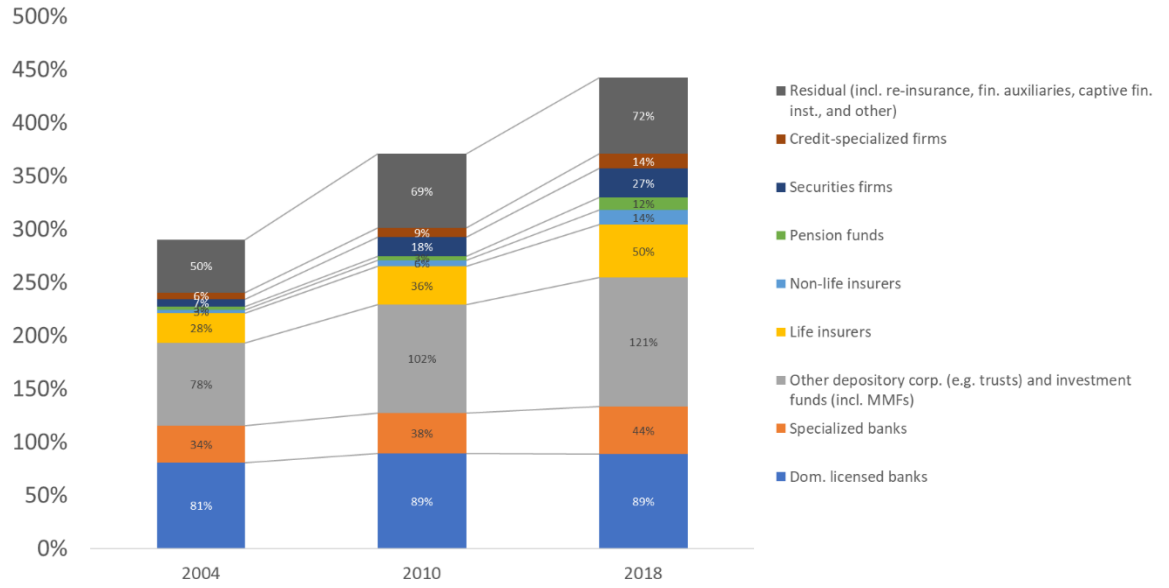
Sources: IMF staff.

131. A quantitative assessment has been conducted for the purpose of deriving scenario-conditional forecasts of the nominal size of different components of the financial system. A long-run equilibrium vector model has been set up and estimated which relate the total asset dynamics for the nine components of the financial system as shown in Figure 51 to macroeconomic variables to thereby capture their dependence on cyclical factors as well as on population growth and dependency ratios[54]. Historically, the insurance sector and the pension fund sector have yet grown significantly in Korea (Figure 51).

132. Long-term scenarios regarding population growth and dependency ratios were sourced from KOSTAT and form the basis for the analysis[55]. A scenario-conditional forecast for the financial system assets has then been derived until the year 2040, conditional on 27 scenarios in terms of population growth and dependency ratios (Figure 52). The 27 scenarios are the result of different assumptions for three drivers of population dynamics, that is, fertility, life expectancy, and migration.

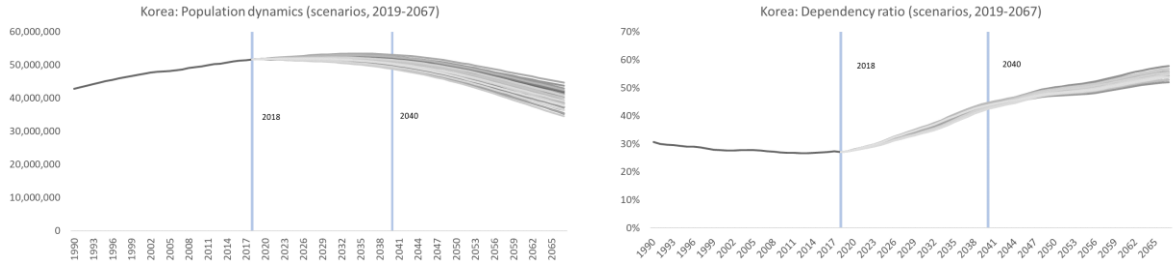
[54] The model variables include GDP per capita, equity price levels, short- and long-term interest rates, GDP deflator levels, the USD-KRW exchange rate, as well as the population and dependency ratio variables. The latter two are exogenous, all others endogenous.
[55] See "Population Projections for Korea (2017-2067)", KOSTAT, 2019.

Figure 51. Korea: Korean Financial System's Total Asset Dynamics



Sources: Bank of Korea, Flow of Funds Statistics. Only second-pillar pension funds (retirement pensions) are included in the pension fund category in this chart. The National Pension Service (NPS) is included in the residual category.

Figure 52. Korea: Scenarios for Population Growth and Dependency Ratios in Korea until 2067



