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MALTA

FINANCIAL SECTOR ASSESSMENT PROGRAM

November 2019

TECHNICAL NOTE—RISK ANALYSIS

This Technical Note on Risk Analysis for Malta 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 November 2019.

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November 6, 2019

TECHNICAL NOTE

RISK ANALYSIS

Prepared By
Monetary and Capital Markets Department

This Technical Note was prepared by IMF staff in the context of an IMF Financial Sector Assessment Program (FSAP) mission in Malta during September 10–26, 2018, overseen by the Monetary and Capital Markets Department, IMF. It contains technical analysis and detailed information underpinning the FSAP's findings and recommendations as of September 2018. Further information on the FSAP program can be found at http://www.imf.org/external/np/fsap/fssa.aspx.

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AE	Advanced Economy
CAR	Capital Adequacy Ratio
CBM	Central Bank of Malta
CCoB	Capital Conservation Buffer
CCyB	Countercyclical Buffer
CDS	Credit Default Swap
CET1	Common Equity Tier 1
CoMap	Contagion Mapping
COREP	Common Reporting Framework
CRR	Capital Requirements Regulation (EU)
EBA	European Banking Authority
ECB	European Central Bank
EDF	Expected Default Frequency
EFM	Extended Financial Margin
EU	European Union
FDI	Foreign Direct Investment
FINREP	Financial Reporting Framework
FSGM	Flexible System of Global Models
FX	Foreign Currency
GBP	British Pound Sterling
GDP	Gross Domestic Product
HQLA	High Quality Liquid Assets
HTM	Held to Maturity
IFRS	International Financial Reporting Standard
IIP	Individual Investor Program
IMF	International Monetary Fund
LCR	Liquidity Coverage Ratio
LGD	Loss Given Default
LSI	Less Significant Institution
MFSA	Malta Financial Services Authority
NFC	Non-financial Corporations
NPL	Non-performing Loan
NSFR	Net Stable Funding Ratio
OFI	Other Financial Institution
O-SII	Other Systemically Important Institution
PD	Probability of Default
RAM	Risk Assessment Matrix
ROW	Rest of the World
RWA	Risk Weighted Assets
SI	Significant Institution

EXECUTIVE SUMMARY

The Malta FSAP stress testing exercise took place immediately following the IMF's 2018 Euro Area FSAP and concurrently with the 2018 stress test of the European Banking Authority (EBA). A comprehensive set of stress tests and interconnectedness analyses were conducted to assess the resilience of Malta's financial system and shed light on potential vulnerabilities, complementing the euro area FSAP and EBA exercises by tailoring the scope and depth to the Maltese financial system. The solvency stress test covered 11 banks representing 93 percent of the banking sector assets (excluding foreign branches) and diverse business models.

The stress scenario combined the materialization of external risks and Malta-specific risks. External risks are driven by structurally weak growth in the euro area and other advanced and emerging economies; policy uncertainties related to Brexit and international trade developments; and tighter global financial conditions. Malta-specific risks consist of a sharp correction in housing prices and shocks to Malta's reputation as an international financial center. A suite of liquidity stress tests was conducted based on several approaches and a variety of scenarios. The interconnectedness analyses looked at contagion risks both from cross-sectoral and cross-border perspectives with a wider scope. Lastly, a household stress-test incorporated micro evidence and provides a useful complementary assessment of solvency risk, based on the same macroeconomic stress scenario.

With total assets at 4⅓ times GDP, the Maltese banking sector is relatively large and has a high share of foreign ownership and external exposures.[1] At end-2017, banks accounted for two-thirds of financial sector assets (excluding captive financial institutions and money lenders, which do not engage in shadow banking). Their business models and market orientation vary considerably. Core domestic banks are exposed mostly to the domestic economy and account for 81 percent of banking sector assets, excluding foreign branches. Other banks have diverse business models and geographical orientation, including towards non-euro area countries. These banks are primarily funded by wholesale and non-resident deposits, with varying but limited exposure to residents. At 1.7 times GDP, foreign bank branches are relatively large, but their Maltese exposure is negligible.

Key metrics suggest that the banking sector is in good health, but challenges exist. Banks are well-capitalized, liquidity is ample, and profitability has been healthy. However, high levels of exposure to key advanced and emerging economies, together with growing exposure of core domestic banks to property-related loans, pose risks as residential housing prices have risen quickly, with some metrics suggesting overvaluation. External shocks would cause slower economic growth and higher unemployment, which could result in higher levels of non-performing loans (NPL). A sharp correction in housing prices would also reduce the value of collateral and result in lower recoveries in default cases. While the NPL ratio is declining and remains below the euro area average, there are pockets of distressed corporate loans that continue to impact bank balance sheets. The high share of non-resident deposits in international and non-core domestic banks

[1] This ratio represents total assets of the banking sector, including foreign branches. Unless otherwise stated, other parts of the report will present the share of sample banks relative to total assets of the banking sector, excluding foreign branches.

makes these banks vulnerable to changes in Malta's comparative tax advantage and reputational risk.

From a cyclical perspective, bank credit indicators are not signaling risk of a broad-based credit boom at this juncture. The credit-to-GDP gap has been negative for several years, reflecting credit slow-down after the Global Financial Crisis. A large decrease in the share of non-financial corporation (NFC) loans to GDP is the main factor contributing to the negative gap. The recent strong economic growth has contributed to the improved bank asset quality and supported the banking sector capital at levels exceeding minimum capital requirements.

The solvency stress tests indicate that the banking sector remains resilient, with vulnerabilities limited to a few small banks. At the aggregate level, the banking sector capital at end-2017 was sufficient to absorb credit and market losses in the event of a very severe macroeconomic shock leading to a sharp deterioration in macrofinancial conditions. Under this adverse scenario, the banking sector's capital adequacy ratio (CAR) would decline from 19.9 percent to 16 percent of total risk-weighted assets, while the common equity tier one (CET1) ratio would decline by 329 bps to 14.5 percent over three years (through end-2017). The main contributions come from loan-loss provisioning, additional risk-weighted assets, and valuation losses from debt securities.[2] Three small banks would be under pressure with total recapitalization needs still remaining manageable (estimated at about 0.14 percent of GDP).

Banks are exposed to credit risk and concentration risk. Under the solvency stress tests, credit risk from corporate and mortgage loans is the main contributor to declining capital ratios. Based on sensitivity analysis, concentration risk is also high, and the default of the largest borrowers would have a significant impact on the capital of several banks, both small and large. For some core domestic banks, large borrowers are concentrated in construction and real estate sectors, which historically have high credit risk. Strong monitoring of bank NPL resolution plans is warranted, particularly for some small banks. Concentration risk should be considered when determining Pillar 2 capital buffers during the ongoing Supervisory Review and Evaluation Process.[3]

The banking sector appears resilient to liquidity pressures, but some small banks are vulnerable to more severe events. A combined shock resulting in withdrawal of wholesale and retail deposits, with additional pressure from withdrawals of non-resident deposits, would reduce the banking system's Liquidity Coverage Ratio (LCR) from 190 percent to 121 percent. Most banks remain resilient under such a shock, but some small banks come under pressure. Cash flow-based liquidity stress tests also suggest similar results. The total liquidity shortfall for the 3-months horizon in the cash flow-based stress test would be about 2.8 percent of GDP. The liquidity stress test based on the Net Stable Funding Ratio (NSFR) indicates that most banks are well placed to meet a level of 100 percent, while a few small banks face structural longer-term refinancing and funding problems. Some banks are reliant on high levels of funding from a few large depositors. On foreign currency (FX) liquidity, some banks showed insufficient liquid assets to cover liquidity withdrawals of certain

[2] The additional risk weight assets are mainly attributed to additional NPLs, new loans granted during the stress test horizon, and the triggered portion of off-balance sheet items (undisbursed credit lines and guarantees).

[3] Please refer to the recommendation in the IMF Technical Note on Banking Supervision prepared under the 2019 Malta FSAP.

major foreign currencies, even under the baseline scenario. These findings suggest there is scope for improved monitoring of liquidity risk. For example, bank regulators could incorporate new dimensions into the stress tests, including longer time horizons for tests, additional run-offs for non-resident deposits, and liquidity stress tests for foreign major currencies. To detect potential shifts in systemic risk, the authorities should also consider conducting regular exercises on funding concentration.

The interconnectedness analysis suggests that contagion risk through interlinkages from within the Maltese financial sector is currently higher and more wide-spread than contagion risk through cross-border interbank exposures. While the "contagion index" (see Appendix VII) produces mild readings within the cross-border network, analysis points to concentrated distresses in smaller banks. At the domestic level, expanding the analysis from the interbank network to include funds and insurers suggests that insurers are vulnerable to contagion risk from core banks. Even if stress tests show that the Maltese financial system is currently in good health, addressing certain structural challenges related to concentration of large exposures could further reduce vulnerabilities that arise from within the domestic financial system as well as those that spill over from outside. Monitoring and conducting periodic analysis of cross-border linkages, and further enhancing the existing inter-sectoral linkages analysis, would provide an early warning before contagion risks accumulate.

Table 1. Malta: Risk Analysis Recommendations

		Agency	Time*
Solvency			
1.	Enhance data management, including data for credit risk analysis, to ensure the ability to run stress tests in a timely and accurate manner. (¶59)	CBM	NT
2.	Move toward expected loss-based credit risk models for stress testing, in particular with the introduction of International Financial Reporting Standard (IFRS) 9 (¶59)	CBM	NT
3.	Conduct regular sensitivity tests for credit risk, e.g., asset concentration, both for individual borrower and sectors of the economy. (¶59)	CBM	NT
Liquidity			
4.	Strengthen the liquidity stress-testing framework by incorporating new dimensions, e.g., differentiating shocks between resident and non-resident deposits, conducting liquidity stress test for each major currency and for longer time horizon. (¶93)	CBM	NT
5.	Conduct regular sensitivity analysis on certain vulnerabilities (e.g., concentration of funding) to detect potential shifts in systemic risk. (¶93)	CBM	NT
6.	Enhance the data management system for liquidity stress-testing exercise, e.g., cross checking to ensure consistency across templates, and prepare for the implementation of NSFR (¶93)	CBM, MFSA	NT
Interconnectedness			
7.	Expand the scope of the interbank analysis based on large exposures and funding concentration to capture cross-border bilateral exposures. (¶116)	CBM, MFSA	MT
8.	Enhance the network analysis of interlinkages within the financial sector – already advanced – to fully incorporate risks due to various transmission channels. (¶116)	MFSA	MT
9.	Integrate contagion risks to the overall macroeconomic stress-testing framework driven by macro scenarios to inform the calibration of tools. (¶116)	CBM	MT

* NT (near term) = 1–2 years; MT (medium term) = 3–5 years; CBM = Central Bank of Malta; MFSA = Malta Financial Services Authority.

INTRODUCTION[4]

A. Financial System Structure and Financial Conditions

1. Malta's financial system is relatively large and heavily connected with the world. The main components of the financial system assets are banks (€48 billion in assets at end-2017, 4.3 times GDP), insurance (1 time GDP) and investment funds (1.1 times GDP) (Table 2). In contrast, the private pension market in Malta is negligible in size. Like other financial systems in the euro area that are active in the intermediation of cross-border capital (notably Ireland, Luxembourg, and the Netherlands), Malta records a large residual category of "other financial institutions" (OFIs).[5] The cross-sectoral linkages show that part of the banking sector, insurers and OFIs hold assets and liabilities mostly vis-à-vis the rest of the world (Figure 1).

2. Maltese banks vary considerably in their business models and market orientation. For analytical purposes, authorities group banks into three categories based on exposures to residents and their potential impact on financial stability (Table 3):[6]

- **Core domestic banks** mainly operate in the domestic economy. With total assets of €23 billion at end-2017, they attract household and corporate deposits and lend mostly domestically. They account for 99 percent of mortgages to *residents*. For supervisory purposes, the three largest core domestic banks are classified as Significant Institutions (SIs) by the European Central Bank's (ECB) Single Supervisory Mechanism and hold 87 percent of this category's assets (42 percent of total bank assets). Three core domestic banks are foreign-owned. Debt securities (foreign and Maltese government) account for a quarter of their total assets. Claims on the Eurosystem are high, reflecting excess liquidity of these banks. Two core domestic banks each own a large domestic insurer.

- **Non-core domestic banks** are small, foreign-owned, funded primarily from wholesale markets and non-resident deposits, and have some exposure to residents. With total assets of €2.2 billion, their business models vary widely, with some banks focusing on syndication, factoring and finance, and other banks on private banking and conventional lending. Two banks account for about 80 percent of this category's assets.

[4] This note reflects the discussions and recommendations of the FSAP mission as of September 2018. It was prepared by Ziya Gorpe and Irman Pardede of the IMF's Monetary and Capital Markets (MCM) Department. Haonan Qu (IMF European Department) contributed to the household stress-test section and Tadeusz Galeza (MCM) provided the results of the market-based interconnectedness analysis. The FSAP team would like to express its deepest gratitude to counterparts at the CBM and MFSA, in particular, Alessandra Donini, Mariana Gkoutse, and David Stephen Law, for close cooperation in facilitating this comprehensive stress testing exercise.

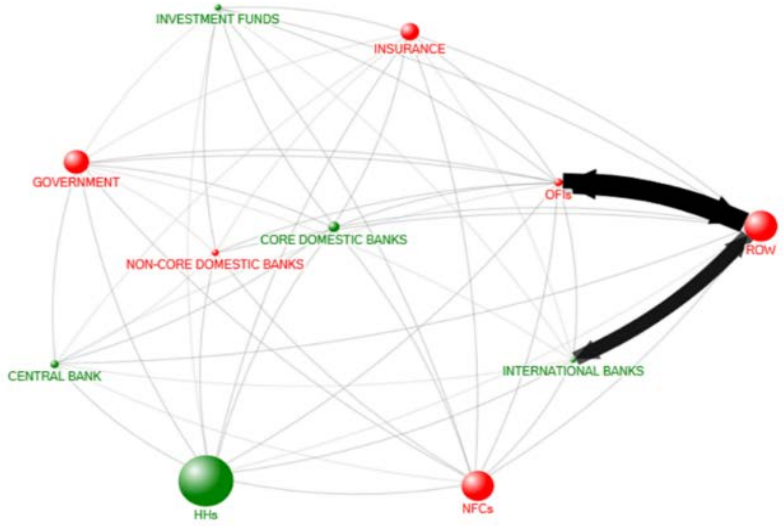
[5] The residual OFI sector refers to sector 127 (Captive Institutions and Money Lenders) of the European system of national and regional accounts (ESA 2010). It comprises financial and quasi-corporations that are neither engaged in financial intermediation nor provide financial auxiliary services and do not transact on open markets.

[6] For more detail on how banks are categorized by the authorities, please see the 2014 Financial Stability Report (Box 3) of the Central Bank of Malta.