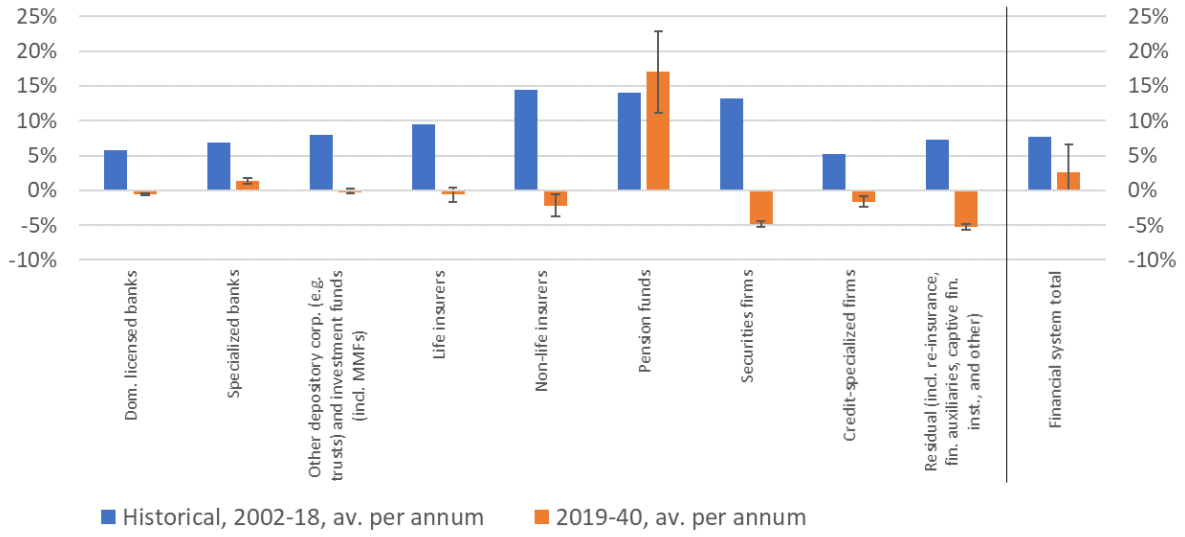
Sources: KOSTAT.

133. The demographics scenario-conditional forecasts of the nominal size of different components of the financial system more broadly suggest that the system may likely grow less intensely and shrink in some sub-segments. Figure 53 shows that the scenario-conditional paths for average per annum total asset growth from 2019-40 varies across segments: all financial sector components except pension funds are expected to shrink or move side-wards. For pension funds, the rising old age dependency ratio appears to dominate and let the sector grow[56]. Banks, including nation-wide, regional and specialized banks, are expected to move sideward in terms of

[56] The estimated elasticities relating total assets to the population and the level dependency ratio suggest that all financial system components depend positively on population growth. The pension fund sector would benefit from a rising dependency ratio. Hence, the pension fund sector would face two opposing effects (slowing population growth, rising dependency ratios), making the sign of the net effect on its asset growth not pre-determined a priori.

nominal asset size, without much of a dependence on the demographic scenarios (reflected by the small range of the cross-scenario bounds).

Figure 53. Korea: Demographics Scenario-Conditional Total Asset Dynamics



Sources: KOSTAT, Bank of Korea, and IMF staff calculations. Percentages are natural log percent. The bars depict the median of the average per annum growth rates across the 27 scenarios; the lower and upper bounds mark their 10th and 90th percentiles.

134. The analysis suggests that non-life insurers and pension funds are most dependent on the demographic scenario assumptions. This is reflected by the wider bounds around the median estimates in Figure 53. The analysis also suggests that the pension fund asset growth trajectories depend most on the assumptions about fertility, while all other financial sector components depend more on the assumptions about migration[57].

135. Monetary policy ought to be conducted with particular care at times of slow-moving, yet significant, demographic change. It is important that models for supporting monetary policy be designed in a way that take explicit account of population dynamics (per capita thinking is warranted), to thereby be able to delineate cyclical and structural (demographic in this case) factors.

136. Fiscal policies to counteract adverse demographic developments naturally come along with sizable implementation lags. Modifying fiscal policy measures nowadays, such as in relation to retirement age and policies to foster family creation, take a long time to reveal their effect. That is the reason why demographics-related analyses and policies should be conducted in a very forward-looking, pre-emptive manner.

[57] It should be kept in mind that the projections are conditional on the assumption of 'no structural change', as they are based on a model that captures the financial system dynamics over the past. Financial system structural change due to FinTech developments, for example, may exert an impact that would let future asset size dynamics vary from the ones implied by the model. The analysis is overall meant to be indicative, that is, no too strong emphasis shall be placed on the total asset projections growth in absolute terms, but rather be seen in a comparative manner.

137. The materiality of the concerns stemming from demographic change in Korea warrant great attention going forward. Meanwhile, the banking system does not appear to be at particular high risk of a *sudden* disruption due to a structurally slow-moving demographic change.

Appendix I. FSAP Risk Assessment Matrix (RAM)

Risk	Overall Level of Concern	
	Relative Likelihood	**Expected Impact if Materialized**
Sharp rise in risk premia	**High** Despite renewed policy easing by the Fed and ECB, global recession fears could push up risk and term premia, strengthen the U.S. dollar, Yen and the euro vis-à-vis other Asian currencies, and correct market valuations. Adjustments could be disruptive if there are policy surprises.	**Medium** Less favorable borrowing conditions could weigh on private sector and public sector balance sheets, with implications for growth. Valuation losses on financial institutions' assets, reduced value of collateral, and lower recovery in default cases, which could be amplified through exposures to high spread EA countries. Negative impact on FX liquidity of financial institutions.
Rising protectionism and retreat from multilateralism	**High** A fraying consensus about the benefits of globalization lead to protectionism and economic isolationism, resulting in reduced global and regional policy collaboration with negative consequences for trade, capital and labor flows, sentiment, and growth.	**High** A rise in trade protectionism could significantly weaken Korea export growth, trigger capital outflows and depreciation pressures, and lead to higher equity market volatility, given that Korea is an open economy with large export-orientated corporations.
Weaker-than-expected global growth	**High** Should a sharp economic slowdown occur in China, this would entail weak domestic demand, which in turn would lower commodity prices, roil global financial markets, and reduce global growth.	**High** China is Korea's largest trading partner; it makes Korea vulnerable to a slowdown in China. Second-round effects could also be significant, as China slowdown would impact global growth and market sentiment. Moreover, Korea could be subject to financial contagion as Korean financial assets and the Won are often used as "proxy trades" for Chinese and other smaller regional asset markets reflecting their higher market liquidity.
Surge in external competitive pressures	**Medium** Fierce competition from firms in China, India, and other EMs may displace goods made in Korea by several large NFCs (large corporations), such as autos, semi-conductors, electronic devices, etc.	**High** Major Korean nonfinancial corporates to face pressure. Spillovers through intra-firm corporate investment network. Rising unemployment and sustained slowdown in macro activity. Increase in the government's contingent liabilities through exposure of policy banks.
Sharp domestic house price correction	**Medium** An economic slowdown with rising unemployment and higher funding costs trigger mortgage defaults and negative feedback loops that weigh on the housing market given high leverage and stretched valuations	**High** Deteriorating asset quality, particularly related to mortgage lending and real estate financing and contagion to other markets that fund mortgage lending. Increase in the government's contingent liabilities through claims on mortgage insurance.