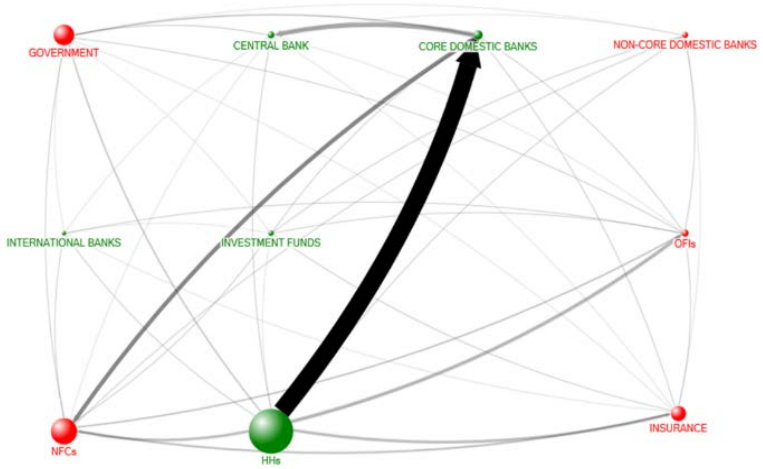
- **International banks** are foreign-owned with insignificant domestic exposures. Their total assets amount to €23 billion and they rely mostly on wholesale (including intra-group) funding of relatively long maturities. They focus on activities for their group (e.g., custodian services, trade finance, investment banking). These banks account for over 77 percent of the banking system's total non-resident deposits and about 78 percent of lending to non-residents. Two non-EU branches account for 83 percent of this category's assets (€19 billion). The branches have a negligible exposure to the Maltese economy.

Figure 1. Malta: Cross Sectoral Linkages (Gross Exposure, 2017)[1,2,3]

Full Network Map



Network Map without the Rest of the World



Sources: CBM and IMF staff estimates.

[1] Prepared by Giovanni Ugazio (Statistics Department, IMF).

[2] Based on financial account data ("from-who-to-whom"), the node size represents the size of the net balance between funds borrowed and lent by a sector, while the node color represents whether a sector is a net debtor (red) or creditor (green). The thickness of arrows from a sector to another depicts the bilateral exposures. HH stands for households.

[3] OFIs include captive financial institutions and money lenders.

Table 2. Malta: Structure of the Financial System, 2004–17
(Assets in multiples of GDP, unless otherwise indicated)[1]

	2004	2010	2017
Financial Institutions, total	8.7	28.0	22.9
Banks	4.2	7.5	4.3
Money market funds (MMF)	0.0	0.0	0.0
Non-MMF investment funds	0.5	1.1	1.1
Other financial intermediaries and auxiliaries	0.0	0.0	0.1
Insurance corporations	0.3	0.8	1.0
Pension funds	...	...	...
Other financial institutions	3.7	18.5	16.5
Financial institutions total (millions of euro)	42,190	184,720	257,860
Nominal GDP (millions of euro)	4,852	6,600	11,295

Sources: CBM and MFSA.
[1] European system of national and regional accounts (ESA 2010); CBM excluded. OFIs comprise captive financial institutions and money lenders.

3. Key metrics suggest that the banking system is in good health, but some challenges exist. Banks' total capital adequacy ratio is high (21.2 percent of risk-weighted-assets (RWA) in 2017; Tier 1 Capital ratio at 19.0 percent), and liquidity is ample (Figure 2).[7]

- *Bank profitability remains good, but uncertain going forward.* In aggregate, stable net interest margins and operating costs help maintain profitability. For core domestic banks, margins are supported by increasing interest rate spreads, which are high by euro area comparison. However, if corporate loan books continue contracting and the property market weakens, the sustainability of core bank profitability and business models would be challenging. Among the challenges are: large exposures to low-yield bonds; increased regulatory compliance costs; higher loan loss provisioning requirements; and the implementation of the EBA guidelines on Minimum Required Eligible Liabilities which will likely raise funding costs.[8]

[7] These figures are for all banks, including non-EU branches. The core domestic banks' capital ratio improved from 16.8 percent in 2017Q4 to 17.2 percent in 2018Q1.

[8] According to EBA estimates for euro area banks, the implementation of IFRS 9 is expected to reduce the average Common Equity Tier 1 (CET1) ratio for LSIs by 45 bps on average (see EBA Report on Results from the Second EBA Impact Assessment of IFRS 9, July 13, 2017). The authorities are undertaking an assessment of the effect on Maltese banks with assistance from an auditing firm.

Table 3. Malta: Bank Market Share
(end-2017, percent)

	No. of banks	Deposits		Loans				
		Resident	Non-resident	To residents				To non-residents
				Total	Household	Corporate	Other 1/	Total
Authorities' classification								
Core-domestic banks	6	95.3	14.8	98.4	99.6	96.9	97.1	14.7
Non-core domestic banks	5	3.1	7.9	1.4	0.4	2.7	2.4	7.0
International banks 2/	14	1.7	77.3	0.2	0.0	0.4	0.5	78.4
Total	25	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ECB's classification								
SIs	3	81.7	13.4	79.4	80.2	76.4	84.2	13.9
LSIs	18	18.2	14.9	20.6	19.8	23.6	15.6	22.5
Non-EU branches	2	0.0	65.4	0.0	0.0	0.0	0.0	51.3
Other 3/	2	0.0	6.3	0.0	0.0	0.0	0.2	12.3
Total	25	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Sources: Maltese authorities and IMF staff calculations.
1/ "Other" includes credit and financial institutions, investment funds, and government.
2/ About half of resident deposits of international banks are concentrated in one bank (classified as an LSI) and were largely accumulated during 2016 and 2017. The two non-EU branches are branches of Turkish banks and are both "international banks" under the authorities' classification.
3/ These are a subsidiary and a branch of banks of other euro area countries and are classified under the home state of their respective group parent.

- *Asset quality has been improving, but challenges remain in real estate-related lending*. At end-2017, the NPL ratio stood at 4.1 percent of total loans (excluding non-EU branches), down from 6.6 percent in 2014Q4. The ratio for core domestic, non-core domestic, and international banks (excluding non-EU branches) stood at 4.1 percent, 2.3 percent, and 5.3 percent, respectively.[9] Excluding non-EU branches, NPLs of NFCs have declined from 11.8 percent in 2014Q4 to 9 percent in 2017. Asset quality in a few small banks remains weak and authorities are monitoring their NPL reduction plans in line with a 2016 regulation that mandated all banks to reduce their NPL ratio below 6 percent over five years. NPLs remain persistently high in construction (27.8 percent) and corporate real estate (13.9 percent). The loan loss provisioning for total loans was about 34 percent of NPLs in core domestic and international banks, and 57 percent in non-core domestic banks.
- *Funding has been ample but depends on bank business models*. While bank funding structures vary by business orientation, loan-to-deposit ratios are generally low, and liquidity is high. However, the growing shares of non-resident deposits (especially by smaller banks) and the high share of sight deposits raise concerns about funding stability in the case of adverse shocks.

[9] For core domestic banks, the NPL ratio remained stable at around 4.1 percent in 2017Q4 and in 2018Q1.

- *Some banks' correspondent banking relationships are subject to pressures and various restrictions*, particularly when they themselves provide correspondent banking services and channel flows from high-risk jurisdictions or deal with high-risk clients (e.g., nonresidents, e-gaming, virtual-asset operators, participants in the Individual Investor Program (IIP),[10] and politically exposed persons). The concerns stem from reasons such as profitability (e.g., low volume of transactions and high compliance costs), risk appetite, and reputational risk.

4. Banks' exposure to government debt is low but concentrated. Malta's sovereign debt is largely domestically held. Banks held 29 percent of total government debt (3.3 percent in terms of assets share) in 2017. Over 90 percent of these holdings are concentrated in core banks (6.6 percent of their assets).

5. From a cyclical perspective, credit indicators are not currently signaling risk of a broad-based credit boom. The credit-to-GDP gap has been negative for several years, reflecting the broad-based slowdown in credit growth after the Global Financial Crisis. A large decrease in the share of non-financial corporation's (NFC) loans to GDP is the main factor contributing to the negative gap. The recent strong economic growth has helped improve bank asset quality and contributed to maintaining the banking sector capital at levels exceeding minimum capital requirements.

6. Intermediation to NFCs has been shifting from banks to intercompany lending. This development is driven by both demand and supply factors. The bank lending rate is higher than in the euro area (by 160 basis points on average), and bank loans are highly collateralized in Malta. This makes bank loans very costly for Maltese corporations. On the other hand, strong economic growth in recent years supported firms' profitability. As firms diversify their operations via forming bigger groups, they are able to manage financing needs using internal funds within their groups, which explains why increasing intercompany lending consists mostly of intra-group lending or related-group lending. The structural change of the economy towards less capital-intensive sectors, such as services, also reduces demand for bank loans to finance large investment.

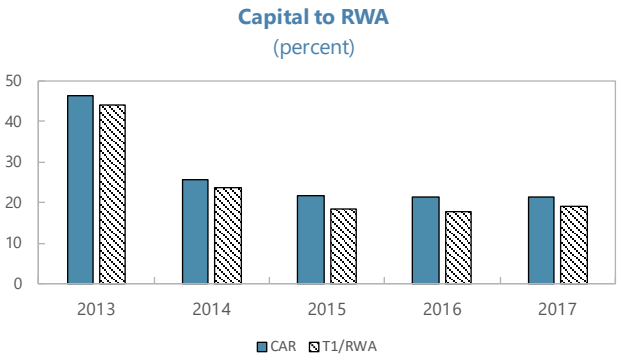
7. At this juncture, intercompany lending does not appear to pose systemic risk.[11] Intercompany lending reflects internal financing within groups or related companies. While the reliance on internal cash buffers may expose firms to business cycle risks, their impact on the banking sector would be manageable because of declining bank exposure to NFCs. Also, banking regulators have noted the limited use of collateral for intercompany lending, which limits spill-overs to the banking system through fire sales.

[10] The IIP is a citizenship-by-investment program that allows individuals to acquire citizenship in exchange for major investment in the Maltese economy, including in real estate (Box 1 of IMF 2017).

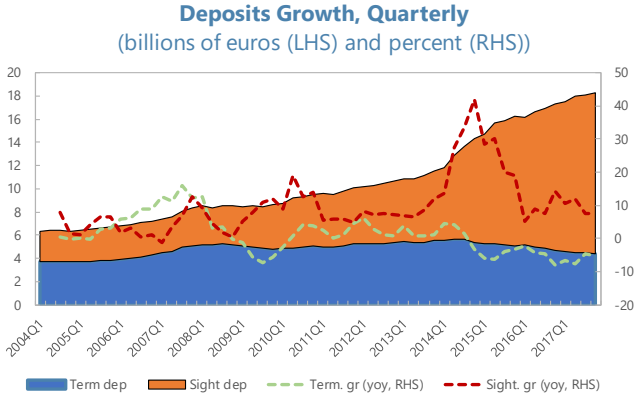
[11] For more detailed analysis of intercompany lending, see the FSAP Technical Note on Macroprudential Policy.

Figure 2. Malta: Banking Sector Overview

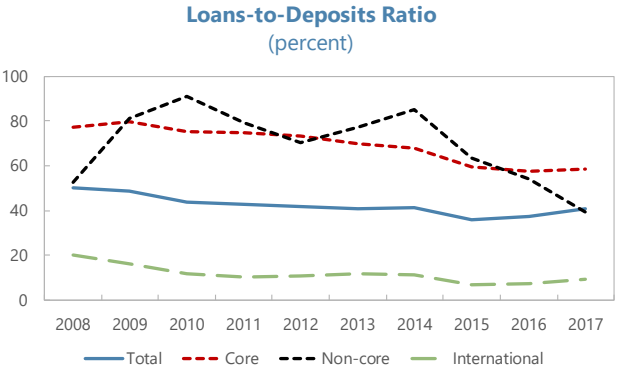
Banks are well capitalized…[1/]



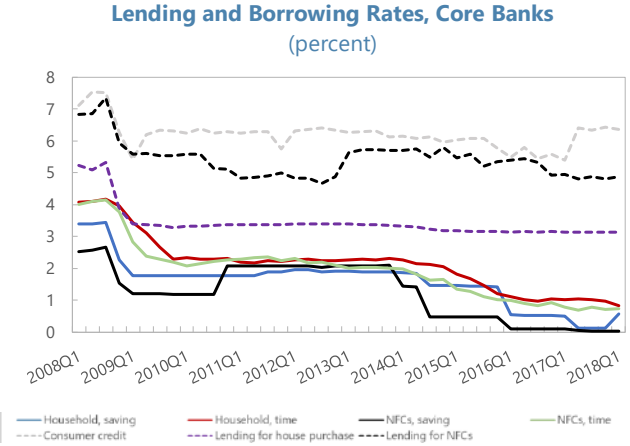
…and deposits are growing.[1/]



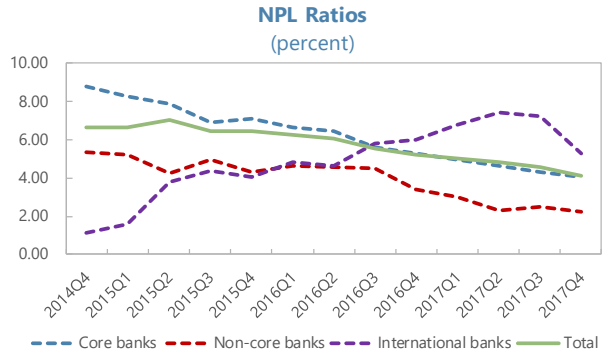
Slower lending growth is reflected in low low-to-deposit ratios…[1/]



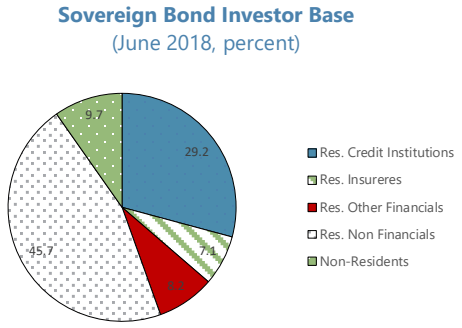
…but the interest spread is increasing for all banks and supports profitability…[2/]



NPLs are decreasing for all groups of banks.[3/]



The banking sector holds 29 percent of the total stock of Maltese government bonds…[1/]



Sources: CBM, MFSA, and IMF staff calculations.

[1] Total banking sector, including non-EU branches.

[2] Sample banks (11 banks), covering 93 percent of total assets, foreign branches excluded.

[3] Total banking sector excluding foreign branches.

8. Despite a decreasing trend of bank intermediation to Maltese NFCs, their leverage is still high compared to its pre-crisis average and to European peers. There are several reasons for this. First, there is a significant presence of SMEs in Malta, which tend to have higher leverage ratios compared to large firms, and relatively less developed capital markets that inhibits equity financing.[12] Second, firm-level data indicate that the construction and real estate sectors exhibit the highest leverage ratios – possibly reflecting the capital-intensive nature in these sectors and high collateral requirements for bank financing (see below) – followed by the manufacturing and service sectors.[13] Third, a statistical issue related to cross-border intra-group financing may be a contributing factor to the high leverage ratios.[14] Mitigating factors for the Maltese banks include the relatively high profitability of Maltese firms, high degree of collateralization of bank loans, and reliance on inter-company lending.