Appendix II. Solvency and Liquidity Stress Test Matrices for Banks and Insurers (STeMs)

Domain		Framework
		Top-Down by FSAP Team
Banking Sector: Solvency Stress Test		
Institutional perimeter, horizon and main data inputs	Institutions in-scope	24 banks in total. Composed of 19 banks and five groups of aggregate ("consolidated") banks: four nation-wide commercial banks, two foreign subsidiaries, two internet-only banks, six regional banks, five specialized ("policy") banks. Five groups of aggregate ("consolidated") banks: Credit Unions (929 underlying entities), Mutual Savings Banks (79 entities), Agricultural Cooperative Banks (1,122), Fisheries Cooperative Banks (90), Forestry Cooperative Banks (137).
	Banking system coverage	About 95 percent of the banking system as of 2018Q4 in terms of total assets, with "banking system" being defined as all institutions listed above plus Community Credit Cooperatives (5 percent). The latter are excluded due to insufficient data availability.[1] "Banking system" excludes foreign bank branches for what concerns the solvency stress test scope. Banks are either stand-alone entities or subsidiaries of higher-ranking FHCs.
	Cut-off date and scenario horizon	Cut-off date 2018Q4. Scenario horizon five years. Banks' solvency position will be reported as of their "low-point" along the scenario horizon
	Scope of banks' operations	Emphasis on banks' domestic, Korean exposures as foreign exposures are deemed to be sufficiently small (as of 2018Q4, the above-defined bank sample's foreign exposures in terms of loans and security holdings outside Korea amounted to 5.4 percent).
	Main data sources	Regular supervisory reporting + ad-hoc data request to all banks + public data sources (e.g., Bloomberg, public disclosures of banks through annual and financial reports, etc.)
Stress test methodology	Credit risk – accounting	Compatible with K-IFRS 1109 (Korean version of IFRS 9). Satellite models for PDs and employing a "hybrid" methodology that combines scenario-conditional PD forecasts with a Z-factor methodology to project bank-portfolio-specific transition flow matrices. Structural LGD model for real estate collateralized portfolios.
	Credit risk - regulatory risk weight treatment	Risk weights for STA portfolios constant, risk weights for IRB portfolios conditional on scenarios through link to point-in-time default rates consistent with weighted average of two (S1 and S2's) default rates from the transition matrices. Smoothing factor to be employed for that link to reflect a through-the-cycle rationale of regulatory risk parameters (modeled through Basel risk weight formulas).
	Credit risk – provisioning	Both regulatory provisioning rules as well as accounting provisioning principles to be employed in parallel (results will be presented separately and in conjunction).

[1] The coverage as described here would amount to 89 percent of total banking system assets when foreign bank branches were part of the aggregate banking system.

Domain		Framework
		Top-Down by FSAP Team
	Interest rate risk	Wholesale funding stress consistent with scenario. Pass-through to asset side captured through cross-bank portfolio-specific panel models. Model suite considered: net interest margin-based, vs. individual models on interest income and expense rates separately.
	Feedback from interest rate risk to credit risk	Accounted for through incorporation of interest rates (those that loan contracts are linked to), in the Z-factor models for credit risk. Reversely, interest income a function of credit risk, as only performing loans generate interest income by assumption.
	Feedback from banks' solvency to funding conditions	Accounted for through incorporation of banks' capital adequacy metrics in their funding cost satellite models (lagged at quarterly frequency, i.e. sufficiently simultaneously at lower than quarterly frequency).
	Market risk (other than interest rate risk)	Trading book equity positions revalued in line with equity market price trajectories in scenario. Bond holdings in the trading book revalued in line with maturity-corresponding bond yield (and implied price) paths from the scenario.
	Other P&L	Satellite models for net fee and commission income.
	Balance sheet dynamics	Two cases: static balance sheet (sum of performing and nonperforming banking book assets stays constant, no write offs nor asset sales), vs. dynamic balance sheet (gross loan book can move consistent with the scenario). Under dynamic balance sheet scenario, corporate and retail loan book may grow at different rates. Write-offs and asset sales will be allowed and optionally dis-allowed under the dynamic balance sheet scenario. Asset sales are important and sizable for Korean banks, given their continuous NPL selling to the NPL market.
	Tax assumptions	Statutory tax rates.
	Dividend payout assumptions	Dividend payout ratios were kept constant at their ratios (defined relative to net income after tax) as observed at the bank-level at end-2018. Net income after tax turning negative implies zero dividends by assumption.
	Capital ratio thresholds	Basel III min capital requirements for CET1 and total capital (T1+T2) ratios including CCB, and incl. capital surcharge for D-SIBs of 1 percent (Kookmin Bank, Shinhan, KEB Hana, Woori, Jeju Bank, NongHyup Bank). For D-SIBs, the CET1/RWA and total capital/RWA thresholds stand at 5.5 and 9 percent; for non-D-SIBs other than ODIs, they are 4.5 and 8 percent, all inclusive of the 2.5 percent CCB. Mutual Savings Banks subject to total capital ratio threshold only. All other mutual credit cooperatives (credit unions and cooperatives) subject to risk-unweighted net worth ratio constraint at their respective minima as stipulated through regulation. CCB allowed to be depleted under adverse scenario.