9. Property-related lending is high and increasing. With resident mortgage lending growing by 8.5 percent annually since 2013, and bank lending to NFCs declining, concentration of mortgage loans has risen. In total, property-based lending to residents, including credit to construction and real estate, accounts for 62 percent of core domestic banks' total loans to residents, making them susceptible to a potential sharp decline in house prices.[15]

10. Residential housing prices have risen quickly in recent years. Strong employment growth, rising disposable income, an influx of foreign workers, and portfolio rebalancing largely by households toward property investments in a low interest rate environment, have pushed residential property prices up by about 33 percent between 2010Q4 and 2017Q4. Demand also stems from buoyant tourism, lower withholding tax on rental income, and the IIP.[16] Construction investment has recently picked up, reflecting a supply response to rising property prices. Recently, house price indices have gone beyond their long-term trends and conventional price indicators have increased.[17]

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[12] According to Eurostat, SMEs in Malta generate 81 percent of value-added within the non-financial business economy and 80.9 percent of employment, comparing to 56.8 percent and 66.4 percent, respectively, for the EU. See the "2018 SBA Fact Sheet Malta," available at https://ec.europa.eu/growth/smes/business-friendly-environment/performance-review_en#sba-fact-sheets).

[13] See "Non-bank Sources of Corporate Financing in Malta" (IMF Selected Issues Paper, January 2018); and "The Non-Financial Corporate Sector in Malta: Balance Sheet Vulnerabilities and Impact on Innovation" (IMF Selected Issues Paper, February 2017).

[14] Since the NFC data is consolidated only at the domestic group level, financial data would not be comprehensive for the NFCs that are part of non-resident group. For example, loans from a non-resident parent company appear as external debt for its resident subsidiaries, although they are internal finance.

[15] Due to low loan-to-deposit ratios, the share of property lending to total assets is only 25 percent for core domestic banks and 22 percent for all banks included in the stress test sample.

[16] The IIP has added to housing demand, however, its contribution to overall housing market development is assessed to be low because of the relatively low number of approved applications (about 200 per year since the IIP's inception in 2014 based on the Office of the Regulator Individual Investor Program Annual Reports).

[17] The house price-to-income ratio is still around its historical average but the house price-to-rent ratio is higher as of end-2017. In addition, econometric analyses of equilibrium house prices conducted by IMF staff suggest some overvaluation, although the estimated size of overvaluation varies, depending on the choice of house price index. Authorities' econometric models also point to some overvaluations, but they are small at this juncture. See Technical Note on Macroprudential Policy Framework and Tools for more details.

11. Notwithstanding relatively high household indebtedness and the prevalence of variable rate mortgages, household balance sheets appear sound.[18] At 108 percent of gross disposable income in 2017, Maltese household debt is slightly above the euro area average.[19] This reflects a home ownership ratio of 82 percent (2017), compared with a euro area average of 66 percent (2016). An adverse shock to house prices could negatively affect household balance sheets. Household debt service capacity could rapidly deteriorate in an "adverse scenario" (e.g., falling incomes, rising interest rates), particularly for low-income households, as mortgages are mainly at variable interest rates.[20] However, the share of homeowners with debt is small, at about 20 percent. Household financial wealth has also increased, leaving the debt-to-financial-wealth ratio stable at 23 percent. The loan-to-value ratio and the debt-service-to-income ratio of new mortgages has remained broadly unchanged since 2011, averaging 77 percent and 21 percent, respectively, in 2017Q4. These ratios became more prudent in 2017 for secondary residence and buy-to-let property loans. An analysis of household balance sheets indicates that they are overall resilient against adverse economic shocks (last section of this Note).

12. Reputational risks, including from money laundering and terrorism financing, and changes in international corporate taxation, could negatively affect Malta's attractiveness as a business location. In the last two years, Malta has seen some high-profile money laundering and terrorism financing-related incidents, including one linked to an LSI.[21] The large remote gaming sector and the Government's aspiration to host fintech-related industries pose challenges for banks that choose to enter into business relationships with these sectors. These include containing regulatory compliance costs and financial integrity risks, which is crucial to maintaining correspondent banking relationships. Shocks to Malta's reputation, together with potential changes in the country's comparative tax advantage and the high exposure to non-resident deposits of international and non-core domestic banks could result in capital flight and relocation of companies away from Malta.[22]

13. The impact of Brexit is highly uncertain but is assumed to mostly affect insurers and investment funds with foreign-oriented business models. The MFSA is closely monitoring the potential impact arising from a "hard" Brexit. Under this scenario, about 10 insurers who write business in the U.K. exclusively and two insurers with more than 50 percent of their business in the U.K. may decide to cease operations. in Malta and establish an entity in the U.K.[23] In addition, U.K. insurers have

[18] Household leverage includes non-profit institutions serving the household sector.

[19] It is worth noting that the difference could partly reflect potential coverage of household debt data. The household debt data for Malta covers bank loans as well as other accounts payable and loans, while the euro area average covers household debt arising from loans.

[20] A quarter of mortgage lending have a fixed interest period of about 2 to 3 years, after which variable interest rates apply.

[21] In March 2018, the MFSA appointed a competent person to assume control of the Pilatus Bank (0.7 percent of system assets, excluding non-EU branches), following an indictment in the United States of the bank's chairman/CEO and the ultimate beneficial owner (one and the same person). MFSA proposed withdrawing the bank´s license in September 2018 and the ECB made the decision in November 2018.

[22] Malta is the only EU member utilizing the full tax imputation system and offering a refundable tax credit.

[23] Some of these insurance undertakings have already informed the MFSA of their plans while others are still considering options and engaging with the MFSA to ensure a smooth transition of business that takes into account the interests of policy holders.

been writing a substantial volume of health insurance policies in Malta via the EU's passporting of services. Should the U.K. be considered as a third country, these insurers would either need to operate in Malta via a third country branch or cease carrying on business in Malta, which may affect consumer choices.[24] For the banking sector, core domestic banks have about 8 percent of their total assets in the U.K., mostly in terms of loans to corporates. Two core banks have relatively high share of assets, accounting for more than 15 percent of their total assets. However, these two banks are not expected to be affected by Brexit because they are part of financial groups based in the U.K. On funding side, the core banks have minimal amounts of deposits from the U.K.

14. The Risk Assessment Matrix (RAM) identifies key macrofinancial risks from both global and Malta-specific factors (Appendix 1). These include risks emanating from weak growth in advanced economies, tighter and more volatile global financial conditions, policy and geo-political uncertainties, a possible sharp correction in house prices, changes in international corporate taxation, growing reputational risks, and rising regulatory compliance costs.

B. Risk and Vulnerabilities Analysis in the FSAP

15. The purpose of the risk and vulnerability analysis under the Malta FSAP is to assess the capacity of the financial system to withstand severe but plausible macroeconomic shocks. The risk analysis includes solvency and liquidity stress tests for the banking system based on macroeconomic scenarios and sensitivity analysis, as well as interconnectedness analysis in domestic and cross-border markets. The tests are meant to identify vulnerabilities in the financial system and the channels through which adverse shocks might be transmitted. The FSAP stress tests could provide input into the development of policy actions to strengthen banking system resilience and reduce vulnerabilities in the system.

16. Although stress tests are useful to analyze vulnerabilities in a financial system, the results must be interpreted with caution. FSAP stress tests are macroprudential in nature, as they are intended to help identify key sources of systemic risk in the financial system. They differ from supervisory stress tests (micro prudential) as their results are not intended to lead to supervisory actions at the level of individual banks. Another caveat is that the FSAP credit loss estimates and solvency projections in the "adverse scenario" are subject to data and methodological limitations. Adverse stress testing scenarios should not be interpreted as macroeconomic "forecasts," as they capture a combination of external and domestic shocks that are considered "tail" events based on historical distributions.

17. The stress tests covered solvency, liquidity, and contagion risks.

- The solvency tests assessed the impact on banks of severe but plausible external and domestic shocks to the economy over a three-year horizon, from 2017Q4 to 2020Q4. The transmission of these shocks to the banking system used satellite models and methodologies developed by the

[24] However, according to the MFSA, these insurers have now taken steps to either set up a Malta branch of a European-related insurance undertaking/subsidiary of the U.K. insurance undertaking or have entered into arrangements with another Maltese insurance undertakings to start writing Malta health policies, limiting the impact on consumer choices.

IMF. In addition to the scenario-based test, single factor tests were also conducted to assess the resilience of the banking system to individual shocks.

- The liquidity stress tests were conducted using several approaches. The regulatory based approaches include LCR, which focused on short-term liquidity mismatches, and NSFR, which focused on the longer-term structure of liquidity. A cash-flow based approach was also used to assess the liquidity resilience to large withdrawals of funding, using maturity ladder and supervisory data.

- The contagion analysis covered both cross-border interbank exposures and domestic cross-sectoral interlinkages between banks, insurers, and funds, and used supervisory and market data.

18. The top-down stress test for solvency and liquidity are based on supervisory as well as CBM data.[25] The main sources of data were EBA's Implementing Technical Standards (ITS) templates, which cover financial reporting information (FINREP) and common reporting templates (COREP), with end-2017 as a starting point. For the cash-flow based liquidity stress test, the maturity profiles are based on end-March 2018, the first reference date when such data became available. These supervisory data were complemented by CBM historical data sourced from Banking Rule 06, such as for the time-to-repricing gap buckets for assets and liabilities, and the breakdown of resident and non-resident deposits. Other public data sources included Bloomberg, Fitch, Haver Analytics, IMF's *World Economic Outlook* database, and Moody's KMV.

19. The FSAP stress test benefited from a close collaboration with Maltese authorities. The FSAP team worked collaboratively with experts from CBM and MFSA for the stress testing exercise, including in the ECB data room. This included the scenario-based stress testing, both for solvency and liquidity, and the single factor sensitivity analysis.

20. FSAP stress tests may differ from stress tests conducted by other institutions, including EBA and the European Central Bank (ECB). The FSAP team estimated different credit risk models, used a different sample of banks, and developed different macro scenarios and parameters. Nevertheless, the FSAP tests were carried out in close cooperation with the ECB.

21. The remainder of this technical note is structured as follows. The second section presents the solvency stress test, including sensitivity analysis. The third section discusses liquidity stress test using three complementary approaches. The fourth section analyzes the contagion risks from both cross-sectoral and cross-border perspectives. The last section discusses the household stress tests.

[25] The team was given access to supervisory data in a secure data room at the ECB.

SOLVENCY STRESS TESTS

A. Solvency Stress Tests of the Banking Sector

22. The top-down solvency stress tests focus on 11 sampled banks, covering 93 percent of banking sector assets (excluding foreign branches). The sample includes all 6 core domestic banks (including all three SIs), two non-core domestic banks, and three international banks. To ensure confidentiality the results for the latter two groups of banks are presented as "other banks". The sample accounts for 93 percent of banking system total assets (excluding foreign branches), 99 percent of credit to residents and 99 percent of resident deposits (excluding foreign branches). While the foreign branches are large relative to the Maltese GDP, they have negligible exposure to the Maltese economy and therefore were excluded from the stress testing exercise. As is the case with all institutions licensed in Malta, a potential channel of risk from the foreign branches would be through reputation.

23. The solvency stress tests were based on the minimum capital ratios under Pillar I of the Basel II Accord. Individual requirements under Pillar II (supervisory review) were not taken into account. Banks are allowed to deplete the capital conservation buffer of 2.5 percent under the adverse scenario. For SIs, the hurdle rate includes the Other Systemically Important Institutions (O-SII) buffer under baseline and adverse scenarios. The O-SII buffer differs for each O-SII bank, ranging from 0.5 percent to 2.0 in 2020; the phase-in period of the O-SII buffers during 2018 to 2020 was taken into account.[26] Table 4 shows in detail the calculation of the various hurdle rates used in this exercise.

Table 4. Malta. Malta: Hurdle Rates for Solvency Stress Tests
(percent)

Minimum capital ratios	Hurdle rate (Adverse scenario)	
	O-SII	Other banks (Non-O-SII)
Total capital ratio (total capital to RWAs)	8 + O-SII buffer	8
Tier I capital ratio (Tier 1 capital to RWAs)	6 + O-SII buffer	6
Common Equity Tier I capital ratio (CET1 capital to RWAs)	4.5 + O-SII buffer	4.5
Leverage ratio (Tier 1 capital to total assets)	3	3

Source: Maltese authorities.

[26] See "Statement of Decision on the Methodology for the Identification of Other Systemically Important Institutions and the Related Capital Buffer Calibration," Central Bank of Malta and Malta Financial Services Authority, January 2018.

B. Macroeconomic Risks and Scenarios

24. Solvency stress tests were based on macroeconomic scenarios comprising a baseline and an adverse scenario covering the three-year period from 2018 to 2020.

- *The baseline scenario* is aligned with the April 2018 *World Economic Outlook* projections over a three-year horizon, starting in 2018.[27] The projections include macrofinancial variables for Malta, relevant foreign countries, and financial conditions in global markets. These baseline projections assume a slightly declining GDP growth path converging to its potential over the medium term while unemployment remains below 5 percent and inflation picks up only modestly.

- *The adverse scenario* was developed using the IMF Flexible System of Global Models and calibrated in coordination with the CBM and ECB (see Appendix III). The scenario features a V-shaped GDP profile, commensurate with Malta's high trade diversification, flexible labor markets, and experience from earlier economic downturns (Figures 3 and 4). Designed to cover the risks identified in the RAM, the scenario is driven by a combination of external and domestic shocks, which lead to a decline in exports, capital outflows, shrinkage in the internationally-oriented financial services and remote gaming sectors, declining asset prices, and a sharp GDP contraction. Rising interest rates and reduced income and profits would negatively affect bank asset quality and profitability through higher NPLs, impairment charges, and funding costs. This results in an average decline in GDP of 0.1 percent per annum over the 3-year horizon (-2.3 percent in 2018, -1.0 percent in 2019, and 2.9 percent in 2020), leading to 15.4 percentage points cumulative decline of GDP relative to the baseline (equivalent to a 2.07 standard deviation shock and comparable to recent euro area FSAPs).[28] The adverse scenario reflects realization of shocks that are plausible albeit notably more severe compared to past crisis periods (Dot-com or the Global Financial Crisis) in Malta.

25. In the adverse scenario, Malta would experience a very severe recession underpinned by external and domestic shocks. The Maltese economy is highly open, with exports standing at about 150 percent of GDP. A secular weakening of external demand and lower foreign direct investment (FDI) would adversely affect the domestic economy and its growth prospects, increase unemployment coupled with an outflow of foreign workers that could amplify the housing price correction. Slower growth and higher unemployment would increase NPLs and impact bank profitability through additional provisions and lower interest income. Erosion in profits and capital adequacy ratios could cause wide-spread distress with tightening in lending conditions. Credit crunch could trigger a feedback impact on financial stability and economic growth. Under this scenario, liquidity risk could also materialize, with banks facing deposit funding outflows of retail and wholesale deposits, particularly from non-residents.

[27] Housing prices and compensation for employees (wages) in Malta under the baseline scenario were obtained from the June 2018 Broad Macroeconomic Projection Exercise. Malta long-term yields reflect ECB calculations for June 2018 vintage.

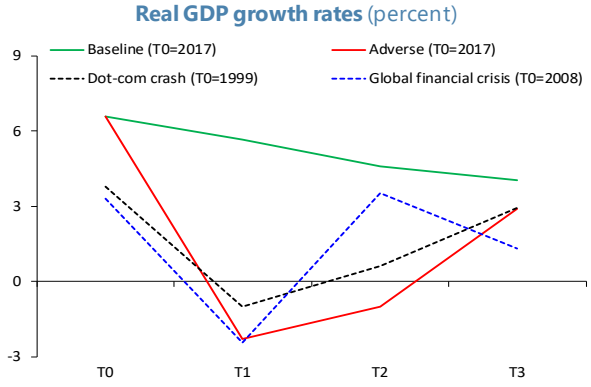
[28] The standard deviation is calculated in terms of cumulative 3-year GDP growth taking 2000–17 as the basis for historical calculations due to a break in GDP series in 2000.