Domain		Framework
		Top-Down by FSAP Team
Macrofinancial scenario	Adverse scenario narrative	Developed along G-RAM and Korea-specific structural features and vulnerabilities. Sudden spread of trade protectionism; material drop in activity in China; material drop in Korea's exports; broad-based world-wide sell-off in equity markets, reflecting general fall in investors' risk appetite; significant capital outflows from Korea coupled with strong depreciation of its currency; potential defaults of export-oriented and FX-indebted non-financial firm conglomerates; cascade effects through Korea's strongly interconnected supply chain; rising unemployment rate; depressed confidence, hence drag on consumption and investment (expectation channel); spillover to housing and mortgage market through less demand and rising unemployment.
	Number of scenarios	Two scenarios: One baseline (WEO) and one adverse scenario.
	Quantification / methodology	Regime-switching structural VAR model based on Korean data (1990Q1-2018Q4), to simulate structurally identified external demand shock (sign constraints); conditional on recession regime identified by the model, to thereby capture dependencies across macro-financial variables as observed throughout crisis/recession times (stronger dependence generally speaking); shock scenario profile scaled such that 1-year ahead real GDP fall matches 5 percent GaR.
	Macro-financial feedback effects	Accounted for by allowing macro-financial feedback at the scenario generation stage in the regime-switching SVAR (banking system credit endogenous, two-way feedback with GDP and other variables).
	Scenario variables	Real GDP, nominal GDP, unemployment rate, CPI inflation, CPI core inflation, residential property prices, commercial property prices, equity prices, USD-KRW exchange rate, long-term interest rate (benchmark sovereign bond yield), short-term money market interest rate, MSCI World Equity Index, gross banking system credit, corporate bond spread, real and nominal GDP components.
	Sensitivity analysis	Sensitivity analysis to be conducted with respect to house prices, to thereby account for the centrality and peculiarity of the housing market in Korea (leasehold rent system, insurance in relation to leasehold loans by state-run institutions, etc.); related results will be presented in the technical note titled “Systemic Risk Analysis and Financial Sector Stress Testing.
Banking Sector: Liquidity Test		
Institutional perimeter	Banking system coverage	18 banks are included, six nation-wide commercial banks, two internet-only banks (KRW only), six regional banks, and four specialized ("policy") banks. In addition, foreign bank branches are included (KRW only).
	Market share	About 90 percent of the banking system as of 2018Q4 in terms of total assets, with 'banking system' being defined as all institutions listed above. Banks are either stand-alone entities or subsidiaries of higher-ranking FHCs.
	Cut-off date	Cut-off date 2018Q4.

Domain		Framework
		Top-Down by FSAP Team
Methodology and scenarios	Methodology	The exercise assesses banks' ability to use counterbalancing capacity withstand net cash outflows, accounting for both contractual and behavioral flows. Assumptions of asset price haircuts are based on the macro-financial scenario used for the bank solvency stress test. The assumed retail and wholesale funding run-off rates consider Korean specific liquidity factors based on the analysis of corporates and households and are conservative to account for liquidity shortages that could occur in other parts of the financial system but that are not included in the stress test due to lack of data. Furthermore, the calibration of run-off estimates uses international experience to account for structural factors that have changed the characteristics of the financial system. Capital shortfalls are measured as percentage of counterbalancing capacity.
	Satellite models for macro-financial linkages	Asset haircuts modeled in the macro financial scenarios.
	Stress test horizon	The stress test horizon is 30 days. The funding gap calculations uses horizons of between 1 month and 10 years.
	Scenario analysis	Four scenarios are considered: (i) asset price falls, (ii) a run on retail deposits, with higher run-off rates for retail deposits; (iii) a run on wholesale funding, with higher run-off rates for corporate deposits and other wholesale funding; and (iv) an "extreme" scenario with combination of runs on retail deposits and wholesale funding (scenario ii and iii). For the cash-flow analysis, a series of scenarios consistent with the solvency stress test and the adverse macro-financial scenario are considered, with a range from mild to severe liquidity conditions. Capital shortfalls are calculated for twenty different gradually more severe scenarios, where the least severe assume the run-off rates used in LCR calculations and the most severe assumes the run-off rates in the "extreme" scenario (iv).
	Buffer assumptions	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, fire sales and collateral supply constraints.
	Other behavioral assumptions	Liquidity from the central bank's emergency lending assistance (ELA) is not considered.
Regulatory and market-based standards and parameters	Calibration of risk parameters	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	An LCR above 100 percent or a non-negative cash balance for the cash-flow analysis, is required to pass, where the balance reflects net cash outflows and counterbalancing capacity.
Reporting format for results	Output presentation	For all currency, KRW and FX, changes in the system-wide liquidity position, including important drivers for cash outflows, cash inflows and counterbalancing capacity. Distribution of banks' and bank categories liquidity positions. Amount of liquidity shortfalls.