26. A recession in the adverse scenario would result in a worsening of financial conditions that might affect the financial system. Following the external and domestic shocks, financial conditions would tighten, with spikes in interest rates and bond yields. Higher debt service and refinancing risks could stress households and corporates, which in turn would cause an increase in NPLs. Banks could face large credit and market losses given their borrowers' impaired repayment capacity and their holding of debt securities, which are sizeable for some banks.

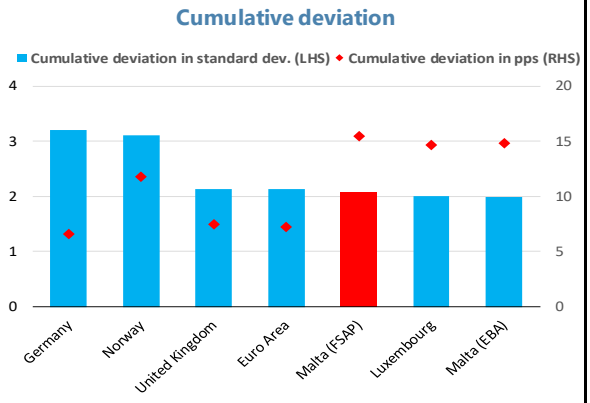
27. The adverse scenario incorporates Malta-specific shocks. First, possible changes in international corporate taxation and/or growing reputational risks and regulatory compliance costs could weaken Malta's attractiveness as a financial and business location. A prolonged period of unfavorable operating conditions could result in the shrinkage of the international sector, including within the financial system. This could erode the tax base significantly, increase unemployment, and suppress economic growth. Stress in public finances would spill over into the banking system given its strong home bias. The financial sector (including ancillary professions) generates an estimated 10 percent gross value added to the economy (MFSA 2017), and the gaming sector's share in economic value-added stands at 11 percent of GDP (Malta Gaming Authority 2018). The impact of the shocks to Malta's attractiveness as a business and financial hub was captured through significant contractions in these two key international sectors. Second, there could be a sharp correction in historically high housing prices with wide-spread economic repercussions. The FSAP team made exogenous adjustments to house prices, which were assumed to decline by 30 percent in cumulative terms over the 3-year stress horizon.[29] The decline in turn triggers adverse wealth-effects, creating a negative feedback loop with weakening domestic demand and deflation, and a further deterioration of NPLs.

Figure 3. Malta. Malta: FSAP Stress Test Scenario

Scenario severity from historical perspective



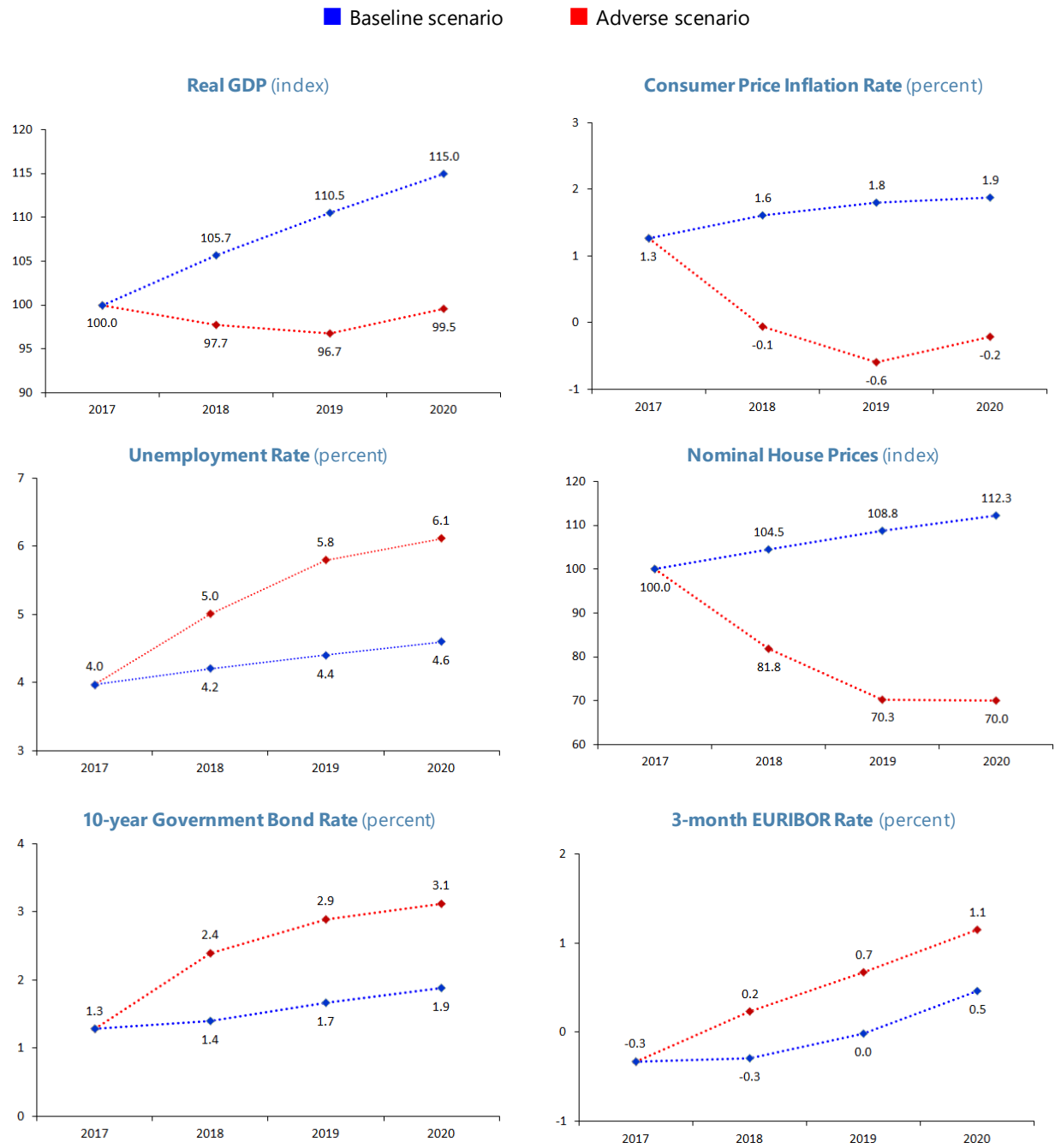
Comparing the size of GDP shock



Sources: CBM, ECB, and IMF staff calculations.

[29] Such a drop would be in line with international experience during financial crisis periods (e.g., Hong Kong, Ireland, Spain) and would be comparable with the assumptions made in recent European and other advanced country FSAPs (e.g., Luxembourg, New Zealand, Sweden). See Appendix III for further details.

Figure 4. Malta: FSAP Macro Projections



Sources: CBM, ECB, and IMF staff calculations.

C. Methodological Approaches for the Scenario-Based Solvency Stress Test

28. The top-down solvency stress test covered a comprehensive set of risks. The FSAP team used an internally developed solvency stress test framework to capture credit risk, sovereign risk, market risk (including foreign exchange and interest rate risk), and interest rate risk in the banking book. The solvency stress test was based on International Accounting Standard 39 principles, particularly for the provisioning approach.

Balance Sheet and Income Projections

29. The balance sheet projection followed a quasi-static approach, which is the standard approach for FSAP stress testing. The approach assumes that balance sheets grow in line with nominal GDP growth under baseline and adverse scenarios. Thus, the size of the banking system in terms of assets remained constant relative to the size of the economy.[30] The balance sheet growth was measured for each individual bank, using the weighted average GDP growth of all countries where the bank has significant exposure of assets. Other factors affecting balance sheet growth are the revaluation of foreign currency exposures in accordance with the applicable foreign exchange movement and triggered off-balance sheet items (i.e., credit lines and guarantees). The structure and composition of assets and liabilities were assumed to remain unchanged across the projection period. Additional funding could be needed to cover the gap between assets and equity.

30. The projections of RWAs accounted for balance sheet growth, impairments, changes in exchange rates, and triggered credit lines and guarantees. RWA projections increased due to the balance sheet growth, accounting for: (i) new provisions for credit losses and exchange rate movements for foreign currency exposures; (ii) additional risk weights on new defaulted loans; and (iii) a triggered portion of off-balance sheet items (undisbursed credit lines and guarantees).[31] The risk weight for new defaulted loans was topped up to 120 percent of net amount, i.e., net of specific provisions. This additional RWA was based on historical RWAs of defaulted exposures reported by sample banks. This is also in line with the Basel II standardized approach framework, under which defaulted exposures are risk-weighted between 100 and 150 percent.

31. Income (profit and loss) was projected using all the risk factors in the stress test. Most non-interest income items were projected to follow nominal GDP growth. This included the projection of net fee and commission income, and operational and administrative expenses. Under the adverse scenario, a floor of zero percent was set for growth in non-interest income and expenses. Extraordinary income and losses were assumed not to recur during the projection period. The income tax was also reflected in the profit and loss calculations, based on the historical tax rate in the system, with a floor set at 28 percent, which was the median tax rate of the sampled banks. Interest income was projected using base and interest rate risk components that incorporated interest rate risk in the banking book. Loss provision was projected using the credit satellite model, while valuation losses of debt securities (both for trading and available-for-sale) was calculated using modified duration approaches. The loan loss provision is a final loss, identical to a write-off. These approaches captured credit, market, and sovereign risks in bank portfolios.

[30] The model caps bank deleveraging at zero percent under adverse scenario, i.e., balance sheets do not contract in nominal terms. For further details, please see the Stress Test Matrix in Appendix II.

[31] The triggered portion was assumed to be 5 percent of the off-balance sheet items for the baseline and 10 percent for the adverse scenario.

32. Distribution of after-tax profit was assumed only if bank net profit was positive. If the net profit was positive, the dividend payout ratio was set at the historical dividend payment of each bank. Maturing Tier 2 capital instruments during the three-year horizon were assumed not to be renewed.

33. For comparison purposes, the solvency stress test was also conducted under a static balance sheet approach. Unlike the quasi-static approach, the static approach assumes bank balance sheets remain at end-2017 levels.[32] Maturing assets were replaced by exposures of the same type and risk. Income projection follows all the risk factors in the stress test, including accrued income for non-defaulted assets. Other components of income follow the same approach as with the quasi-static approach.

Credit Risk Analysis

34. Credit risk constituted the largest risk factor for the banking system (Figure 5). Credit risk accounts for 90 percent of total RWA in the sample banks, in line with the banking system's assets composition. The largest portion of assets was loans, representing 71 percent, followed by debt securities. By sector, loans were mostly to NFCs (30 percent), followed by mortgages (24 percent), and placement in the central bank (22 percent). By currencies, 88 percent of the loans were denominated in domestic currencies. Loans in foreign currencies were dominated by U.S. dollar (6 percent) and British pounds (3 percent).

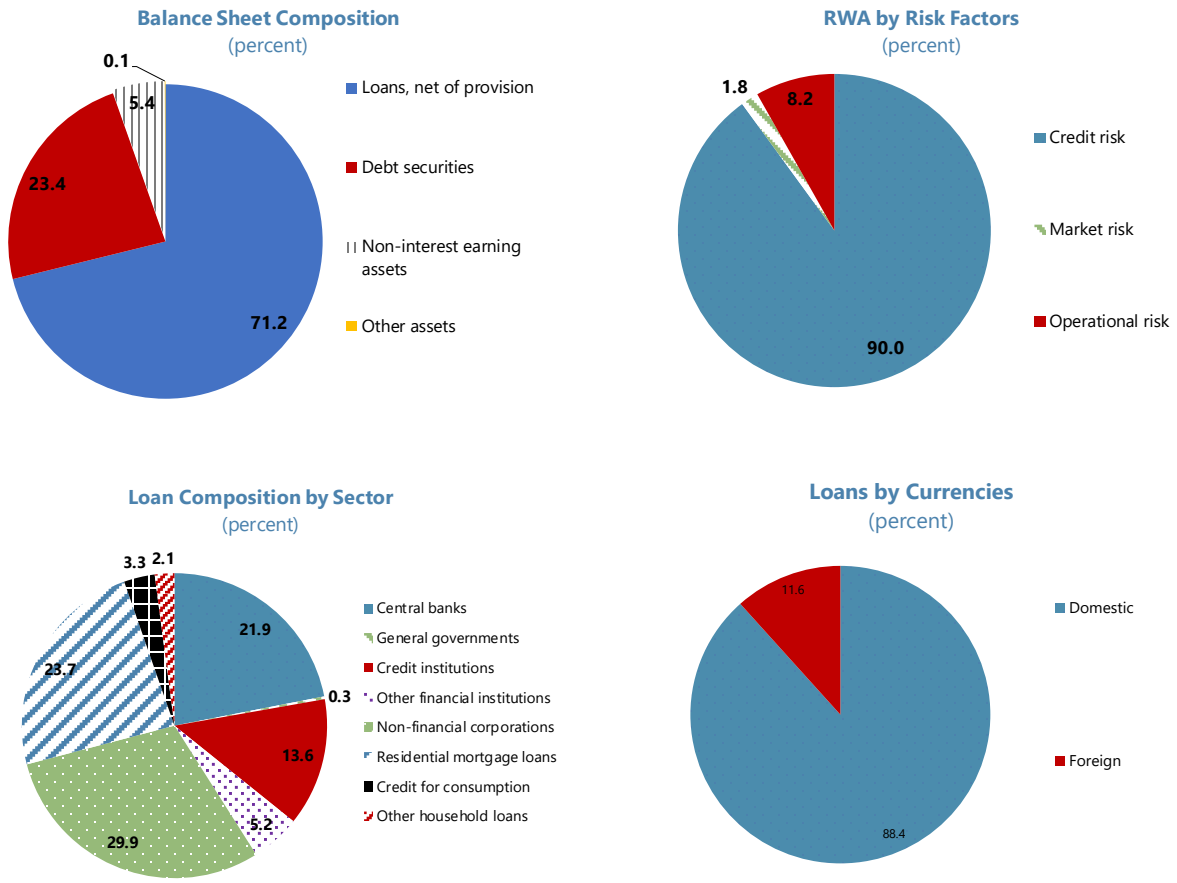
35. The variety of the bank business models led to different loan exposures for each sample bank. Loans to NFC's dominated in bank books for both core domestic and other banks. However, for mortgages, about 99 percent were provided by core domestic banks. Placements with the central bank were about 23 percent of total loans for both core domestic and other banks, reflecting ample liquidity in the banking system. For loans to financial institutions (including lending to credit institutions), other banks had a higher portion (33 percent of their total loans) than core domestic banks (18 percent).

36. The stress test made use of satellite models to estimate the credit losses in the banking system. Given that all sample banks are under a standardized regulatory framework, calculations for Probability of Default (PD) and Loss Given Default (LGD) were not readily available. Instead, NPL ratios were projected using fixed-effect panel regression techniques for two exposure classes: nonfinancial corporation and mortgages. Credit risk estimation of loans to financial institutions were proxied using Moody's Expected Default Frequency (EDF) series and projected using a fixed-effect panel regression model. Due to the unavailability of consistent NPL data series for consumer loans (non-mortgages), the credit risk for this category was estimated by benchmark PDs and LGDs provided by the ECB. Sovereign exposures and held to maturity (HTM) securities were stressed by migrating exposures by three notches down in the adverse scenario and applying corresponding long-term PDs and LGDs from Moody's.[33]

[32] This approach was run to reflect the rather weak relationship between GDP and credit growth, particularly NFC credit, and to facilitate the interpretation of results. Under this approach, the growth of assets is assumed to be zero. This approach may not be comparable with the static balance sheet approach in stress tests run by other institutions.

[33] See Moody's (2018), Sovereign default and Recovery Rate, 1983–2017.

Figure 5. Malta: Sample Bank Balance Sheet Composition



Sources: Maltese authorities and IMF staff calculations.

37. NFC credit losses were estimated separately for banks with unique geographically distributed loan books. Some banks have different geographical areas of lending operations for NFCs, leading the FSAP team to use credit satellite models for individual bank or subgroups of banks. This was to capture the specific macro risk factors related to these banks. The detail of credit risk satellite models is presented in Appendix IV.

38. Provisioning ratios for the NPL-based approach were calculated based on the collateral coverage for each type of loan, with a floor of provisioning coverage ratio set at 65 percent. Banks report on the collateral coverage of defaulted exposures in COREP. The uncovered portion of each loan represents the basis provisioning calculation. Under the adverse scenario, a minimum of 65 percent coverage was applied.[34]

39. Credit loss projections of loans to credit and financial institutions were estimated using Moody's EDF for geographical areas that were significant for the sample banks. Given that

[34] This provisioning coverage ratio is also comparable to the ratio used in the euro area FSAP 2017. Using the provisioning ratio for new defaulted loans brings up the total system-wide provisioning coverage of nonperforming loans to more than 50 percent.

sample banks have exposures to credit and other financial institutions in countries outside Malta, the proxied PD for banking and financial groups were calculated for ten sample countries of exposure, including euro area countries, using data from 2004Q1 onward. The proxied PD was then mapped to each bank according to their geographical loan distribution and the type of loans made to institutions (credit or other financial institutions). Due to the unavailability of EDF for financial institutions in Malta, the PD projection for loans to credit and financial institutions was calculated as the median PD of euro area countries in the sample.

40. Starting points for default rate for each bank were constructed using historical data of the ratio of stock of exposures in default to the amount of total exposures to institutions. Banks have reported the NPL ratio for credit and financial institutions in FINREP since 2014. To convert this stock-based metric into a flow-based measure, the flow of new defaults was calculated from the changes in stock, incorporating the write-offs and expert judgment based on individual management of problem loans.

41. The provision expense for the PD-model approach was calculated as a percentage of the value of the average balance of performing loans.[35] The provision expense is the result of multiplying the PD, LGD, and the average balance of performing loans. For loans to financial institutions, a minimum 50 percent LGD floor was imposed.

Market Risk Analysis

42. Stress tests also assessed the resilience of banks when facing different sources of market risk. In addition to credit risks, banks also faced risks from changes in market variables, such as interest rates and exchange rates. These losses might be transmitted into bank books through the existence of net open positions in foreign currencies and market valuation losses for debt securities ("held for trading" and "available for sale") due to changes in market yield.

43. The direct impact from foreign exchange movements was minimal in the banking system. This was shown by the low level of net open positions in the sample banks. The median of absolute net open positions to total capital was 0.12 percent. The foreign exchange rate risks resulting from net open positions impacted net profits directly.

44. Market valuation losses corresponding to holdings of debt securities were estimated using the modified duration approach. For every country and year, sovereign yield curves were constructed by linear interpolation of short- and long- term interest rates, as specified in the macroeconomic scenarios. The average duration of debt portfolio was then calculated for each bank based on the authorities' granular securities data. Losses were calculated as the product of the size of each bond portfolio, average duration, and the changes in the yields. For non-sovereign securities, the

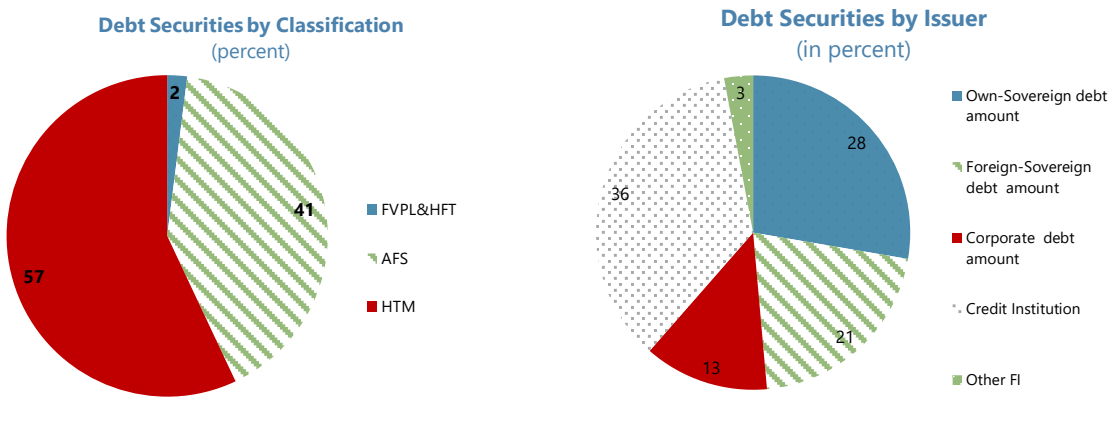
[35] The same approach was used to calculate provisions for consumer loans, using benchmark PD and LGD from the ECB.

yield change included the credit spread along the three-year horizon.[36] The following formula represents the modified duration approach in the stress test:

$$\frac{\Delta \text{ Valuation}}{\text{Valuation}} = - MD \,.\, \Delta y_{MD}$$

where MD is the modified duration of the portfolio and Δy_{MD} is the change in the yield caused by the shift in the yield curve (vis-à-vis the value prevailing in the previous year) and measured at a point in time that matches the modified duration of the portfolio.

Figure 6. Malta: Sample Bank Debt Holdings



Sources: Maltese Authorities; and IMF staff calculations.

AFS = available for sale; FVPL = fair value through profit or loss; HFT = held for trading; HTM = held to maturity.

Interest Rate Risks in the Banking Book

45. Interest rate risks in the banking book were assessed using time-to-repricing gap analysis. The interest rate sensitive assets and liabilities were grouped together in different buckets, depending on their time-to-repricing.[37] The impact of funding and lending interest rate shocks on net interest income was estimated by measuring the gap between interest sensitive assets and liabilities in each time-to-repricing bucket.

46. Effective liability (funding) interest rates were estimated using satellite models with fixed-effect panel regression techniques. The effective interest rate of liabilities was sensitive to 3-month Euribor rate and U.S. dollar Libor rate. Under the adverse scenario, the relationship between the funding and lending rates was estimated using quantile regression that implies a tightening net interest margin. The detail satellite models for effective funding rates is presented in Appendix V.

[36] The credit spread is determined using ITraxx data, i.e. EUR 5 yr, iTraxx cross-over, and the European Senior Financial Index. The average credit spread was 190 bps, which is comparable with the CBM approach for market risk stress test of MTM securities, the results of which are published in the CBM's Financial Stability Report.

[37] The buckets were divided into < 1 month, 1–2 months, 2–3 months, 3–6 months, and 6–12 months.

D. Results of the Scenario-Based Solvency Stress Test

47. Using the quasi-static approach, the banking system is resilient under the baseline scenario (Figure 7 and Table 5). The aggregate total capital ratio stabilized at about 19.4 percent and the leverage ratio (Tier 1 to total assets) at 9.1 percent for all sample banks during the three-year stress horizon. The slight decline in the capital ratio is mostly due to a rise in RWA and valuation losses of debt securities due to a rise in the yield under the baseline scenario. No bank faces difficulties in fulfilling the minimum requirement of capital and leverage ratio.

48. Most banks remain resilient under a severe economic downturn, but vulnerabilities were found in three small banks. Under the adverse scenario using the quasi-static balance sheet approach, all regulatory capital adequacy ratios were met in the aggregate, owing to the high starting capital ratio of the banking sector.

- Using the full Basel III regulatory requirements, the aggregate Common Equity Tier 1 (CET1) ratio would decline by 329 basis points (bps) to 14.5 percent in 2020.[38] The decline is less for core domestic banks, with a 270 bps decline to 12.4 percent, while for other banks, the decline is 564 bps resulting in a 24.3 percent CET1 ratio. One small bank would see its CET1 ratio fall below the minimum regulatory requirement of 4.5 percent in 2020, by an amount equal to 0.01 percent of GDP.
- The aggregate ratio of bank Tier 1 capital relative to RWA would decline by a similar amount with the CET1 ratio (329 bps to 14.5 percent) due to negligible additional Tier 1 capital instruments in the banking sector. Similarly, for core domestic banks, the decline is 271 bps, while for other banks, the ratio would decline by 564 bps. Two small banks would see their Tier 1 capital ratio decline below the regulatory threshold of 6 percent, with total recapitalization needs amounting to 0.13 percent of GDP.
- The aggregate bank total capital adequacy ratio (CAR) declined by 390 bps to 16.0 percent, with core domestic banks experiencing a decrease of 341 bps to 13.9 percent, while other banks see a decline of 580 bps to 26.0 percent. The decrease in the CAR is larger than the Tier 1 capital ratio due to stress test assumptions that maturing Tier 2 capital instruments during the stress test horizon are not renewed. Two small banks would see their CAR decline below the regulatory threshold of 8 percent, resulting in total recapitalization needs amounting to 0.14 percent of GDP.
- Three banks could not meet the regulatory minimum for one or more of the three capital ratios (total capital, Tier 1 capital, or CET1), with total recapitalization needs relative to GDP still manageable.[39] Higher vulnerability in these three banks mainly stems from lower starting point capital ratios and lower quality of loan portfolios, particularly in the corporate sector. Two of the banks are exposed to

[38] Even though not required by the regulatory framework, as an additional robustness check, HTM debt securities could also be stressed using the modified duration method. With this approach, the aggregate CET1 ratio would decrease to 13.2 percent, a 455 basis points decline from the CET1 ratio at end-2017. The result shows the banking system remains resilient at the aggregate level, with no additional banks failing the test.

[39] Among the three banks that failed, (i) one failed to meet CET1, T1, and total capital requirement, (ii) one failed to meet T1 requirement only, and (iii) one failed to meet the total capital requirement only. In early 2018, two of the three banks had capital injected by their owners. Based on the end-2017 balance sheets of the two banks, and under the assumption that their risk profiles remain unchanged, the capital injections already effectively address the capital deficiency detected in these banks.

property lending, both through mortgage and corporate lending to real estate and construction sectors.

- The aggregate ratio of bank Tier 1 capital relative to their total (not risk weighted) assets, i.e., the leverage ratio, would decline by 129 bps from 8.9 to 7.7 percent. There are no banks with leverage ratios below the 3 percent threshold, but one bank would see its leverage ratio very close to the threshold.

Table 5. Malta: Solvency Stress Test Results

	Average CET1 ratio in 2020 *(in percent)*			Number of banks with CET1<4.5%	Number of banks with T1<6%	Number of banks with CAR<8%	Max capital shortfall: CAR-to-GDP *(in percent)*	Average leverage ratio in 2020		
	All 11 banks	Core-domestic banks	Other banks					All 11 banks	Core-domestic banks	Other banks
Before Stress (end-2017)	17.8	15.1	29.9	0	0	0	0.0	8.9	7.3	19.0
Quasi-static approach										
Baseline	17.4	15.4	27.2	0	0	0	0.0	9.1	7.7	18.1
Adverse	14.5	12.4	24.3	1	2	2	0.14	7.7	6.3	16.2
Static approach										
Baseline	21.4	18.9	32.9	0	0	0	0.0	10.9	9.2	21.8
Adverse	15.5	13.3	26.4	0	0	1	0.02	8.2	6.7	17.5

Source: IMF staff calculations.

49. The impact of the adverse scenario on bank capital positions mainly reflects loan loss provisions, increased RWA, and valuation losses of debt securities (Figure 8).

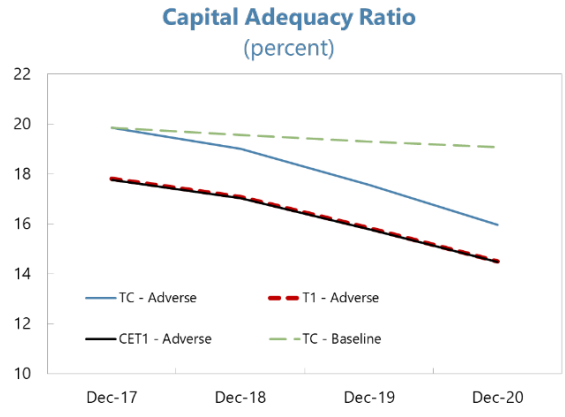
- *Credit risk* in terms of loan loss provisioning is the most significant driver for overall losses in the system, reflecting the dominance of the loan book on bank balance sheets (90 percent of RWAs), and accounting for a 506 bps decline in the CET1 ratio over the 3-year stress testing horizon.
  - For corporate loans, the increase in NPLs are mainly explained by the GDP growth in the respective geographical areas of bank exposures. In other cases, oil prices,[40] which were used to represent the GDP growth of a country where one sample bank operates, and home prices, which were used in another country for a sample bank with significant exposure to real-estate corporate lending, were significant factors in explaining the increase in the respective NPL ratios.
  - For the five banks concentrated in the domestic market, the decline in GDP growth due to external and domestic shocks was one of the significant factors contributing to the increase in corporate NPLs. In addition, the assumed decline in housing prices was also a large contributor, reflecting (i) the high share of lending to real estate and construction, and (ii) the nature of the corporate sector in Malta, which is dominated by small- and medium-sized enterprises (the major share of wealth of which is in property).[41] Other factors that also drive the NPL ratio of corporate loans were interest rates (either the annual change or level), and sovereign spreads.

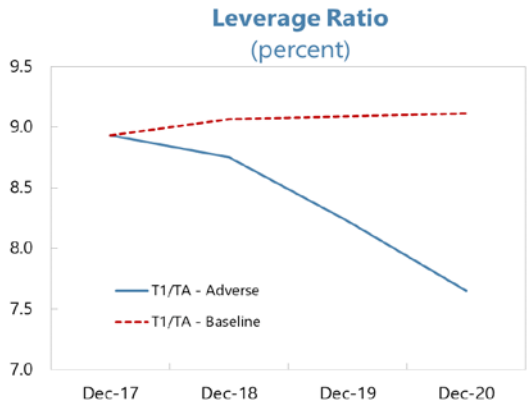
[40] In the scenario, the average oil price decline was 7.7 percent from the baseline during the three-year stress horizon, with the largest decline at 13.5 percent in the 2018.

[41] Estimate indicate that in 2015, around 99.8 percent of firms in Malta were small- and medium-sized enterprises. See "Access to Finance for Firms in Malta: Estimating the Impact of Reduced Credit" (Zerafa 2017).