Insurance Sector: Solvency Risk		
1. Institutional perimeter	Institutions included	• Seven life insurers, and six non-life insurers.
	Market share	• Life: 73 percent (balance sheet assets). • Non-life: 76 percent (balance sheet assets).
	Data	• Regulatory reporting.
	Reference date	• December 31, 2018.
2. Channels of risk propagation	Methodology	• Investment assets: market value changes of available-for-sale securities after price shocks, increase in the default rate for corporate and mortgage loan exposures. • Insurance liabilities: unaffected by change in interest rates as discount rates are based on historic cost accounting. • Sensitivity analysis: effect on available capital and solvency position.
	Time horizon	• Instantaneous shock.

3. Tail shocks	Scenario analysis	• Adverse scenario:
		  • Short-term KRW sovereign bond yield -20 basis points, long-term KRW sovereign bond yield +250 basis points;
		  • Stock prices -39.0 percent (Korea), -35.0 percent (other advanced economies), mutual funds -12.5 percent;
		  • Korean corporate bond spreads between +120 basis points (AAA) and +400 basis points (BB and lower), foreign corporate bond spreads between +70 basis points (AAA) and +300 basis points (BB and lower);
		  • Haircut on unsecured loans -1.5 percent, haircut on sub-standard loans -30 percent;
		  • 37 percent appreciation of KRW against USD.

	Sensitivity analysis	• Variations of short- and long-term sovereign bond yields.
4. Risks and buffers	Risks/factors assessed	• Market risks: interest rates, share prices, property prices, credit spreads. • Summation of risks, no diversification effects.
	Buffers	• Accounting designation (23 percent of assets in the general account held to maturity).
	Behavioral adjustments	• None.
5. Regulatory standards and parameters	Regulatory/accounting standards	• Korean Risk-Based Capital (RBC). • National GAAP.
6. Reporting format for results	Output presentation	• Impact on solvency ratios. • Contribution of individual shocks. • Dispersion measures of solvency ratios and net income.

Appendix III. Liquidity Stress Test – Calibration Details

A. Eligibility of liquid assets					
	LCR	**S1 - Asset price shock**	**S2 -retail funding shock**	**S3 - wholesale funding shock**	**S4 - extreme**
Level 1 Assets	100%	100%	100%	100%	100%
Coins and bank notes Qualifying marketable securities form sovereigns, central banks, PSEs, and multilat. Dev banks Qualifying central bank reserves Domestic sovereign or central bank debt for nonzero risk-weighted entities					
Level 2a Assets	85%	70%	85%	85%	70%
Qualifying marketable securities form sovereigns, central banks, PSEs, and multilat. dev banks (with 20% risk weighting) Qualifying corporate debt securities rated AA- or higher Qualifying covered bonds rated AA- or better					
Level 2b Assets					
Qualifying Mortgage Backed Securities	75%	60%	75%	75%	60%
Qualifying corporate debt securities rated between A+ and BBB-	50%	45%	50%	50%	45%
Qualifying common equity shares	50%	45%	50%	50%	45%
B. Haircuts on Inflows of liquid assets (over 30 days)					
	LCR	**S1**	**S2**	**S3**	**S4**
Level 1 assets	0%	0%	0%	0%	0%
Level 2a assets	15%	30%	15%	15%	30%
Level 2b assets					
Eligible RMBS	25%	40%	25%	25%	40%
Other	50%	55%	50%	50%	55%
Margin lending backed by all other collateral	50%	55%	50%	50%	55%
All other assets	100%	100%	100%	100%	100%
Credit or liquidity facilities	0%	0%	0%	0%	0%
Operational deposits held at other financial institutions	0%	0%	0%	0%	0%
Other inflows, by counterparty					
Retail counterparties	50%	50%	50%	50%	50%
Nonfinancial wholesale counterparties, transactions not listed above	50%	50%	50%	50%	50%

Financial institutions and central banks, transactions not listed above	100%	100%	100%	100%	100%
Net derivative cash inflows	100%	100%	100%	100%	100%
Other (contractual) cash inflows	100%	100%	100%	100%	100%
C. Outflows of liquid assets (over 30 days)					
Scenario:	**LCR**	**S1 - haircut**	**S2 - retail**	**S3 - wholesale**	**S4 - extreme**
Retail Deposits					
Demand deposits					
Stable deposits	5%	5%	10%	5%	10%
Less stable retail deposits	10%	10%	20%	10%	20%
Term deposits, residual maturity > 30d	0%	0%	0%	0%	0%
Unsecured Wholesale Funding					
Demand and term deposits, residual maturity < 30d, small business					
Stable deposits	5%	5%	5%	10%	10%
Less stable deposits	10%	10%	10%	20%	20%
Operational deposits generated by clearing, custody, and cash management activities	25%	25%	25%	50%	50%
Portion covered by deposit insurance	5%	5%	5%	5%	5%
Cooperative banks in an institutional network	25%	25%	25%	25%	25%
Nonfinancial corporates, sovereigns, central banks, multilat development banks, PSEs					
Fully covered by deposit insurance	20%	20%	20%	20%	20%
Not fully covered by deposit insurance	40%	40%	40%	50%	50%
Other legal entity customers	100%	100%	100%	100%	100%
Secured Funding					
Secured funding with a central bank, or backed by Level 1 assets	0%	0%	0%	0%	0%
Secured funding backed by Level 2A assets	15%	15%	15%	15%	15%
Secured funding backed by non-Level 1 or non-Level 2a asset, with domestic sovereign, multilat dev banks, or domestic PSEs as a counterparty	25%	25%	25%	25%	25%
Funding backed by RMBS eligible for Level 2B	25%	25%	25%	25%	25%
Funding backed by other Level 2B assets	50%	50%	50%	50%	50%
Other secured funding transactions	100%	100%	100%	100%	100%
Additional Requirements					
Valuation changes on non-Level 1 posted collateral securing derivatives	20%	20%	20%	20%	20%
Excess collateral held by bank related to derivate transactions that could be called anytime	100%	100%	100%	100%	100%
Liquidity needs related to collateral contractually due on derivatives transactions	100%	100%	100%	100%	100%
Increased liquidity needs related to derivative transactions allowing collateral substitution	100%	100%	100%	100%	100%
ABCP, SIVs, conduits, SPVs, or similar					