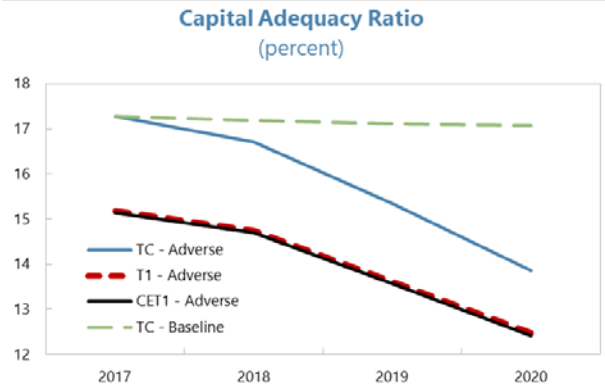
Figure 7. Malta: Results of the Top-Down Solvency Stress Test – Quasi-Static Approach

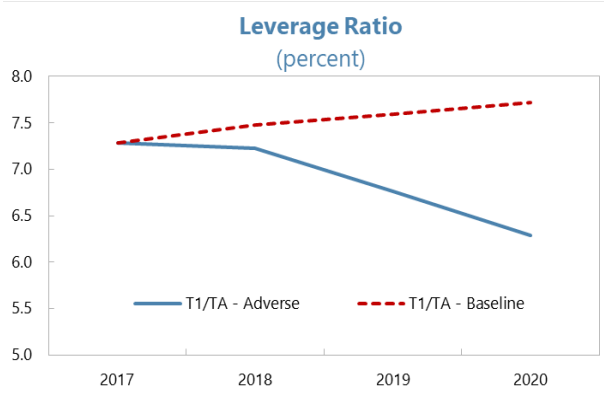
All sample banks



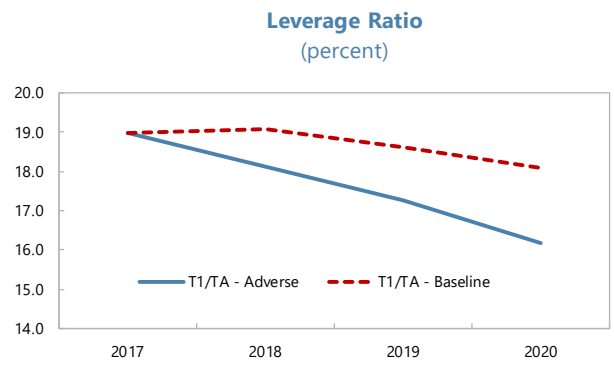


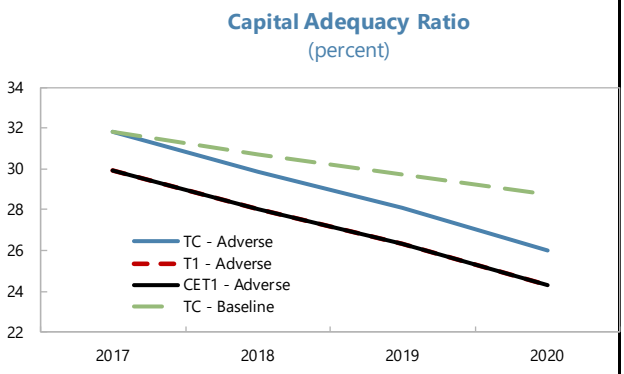
Core domestic banks





Other banks





Source: IMF staff calculations.
Note: T1= Tier 1; TC=Total Capital;

- For mortgage loans, the credit risk was sensitive to changes in housing prices, changes in the unemployment rate, and wage growth. The last two variables reflect the income effects that impact the repayment capacity of households.

- *Additional RWA*, particularly from newly classified NPLs, loan growth, and triggered off-balance sheet items reduce the CET1 ratio by 186 basis points during the three-year stress test horizon.
- *Valuation losses* on security portfolios lead to a decline in the CET1 ratio by 107 bps during the stress-test horizon. The large share of domestic and foreign sovereign debt, most of which is classified as available-for-sale, was stressed by a rise in bond yields. For debt securities issued in Malta, a shock by 120 basis points was assumed in the adverse scenario.[42]
- *Pre-provision net revenue*, including mainly aggregate NII, non-interest income, and non-interest expenses, increase the aggregate CET1 ratio by 474 bps relative to the starting point.

50. Under the static-balance sheet approach, the solvency stress test results improved, with only one small bank falling short of the minimum regulatory capital ratio. At the aggregate level, CET1 and T1 capital ratios declined by 229 bps (from 17.8 percent to 15.5 percent) while the total capital ratio declined by 286 bps (from 19.9 percent to 17.0 percent). One bank would see its total capital ratio fall below the minimum regulatory requirement of 8.0 percent, with total recapitalization needs at 0.02 percent of GDP. The leverage ratio of the banking system would decline from 8.9 percent to 8.2 percent, with no bank breaching the threshold. The difference with the result of the quasi-static approach is mostly due to the lower credit provisions, valuation losses, and RWA, which relates to the static assumption of gross loan and debt securities.[43]

E. Sensitivity Analysis

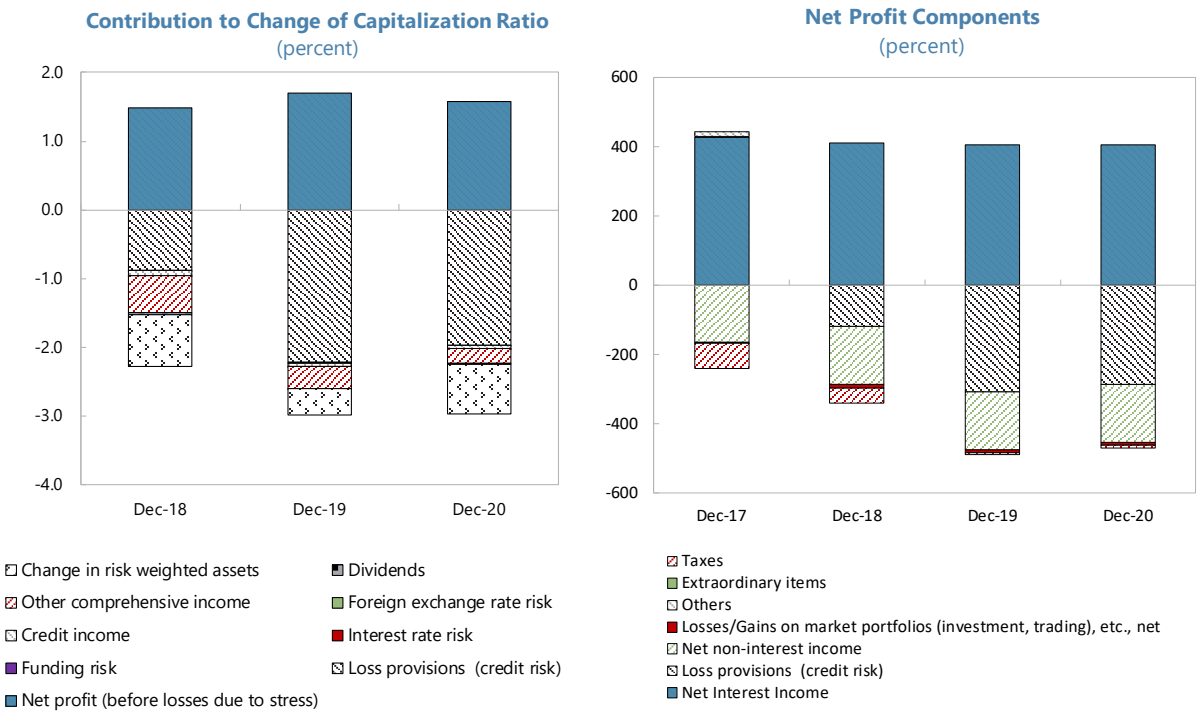
51. A range of sensitivity analysis was conducted to assess the banking system's resilience to single factor shocks. These covered the concentration of assets and the impact of interest rate shocks on bank capital and were run separately from the scenario-based stress test. The result refers to the starting point position of the banks as of end 2017 (Figure 9).

52. The concentration risk of loans was tested by assessing the impact on bank capital from the simultaneous default of their largest exposures. The single largest exposure from supervisory data was used in the test, which includes the exposure at gross and net amounts. The net exposure represents the net amount after incorporating credit mitigation techniques, such as collateral and financial guarantees. The test included household and NFC exposures, but excluded exposures to credit institutions. These are assessed separately in the section on interconnectedness and contagion risk. At the aggregate level of sample banks, the single largest exposure accounts for 15 percent of CET1. However, in three sample banks, the single largest exposure accounts for more than 25 percent of CET1 – net of credit risk mitigants and exemptions.

[42] For sovereign securities issued by other euro area members, the shocks ranged between 70 to 160 bps.

[43] Under quasi-static approach, the balance sheet growth for most banks could still be positive due to several factors, inter alia, the positive-growth of GDP in other countries and balance sheet growth recovery in the third year. Under a low interest rate environment, the net interest income from the growing assets could not balance the increase in loan loss provisions, valuation losses, and RWA, which were calculated based on the projected amount of loans in the quasi-static approach.

Figure 8. Malta: Contribution to the Results of the Top-Down Solvency Stress Test–Quasi-Static Approach
All sample banks



Source: IMF staff calculations.

53. The test also assessed bank resilience under the assumption of a simultaneous hypothetical default of the five largest borrowers of each bank. The analysis used the net amount of the exposures. The results are as follows:

- Using a zero-recovery rate, the simultaneous default of the five largest borrowers would cause the aggregate CET1 ratio of sample banks to decline by 7.1 percentage *points* – from 17.8 percent to 10.6 percent. Four banks would see their CET1 ratio decrease below the 4.5 percent threshold.

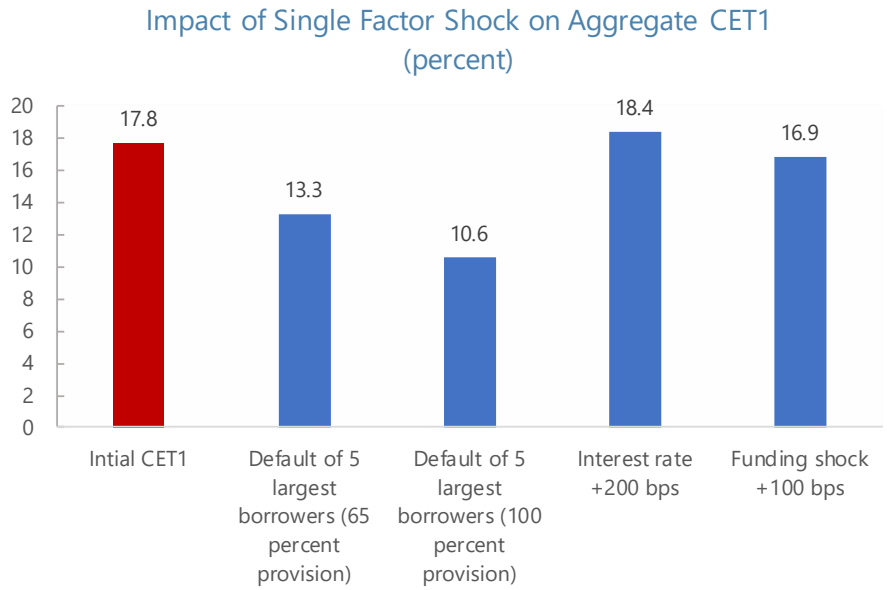
- Using a provisioning rate of 65 percent, the simultaneous default of the five largest borrowers would cause the aggregate CET1 ratio of sample banks to decline by 4.5 percentage points – from 17.8 percent to 13.3 percent. One bank would see its CET1 ratio decrease below the 4.5 percent threshold.

54. For some core domestic banks, the largest borrowers are concentrated in the construction and real estate sectors. Three core domestic banks have large borrowers whose business is in the construction and real estate sectors. Total exposure to these large borrowers ranges from 28 percent to 60 percent of the bank CET1, implying high lending concentrations to certain economic sectors.

55. The sensitivity test also captures the direct impact of "parallel yield shock" of interest rates.[44] The single factor shock of a parallel interest rate increase by 200 bps would increase the aggregate CET1 ratio by 0.6 percentage point, showing that banks are not exposed to high interest rate risks in their banking books. However, four banks would see their CET1 ratio decrease, albeit the impact is minimal. The average positive direct impact of the interest rate upward shock is due to positive repricing gap of assets and liabilities in the many sample banks, reflecting the dominance of loans with variable rate, including mortgages.

56. The single factor funding shock also showed banking system resilience. The test assumed a funding cost shock of 100 bps that translates to bank capital through increased funding cost for liabilities with repricing profiles less than one year. At the aggregate level, the CET1 ratio would decline by 0.9 percentage point, and no sample bank would breach the minimum CET1 ratio threshold.

Figure 9. Malta: Sensitivity Test of Concentration and Interest Rate Risks



Sources: CBM, IMF staff calculations, and MFSA.

F. Summary and Policy Implications

57. The Maltese banking system remains resilient under a severe economic downturn, but vulnerabilities were found in some small banks. Under the adverse scenario, the aggregate total capital ratio would decline by 390 basis points – from 19.9 percent to 16.0 percent, while the CET1 ratio would decline by 330 bps to 14.5 percent. The main contributors of the decline are credit risks, both in terms of additional loan-loss provisioning and RWA; and valuation losses on debt securities. Three small banks would not meet at least one of the minimum regulatory capital requirements, and their recapitalization needs would be 0.14 percent of GDP. The vulnerabilities in the three small banks

[44] A parallel shock refers to a shift in the yield curve. The change in yield is assumed to be the same for all maturities.

were partly due to weaker starting point capital ratios and lower quality corporate loan portfolios, particularly due to high exposure to property lending.

58. Asset concentration is relatively high in some banks, leaving them vulnerable to the credit quality of their large exposures. A sensitivity test for the default of the five largest exposures would result in the failure of three to five banks, depending on the provisioning ratio used in the test. The test also showed that in some core domestic banks, large borrowers have concentrated business in construction and real estate sectors, which historically have relatively high shares of NPLs.

59. The mission recommends addressing the vulnerabilities in the banking system and strengthening the Maltese solvency stress testing framework. The policy recommendations are based on the findings in the solvency stress tests and risk analysis and aim to strengthen the resilience of Malta's banking system. There are also some areas that warrant further supervisory and regulatory attention.

- *Conduct regular sensitivity tests for assets concentration*. The assets concentration, both in terms of individual borrowers (name concentration) and sector concentration, should be monitored periodically, including by conducting sensitivity tests. The concentration risk should be considered when determining Pillar 2 capital buffers during the ongoing Supervisory Review and Evaluation Process. This refers to our recommendation in the Technical Note on Banking Supervision.

- *Enhance data management for credit risk analysis*. Strengthening the ability to run stress tests in a timely and accurate manner requires enhanced data management, including data for credit risk analysis. In this context, the recent establishment of a Central Credit Register is welcome.

- *Enhance the CBM's macroprudential stress tests*. The current stress test coverage is appropriately based on financial stability considerations and includes all core domestic and non-core domestic banks. The development of expected loss-based credit risk models would improve the stress testing framework, in particular with the introduction of IFRS 9.

LIQUIDITY STRESS TESTS

A. Introduction

60. Top-down liquidity stress tests were conducted to assess bank capacity to withstand large withdrawals of funding under various withdrawal scenarios. The stress tests include LCR, NSFR, and cash-flow based approaches. The LCR-based stress test measured bank ability to meet short-term liquidity needs in a 30-day stress scenario by using a stock of high-quality liquid assets (HQLA).[45] The NSFR-based stress test – was used to gauge structural longer-term refinancing and funding risks (although the NSFR limit is not yet mandatory). The cash-flow approach looked at

[45] See Basel Committee on Banking Supervision (2013), "Basel III: The Liquidity Coverage Ratio and Liquidity Monitoring Tools," January 2013.

maturity buckets and provided a more granular analysis on the availability of bank counterbalancing capacity to cover net-cash outflows resulting from assets and liabilities with different maturities.