Liabilities from maturing	100%	100%	100%	100%	100%
Asset backed securities	100%	100%	100%	100%	100%
Undrawn but committed credit and liquidity facilities					
Retail and small business	5%	5%	5%	5%	5%
Nonfinancial corporates, sovereigns, central banks, multilat dev. banks, PSEs					
Credit facilities	10%	10%	10%	10%	10%
Liquidity facilities	30%	30%	30%	30%	30%
Supervised banks	40%	40%	40%	40%	40%
Other financial institutions					
Credit facilities	40%	40%	40%	40%	40%
Liquidity facilities	100%	100%	100%	100%	100%
Other legal entity customers, credit and liquidity facilities	100%	100%	100%	100%	100%
Other contingent funding liabilities					
Trade finance	5%	5%	5%	5%	5%
Customer short positions covered by customers' collateral	50%	50%	50%	50%	50%
Additional contractual outflows	100%	100%	100%	100%	100%
Net derivate cash outflows	100%	100%	100%	100%	100%
Any other contractual cash outflows (not listed above)	100%	100%	100%	100%	100%

Outflows of liquid assets		
Retail Deposits	**Scenario 1**	**Scenario 20**
Demand deposits		
Stable deposits	5%	10%
Less stable retail deposits	10%	20%
Term deposits, residual maturity > 30d	0%	0%
Unsecured Wholesale Funding		
Demand and term deposits, residual maturity < 30d, small business		
Stable deposits	5%	10%
Less stable deposits	10%	20%
Operational deposits generated by clearing, custody, and cash management activities	25%	50%
	5%	5%
Cooperative banks in an institutional network	25%	25%
Nonfinancial corporates, sovereigns, central banks, multilat development banks, PSEs		
Fully covered by deposit insurance	20%	20%
Not fully covered by deposit insurance	40%	50%
Other legal entity customers	100%	100%

Appendix IV. Solvency Stress Test – Mapping MR and CR Methodology

1. The mapping of the CR and MR methodologies to different line items in the reporting templates for the Korean banks was a function of their accounting treatment. Appendix IV Figure 1 shows the mapping.

Appendix IV. Figure 1. Mapping of CR and MR Methodology to Exposures

Accounting category	Exposure type	Portfolio segment	CR Module In-scope	MR Module In-scope
AC	Loans	Large corporate	1	
		SME	1	
		Household mortgages	1	
		Consumer credit and other retai	1	
	Bonds	Sovereign		1
		Nonfinancial corporate	1	
		Financial corporate		1
FVOCI	Bonds	Sovereign		1
		Nonfinancial corporate	1	1
		Financial corporate		1
	Equity	Domestic		1
		Foreign		1
FVPL	Bonds	Sovereign		1
		Nonfinancial corporate		1
		Financial corporate		1
	Equity	Domestic		1
		Foreign		1

Sources: IMF staff. See glossary for abbreviations.

2. Sovereign bonds under the AC approach were subject to the MR methodology. The reason for doing so was that for the sovereign bond portfolio, no historical no "year 0" transition matrices were available, hence not allowing the application of the transition matrix-based ECL model (see main text for details). The impact from marking-to-market these sovereign bond holdings is not significant, because their exposure share amounts to about 4-6 percent across nation-wide, regional and specialized banks.

3. Sovereign and financial corporate bond holdings under the FVOCI accounting category were subject to only the MR methodology. FVOCI exposures should actually be treated under both the CR and MR methodology; for credit risk-related impairment charges to flow through the P&L and the remainder to a full fair value change be reflected through the OCI account. For sovereign and financial corporate bonds, no historical transition matrices were available, hence not allowing the application of the CR methodology. Their treatment under only the MR methodology is not expected to imply any distortion, however, because net income of the banks under the adverse scenario would be negative anyhow. It would, therefore, not make a difference whether the capital

impact is measured through the P&L or the OCI, as negative income implies zero tax expense by design of the stress test methodology.

4. **Nonfinancial corporate bonds under the FVOCI accounting category were treated under both the MR and CR methodology**. For nonfinancial corporate exposures, historical transition matrix data was available across banks, hence allowing the dual treatment under the MR and CR methodologies.

Appendix V. Solvency Stress Test – Credit and Interest Income and Expense Models

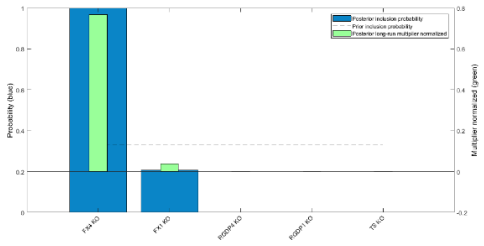
Credit Risk

1. A BMA methodology[1] was employed to develop the models which link bank portfolio PDs to macro-financial variables. The left hand-side variables included historical default rates for large corporates, SME loans, household mortgages and consumer credit. The potential right hand-side predictor variables included real GDP growth and a term spread for all models, the unemployment rate for the mortgage and consumer credit portfolio, and the USD-KRW exchange rate in the large corporate loan portfolio model. The model structures are summarized in Appendix V Figure 1. It shows the LRMs which reflect the sum of the coefficients on a given predictor for its time contemporaneous and possibly lags, where present. Historical data and fit are not presented here because the underlying default rate data by the Korean banks is classified as confidential.

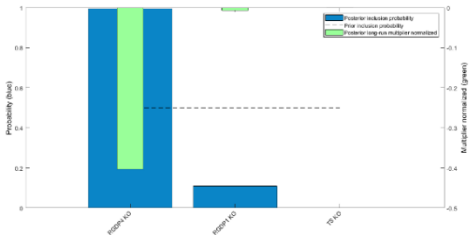
2. The models contain lags of the predictor variables beyond their contemporaneous inclusion, and no autoregressive lags. No autoregressive lags of the LHS default rate variables were allowed to thereby maximize the content that could be extracted from the variation of the predictor variables on the RHS of the models, to make sure that the adverse-baseline gaps for the default rates are not unduly compressed. The large corporate loan portfolio, e.g., contained two lags of the exchange rate in addition to its contemporaneous inclusion. The SME default rate had an additional lag of real GDP growth; the consumer credit portfolio an additional lag of the unemployment rate.

Appendix V. Figure 1. PD Model Structures

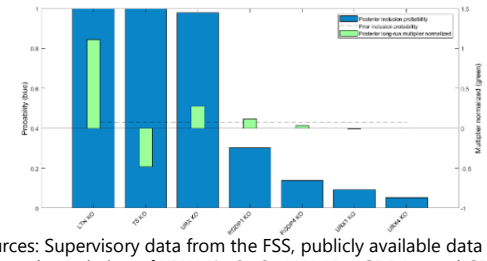
Large nonfinancial corporate loan portfolio



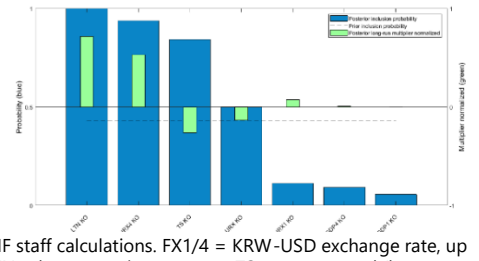
SME lending portfolio



Household mortgage credit portfolio



Consumer credit portfolio



Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations. FX1/4 = KRW-USD exchange rate, up means depreciation of KRW (1=QoQ, 4=YoY). RGDP4 = real GDP growth YoY. LTN = long-term interest rate. TS = term spread (long-term minus short-term interest rate). URX = unemployment rate. The LRM (green bar, right axis) is normalized by multiplying the raw LRM with the ratio of the historical standard deviation of the respective right and left-hand side variables. Where the posterior inclusion probability (blue bar, left axis) exceeds the prior inclusion probability (dashed line, left axis), a predictor variable is said to be significant from a Bayesian perspective. See Gross, M. and Población, J. (2017) for details.

[1] See Gross, M. and Población, J. (2017). "Implications of model uncertainty for bank stress testing". J of Fin Services Research.

Interest Income and Expenses

3. Definition of interest income and expense rates. The interest income rate (IIR) and interest expense rate (IER), both measured at bank-level, were defined as

$$\text{IIR} = 4 \times \frac{\text{II}}{\text{SEC+loans gross of LLA} \times (1 - \text{SBL ratio})} \text{ and } \text{IER} = 4 \times \frac{\text{IE}}{\text{TA net of LLA} - \text{E}}$$

where *II* denotes quarterly interest income flows in nominal terms, *IE* the quarterly total interest expense flows, *SEC* (securities) measured as banks' total financial assets minus their loan stock, *LLA* the loan loss allowance stock (accounting), and *SBL* the substandard and below ratio. The historical data for all variables involved were sourced from the FSS' statistical data warehouse, for a sample of 19 banks (all but ODIs from Table 5), covering the 2000Q4-2018Q4 period (73 time series obs.).

4. The IIR model structure is shown in Appendix V Table 1. The IIR panel model contains a simple distributed lag structure for real GDP growth on the right hand-side; in addition to the bank-specific IER variable which captures the pass-through of banks' funding cost to their loan prices. Numerous alternative model structures were considered, involving the unemployment rate and other macro-financial variables, and considering a market interest rate instead and/or next to the bank-level funding cost variable. The model-implied interest income paths were found to be robust to such alternative model structures. It is interesting to note that the simple model structure as employed here results in sizable R-squares despite its simplicity. The lags of GDP growth and the autoregressive lag were included to reflect that interest income and hence the effective interest rate relate to outstanding business whose interest rate in part were set in past periods at fixed interest rate terms. The IER variable is endogenized using the IER model.

5. The IER model structure is shown in Appendix V Table 2. The IER penal model contains the short- and long-term market interest rates along with a bank-specific level and squared capital ratio term, defined as an accounting ratio (shareholder equity *E* over total assets net of LLA). The inclusion of the short- and long-term interest rates is to capture the pass-through of monetary policy, the market price of risk, and sovereign risk (relevant through implicit/explicit guarantees), to banks' cost of debt. The E/TA terms are lagged by one quarter to avoid the need for Gauss-Seidel-type solution methods; still it is effectively a two-way contemporaneous feedback at annual frequency that the model captures. Importantly, the E/TA terms are connected, i.e. endogenized, through the overall stress test machinery, reflecting all risk drivers that influence banks' capital ratios moving forward in time. As for the IIR model, the IER model is characterized by sizable R-squares despite its simple structure.