61. The liquidity risk analysis used multiple data sources for the stress test. The LCR and NSFR-based stress test approaches were based on COREP reports for end-2017, while the cash-flow stress test approach was based on COREP reports for end-March 2018.[46] To complement the tests, data on resident and non-resident deposits was also taken from MFSA Banking Rule (BR) 06 reports provided by CBM.

62. The liquidity stress test used different thresholds. The LCR-based stress test used an 80 percent threshold, which is the minimum regulatory LCR as of end-2017, while the NSFR-based stress test used a 100 percent threshold, as a forward-looking exercise. The cash-flow based stress test used the amount of counterbalancing capacity as the threshold to assess the resilience of banks, with negative amounts indicating bank failure in the test.

B. Liquid Assets and Funding Structure

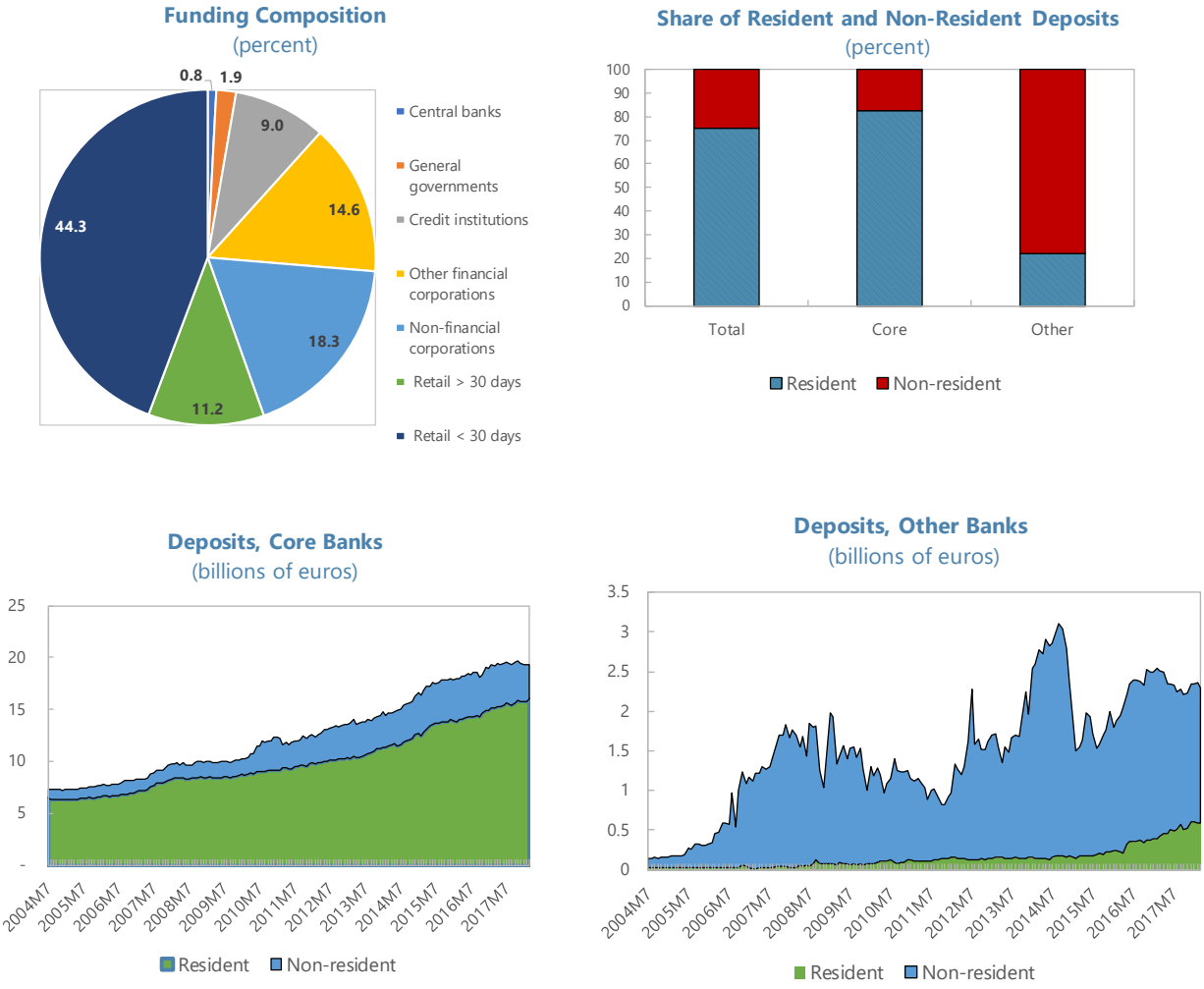
63. The starting point showed that the banking system had ample liquidity buffers. The system-wide loan-to-deposits ratio was only 41 percent, with 58 percent for core domestic banks and 39 percent for other banks. A higher share of excess liquidity was placed in the central bank and debt securities, which account for 46 percent of total deposits of the sample banks. This suggested a high share of liquid assets in the LCR calculation (Figure 10).

64. Funding mostly consists of household deposits with high concentration in short-term maturities. Funding sources are dominated by household funding, which under the LCR reporting standard is classified as retail deposits.[47] Most retail deposits have no specific maturity and are therefore reported as deposits with maturity less than 30 days. As the banking system is exposed to international markets, a share of funding comes from non-resident deposits, with an increasing trend during the last five years. Vulnerabilities in funding comes from the short-term funding maturities and high reliance on non-resident deposits, which historically are less stable than resident deposits.

[46] This is related to the availability of the data for all banks in the sample.

[47] According to CRR and Article 3(8) of the Regulation 2016/61 on Liquidity Coverage Ratio, "retail deposit" means a liability to a natural person or to an SME, where the natural person or the SME would qualify for the retail exposure class under the Standardized or IRB approaches for credit risk, or a liability to a company which is eligible for the treatment set out in the European Banking Authority's Article 153(4) and where the aggregate deposits by all such enterprises on a group basis do not exceed 1 million euro.

Figure 10. Malta: Funding Structure of Sample Banks



Sources: CBM, MFSA, and IMF staff calculations.

C. LCR-Based Liquidity Stress Test

65. Retail funding, which is treated as more stable from an LCR perspective, accounts for 50 percent of core domestic bank total funding (Figure 11).[48] For other banks, retail deposits account for 19 percent of total funding, which reflects more reliance on wholesale deposits.

66. Despite having a lower share of retail deposits, the group of other banks has higher LCR. Other banks have group-wide LCR at 201 percent, which is higher than the core domestic

[48] Total funding here only covers funding that is subject to outflows in the LCR calculation, which are sources below 1-month maturity.

banks at 188 percent. This is partly due to the higher share of HQLA in other banks (53 percent of total funding) than in core domestic banks (41 percent of total funding).

67. The HQLA of all sample banks are concentrated in HQLA level 1, which indicate high levels of liquidity. HQLA level 1 comprised 88 percent of total HQLA. Placement in the central bank and holdings of sovereign securities are the largest portion of HQLA, accounting for 46 percent and 32 percent of total HQLA, respectively.

68. The LCR-based stress test was conducted using four scenarios. These included a baseline and three adverse scenarios tailored to the characteristics of liquidity practices in Maltese banks:

- *The standard LCR scenarios (baseline scenario, B)* applies the same parameters as set out by the CRR. This is carried out at the aggregate currency level, both for total and foreign currencies.

- *The retail and wholesale scenario (scenario S1)* apply higher run-off rates for retail and wholesale deposits. The run-off rates were calibrated using the historical data of deposits and withdrawals in the Maltese banking sector. Under this scenario, banks could use their liquid assets with no additional decline in the market value (the haircut follows the CRR parameters).

- *The retail and wholesale scenario with declining market value in liquid assets (scenario S2)* is similar to the previous scenario, where large withdrawals of retail and wholesale deposits are assumed. However, in this scenario banks also need to liquidate liquid assets to meet withdrawals requests. The liquid assets haircut includes the market value decline, which was derived from the solvency stress tests, and also incorporates the ECB valuation haircut when banks need to repo the liquid assets to the central bank.[49]

- *The retail and wholesale scenario, combined with higher withdrawals of non-resident deposits (scenario S3),* assumes higher run-off rates for non-resident deposits to incorporate the less stable nature of this type of deposit. Banks could cover the withdrawals by liquidating their liquid assets – with additional haircuts from market value declines and an ECB haircut. A summary of scenario assumptions is presented in Appendix VI.

69. Result of the standard (baseline) LCR-based stress test showed that Maltese banks have ample liquidity buffers (Figure 12). All sample banks meet the minimum threshold of 80 percent at end-2017.[50] The aggregate LCR of sample banks shows a decreasing trend over the last six quarters, but still comfortably above the minimum threshold. The aggregate LCR stood at 190 percent with the median around the same number. Only one bank has a LCR below 100 percent but is still higher than the 80 percent minimum limit as of December 2017.

70. The adverse scenario of LCR-based stress test suggests that most sample banks are resilient to stress liquidity conditions, but some banks show vulnerabilities. In the first scenario,

[49] The haircut is mapped into the type of securities of each bank according to Guideline (EU) 2018/571 of the European Central Bank of February 7, 2018.

[50] European Commission Delegated Regulation (EU) 2015/61 phased in the LCR, from 80 percent in 2017 to 100 percent in 2018.

which is the combination of retail and wholesale funding liquidity events, the aggregate LCR would decline to 146 percent. In the second scenario, the funding shocks together with the decline in market value of liquid assets would reduce the aggregate LCR to 142 percent. All sample banks continue to meet the minimum 80 percent regulatory threshold, but three banks approach the threshold. When testing for additional withdrawals of non-resident deposits, the sample bank LCR declines further to 121 percent, with three banks failing the test – which is attributed to the relatively high reliance on wholesale and non-resident deposits.[51] The total liquidity shortfall for the three banks was 0.7 percent of GDP.[52]

71. An LCR-based stress test was also conducted for several major foreign currencies. Using similar assumptions as in the baseline scenario with total currencies stress test, including the 80 percent threshold as the minimum requirement, a separate LCR-based stress test was conducted on bank foreign currency positions. Banks are not required to meet a foreign currency financial threshold, but the exercise was carried out for robustness reasons. There are seven banks that potentially face large cash outflows in U.S. dollars and four in British pounds.

72. The LCR-based stress test for foreign currencies suggests that four banks would struggle to meet cash outflows in foreign currencies.

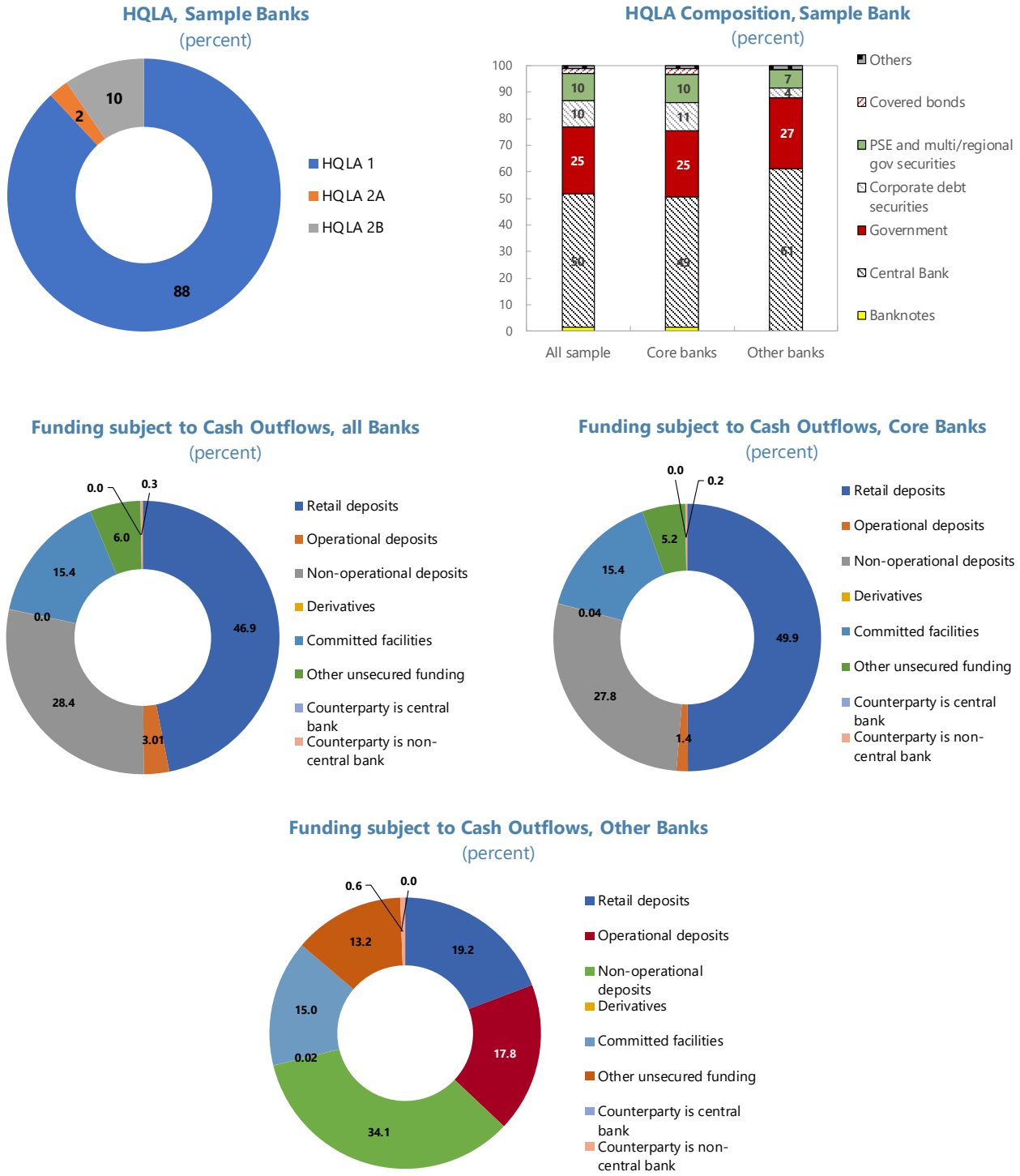
- The aggregate U.S. dollar-LCR of sample banks would decline from 84.1 percent to 56.5 percent in the adverse scenario that incorporates additional cash-outflows of non-resident deposits in dollars. Out of seven banks in the sample, three banks struggle to meet the foreign cash flow in all stress scenarios, and even under the baseline scenario.

- With similar assumptions and scenarios, the aggregate British pound-LCR of sample banks would decline from 156 percent to 105 percent. One of four banks in the sample struggles to meet the 80 percent minimum threshold for all scenarios, including the *baseline*. Funding in pounds amounts to 14 percent of total funding for this bank.

[51] Besides the three banks with LCRs below 80 percent, there are two other banks with LCRs slightly above 100 percent.