6. The inclusion of the quadratic capital ratio term serves to capture a suspected nonlinearity in the relation between banks' capital ratios and their cost of funding. Such nonlinearity is of the kind implied by the trade-off theory of capital structure; suggesting that the marginal benefit of more debt (due to tax benefits) would vanish with higher levels of debt (more risk)[2]. The effect of higher risk will dominate at some point and let the initially negative relation between risk and cost of debt become positive. This rationale is depicted in the schematic in

[2] See Kraus, A. and Litzenberger, R. H. (1973), „A state-preference model of optimal financial leverage", Journal of Finance, 28(4), pp. 911-922. See also Gross, M., Hansen, I. and Kok, C. (2020), "Break-Even Capital Ratios", forthcoming IMF Working Paper.

Appendix V Figure 2. It has found direct empirical support in the estimates for Korea as presented in Appendix V Table 2 and visualized in Figure 23 (main text). Figure 30 (main text) revealed the importance of allowing for the feedback from banks' solvency to their funding cost. It is found to matter in quantitative terms despite the Korean banks' generally and comparably high deposit-in-total liability shares, in turn reflecting that wholesale funding cost pressures would likely be significant under a severe downturn scenario.

7. A steady state adjustment was considered for all IIR and IER models. The steady state adjustment means that the intercepts (fixed effects) in the IIE and IER panel models were adjusted, that is, set to a value for the models to imply a fit that precisely matches the average left hand-side interest rates as observed through the 2018Q1-2018Q4 period; conditional on realized values of all right hand-side variables.

Appendix V. Table 1. IIR Model

	Nation-wide Banks		Regional Banks		Specialized Banks	
	coef.	p-val.	coef.	p-val.	coef.	p-val.
IIR (-1)	0.725	0.000	0.501	0.000	0.618	0.000
IER	0.352	0.000	0.691	0.000	0.348	0.000
D(LOG(RGDP))*100	-0.089	0.000	-0.034	0.099	0.015	0.657
D(LOG(RGDP(-1)))*100	0.141	0.000	0.106	0.000	0.048	0.153
D(LOG(RGDP(-2)))*100	0.043	0.038	0.027	0.186	0.007	0.820
D(LOG(RGDP(-3)))*100	-0.019	0.368	-0.013	0.514	0.036	0.243
Obs. combined T and N	320		414		177	
R2	0.96		0.95		0.95	
SE of residuals	0.28		0.32		0.28	
SE of data	1.41		1.34		1.22	
Mean of data	5.09		5.81		4.25	

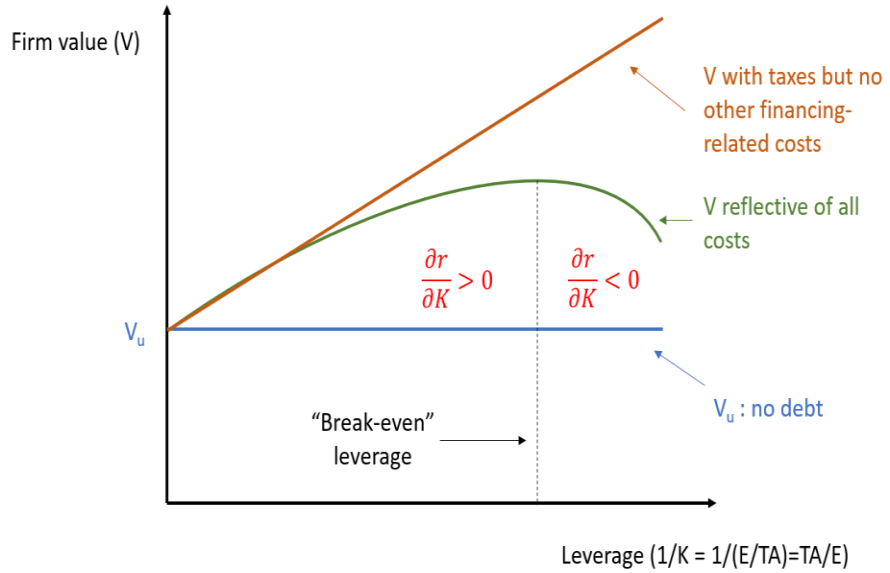
Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations. Quarterly frequency, 2000Q4-2018Q4 (73 time series obs.). LHS: banks' interest income rate (IIR) annualized on [0,100]. IER = bank-level interest expense rate on [0,100]. RGDP = real GDP.

Appendix V. Table 2. IER Model

	Nation-wide Banks		Regional Banks		Specialized Banks	
	coef.	p-val.	coef.	p-val.	coef.	p-val.
STN	0.326	0.000	0.241	0.000	0.364	0.000
LTN	0.356	0.000	0.430	0.000	0.338	0.000
E/TA(-1)	-0.181	0.000	-0.300	0.002	-0.229	0.026
(E/TA(-1))^2	0.005	0.001	0.023	0.004	0.007	0.119
Obs. combined T and N	353		432		218	
R2	0.92		0.87		0.88	
SE of residuals	0.31		0.38		0.37	
SE of data	1.07		1.03		1.07	
Mean of data	2.46		2.73		2.64	

Sources: Supervisory data from the FSS, publicly available data for banks, and IMF staff calculations. Quarterly frequency, 2000Q4-2018Q4 (73 time series obs.). LHS: Banks' interest expense rate (IER) on [0,100]. STN = short-term interest rate. LTN = long-term interest rate. E = shareholder equity. TA = total assets net of accounting LLA.

Appendix V. Figure 2. Rationale Underlying Nonlinear IER Model Structure



Sources: Gross et al. (2020, see footnote above for reference). The schematic illustrates the rationale underlying the trade-off theory of capital, including the hypothesis about how banks' funding costs would behave in relation to changes in capital ratios as a function of initial capital ratios. E denotes equity capital; TA denotes total assets.