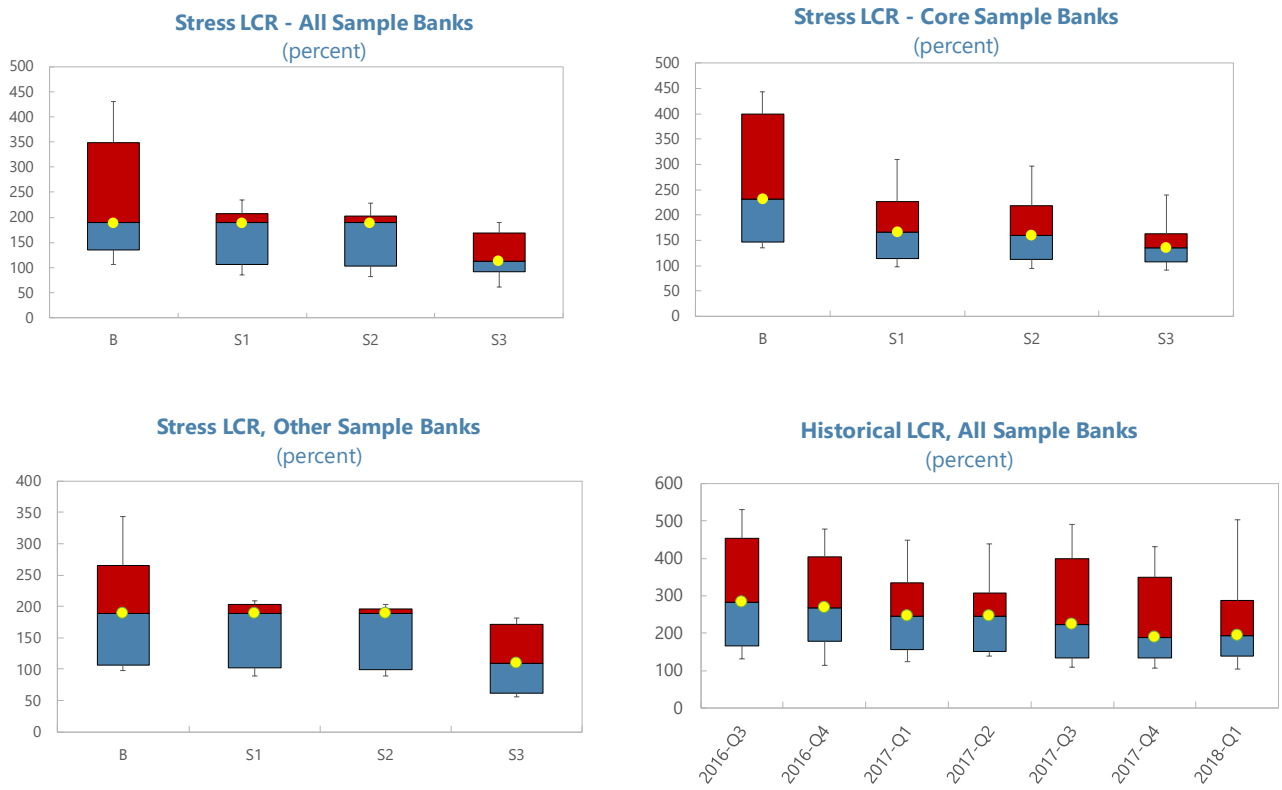
[52] Using a minimum threshold of 100 percent, effective in January 2018, the shortfall would be 1.6 percent of GDP.

Figure 11. Malta: HQLA and Cash Outflows



Sources: CBM, MFSA, and IMF staff calculations.
Note: HQLA: High Quality Liquid Assets

Figure 12. Malta: Results of the LCR-Based Stress Test



Source: IMF staff calculations.

Notes: B = baseline stress test. S1-S3 are the three adverse scenarios described above.

D. NSFR-Based Liquidity Stress Test

73. Two scenarios were considered in the NSFR-based test. The scenarios are consistent with the ones in the LCR-based tests: (i) a *baseline scenario*, which assumes regulatory parameters; and (ii) an *adverse scenario* consistent with that in the LCR-based tests and solvency stress tests. The *adverse scenario* assesses bank capacity to maintain stable funding during a stressed macro financial setup.

74. With the baseline scenario, most banks are well placed regarding implementation of NSFR (Figure 13). At end-2017, the aggregate available stable funding of sample banks was €19.1 billion, and the required stable funding was €11.9 billion. As a result, aggregate NSFR of sample banks stood at 160 percent, comfortably above the minimum requirement of 100 percent. Nevertheless, one core domestic bank saw NSFR below the threshold. The total funding gap for this bank was €681 million.

75. The relatively high ratio of aggregate NSFR under the baseline scenario reflects the high share of retail deposits, which are treated as more stable under the NSFR regulatory framework. The retail deposits and tier 1 capital, both treated as more stable funding, holds

72 percent of total available stable funding. On the required stable funding side, loans and HQLA assets hold the majority of required stable funding with 58 percent and 35 percent, respectively. The high share of HQLA assets also reflects the lower needs of available stable funding.

76. In the adverse scenario, one additional bank would struggle to maintain a stable funding profile. The adverse scenario assumed: (1) higher rates for required stable funding for retail and wholesale deposits, which under the LCR-based test received a higher run-off rate, (2) higher rates for required stable funding for loans due to an increase in credit risk, and (3) pressure in the market that reduces the market value of liquid assets, implying the need for more stable funding. Under this scenario, the aggregate NSFR would decline to 130 percent, with one additional bank finding its NSFR ratio below 100 percent threshold. The total stable funding gap for the two small banks would be €992 million (€311 million, in addition to the baseline shortfall) and equivalent to 8.9 percent of GDP or 3.8 percent of total sample bank assets.

E. Cash Flow-Based Liquidity Stress Test

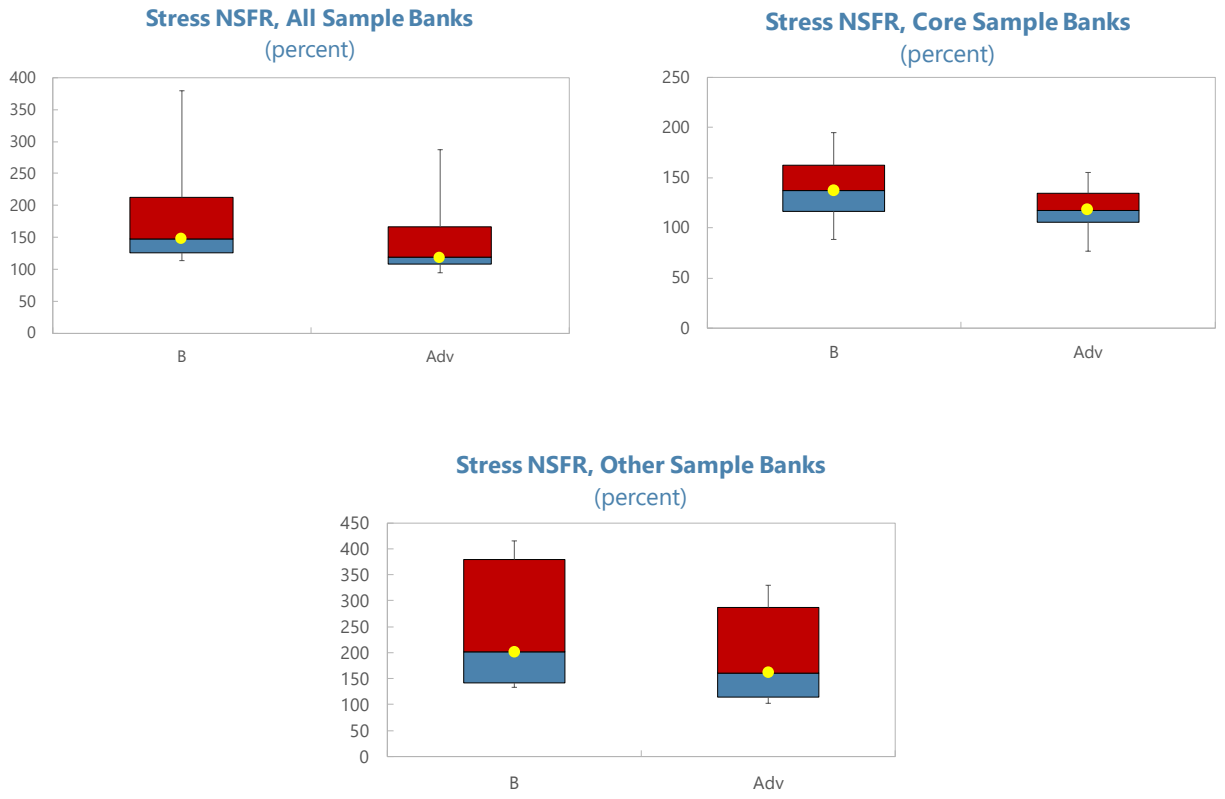
77. The cash-flow based analysis assesses bank resilience to liquidity risk based on net cash balances after funding outflow shocks. If banks experience negative cash balances after utilizing their counterbalancing capacity, they would face a liquidity shortfall and would not be able to meet deposits withdrawals. The net cash balance is the sum of cash positions, counterbalancing capacity, and cash inflows.

78. The cash-flow based liquidity stress test is based on the maturity ladder in the COREP report of March 2018. The COREP template reported contractual cash outflows and inflows based on 21 maturity buckets, from overnight to greater than 5 years. The template also classifies the source of outflows and inflows, both from the perspective of secured or unsecured funding/lending and the type of counterbalancing capacity.

79. The data captures the contractual maturity profile of assets and liabilities (Table 6). About 71 percent of total outflows is below 30 days, with open maturity deposits holding about 66 percent of total outflows. Retail deposits are the largest contributor for short-term funding. For inflows, 74 percent of total inflows is concentrated in buckets longer than 30 days. This implies that banks will rely on the counterbalancing capacity from liquid assets to meet funding shocks for short-term periods. It is also important to note that:

- More than 82 percent of total corporate and retail loans have residual maturities more than 12 months.
- Among total retail and wholesale deposits of the sample banks, 24 percent are non-resident deposits, mostly (85 percent) in current and savings accounts that have open maturities.

Figure 13. Malta: Results of the NSFR-Based Stress Test



Source: IMF staff calculations.
Note: B= baseline scenario; Adv = adverse scenario.

80. Counterbalancing capacity includes bank liquid assets and committed lines from other counterparties. In the cash-flow based stress test, banks would be able to obtain additional cash by selling liquid assets in the markets or through repo operations with the central bank. In addition to the market price declines taken from the solvency stress test, ECB haircuts were applied to measure the value of liquid assets more conservatively. Total cash reserves in the central bank, and marketable securities accounted for about 80 percent of total counterbalancing capacity.

81. Outflow and inflow pressures were captured using some general principles. First, better informed and sophisticated depositors withdraw funding more rapidly than less informed depositors. This is reflected in higher run-off rates for wholesale funding sources compared to retail funding sources. Second, run-off rates on secured funding sources are lower than unsecured funding sources. Third, different run-offs for non-resident deposits was assumed to capture liquidity vulnerability from this type of deposit. Fourth, the inflow parameters are in principle 100 percent of contractual inflows, except for inflows from loans to retail and corporate customers (50 percent). This is in line with the assumption that banks will continue business as normal and cause no significant business disruptions to the real economy.

Table 6. Malta: Contractual Cash Flows

(percent)

Indicators	Total	Overnight	Greater than overnight up to 2 days	Greater than 2 days up to 3 days	Greater than 3 days up to 4 days	Greater than 4 days up to 5 days	Greater than 5 days up to 6 days	Greater than 6 days up to 7 days	Greater than 7 days up to 4 weeks	Greater than 1 months up to 3 months	Greater than 3 months up to 6 months	Greater than 6 months up to 12 months	Greater than 12 months
LT Unsecured issurance	51.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.12	0.38
Secured issuance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ST paper due	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Repo's against 0 percent RW securities	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Repo's against 20 percent RW securities	0.09	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Repo's against covered bonds	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.21	0.00	0.00
Repo's against corporate bonds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Repo's against RMBS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Repo's against other CB eligible assets	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Repo's against non-CB eligible assets	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Retail deposits	42.25	28.91	0.00	0.52	0.03	0.04	0.01	0.03	0.98	1.97	2.37	3.66	3.73
Corporate deposits	18.42	16.64	0.00	0.01	0.00	0.07	0.01	0.00	0.09	0.37	0.78	0.33	0.12
Central bank deposits outflows	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Credit Institutions	2.92	0.42	0.00	0.12	0.00	0.03	0.00	0.00	0.19	0.69	0.33	0.08	1.08
Other financial institutions	4.00	2.94	0.00	0.07	0.01	0.00	0.00	0.00	0.06	0.20	0.29	0.33	0.11
Other dep. Outflows	20.05	15.63	0.00	0.05	0.01	0.02	0.00	0.01	0.33	0.67	0.87	1.55	0.92
FX-swap outflows	4.28	0.00	0.00	0.35	0.04	0.14	0.01	0.13	0.85	2.09	0.37	0.27	0.01
Derivative outflows	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Other outflows	3.53	0.41	0.01	0.00	0.04	0.01	0.00	0.01	0.50	0.75	0.24	0.43	1.14
Total	100.00	66.08	0.01	1.13	0.12	0.41	0.04	0.17	3.10	7.14	6.21	6.87	8.72

Indicators	Total	Overnight	Greater than overnight up to 2 days	Greater than 2 days up to 3 days	Greater than 3 days up to 4 days	Greater than 4 days up to 5 days	Greater than 5 days up to 6 days	Greater than 6 days up to 7 days	Greater than 7 days up to 4 weeks	Greater than 1 months up to 3 months	Greater than 3 months up to 6 months	Greater than 6 months up to 12 months	Greater than 12 months
Rev. Repo's against 0 percent RW securities	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Rev. Repo's against 20 percent RW securities	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.30
Rev. Repo's against covered bonds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rev. Repo's against corporate bonds	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.17
Rev. Repo's against RMBS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rev. Repo's against other CB eligible assets	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Rev. Repo's against non-CB eligible assets	4.56	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.27	4.22
Retail inflows	25.14	0.74	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.26	0.28	0.49	23.32
Corporate inflows	24.65	3.00	0.02	0.01	0.03	0.01	0.00	0.00	0.24	0.95	0.71	1.87	17.81
Credit Institutions inflows	8.51	2.04	0.01	2.83	0.57	0.12	0.00	0.00	0.77	0.36	0.06	0.53	1.23
Other financial institutions inflows	1.43	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.07	0.09	0.10	0.75
Central bank deposits inflows	12.34	12.11	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other dep. Inflows	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.07	0.47
FX-swap inflows	5.54	0.00	0.00	0.44	0.05	0.19	0.02	0.04	1.06	2.60	0.47	0.65	0.02
Derivative inflows	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other inflows	16.66	0.66	0.01	0.02	0.00	0.00	0.00	0.00	0.65	0.69	0.73	1.89	12.01
Total	100.00	18.88	0.03	3.55	0.65	0.32	0.02	0.05	2.90	4.96	2.46	5.88	60.30

Source: IMF staff calculations.

Note: RMBS = residential mortgage-backed securities.

82. In setting the parameters of the stress conditions, some empirical evidence was collected from various countries, regulatory approaches, and literature.[53] The run-off parameters in LCR-based stress testing are also considered in setting test parameters. Here are several examples of past extreme magnitudes of runs on funding:

- *In 1 week*, withdrawal of 7.5 percent of deposits from IndyMac (United States) in June 2008; 8 percent from the Spanish banking system in 1994; and 11 percent from the Saudi Arabian banking system in August 1990;

[53] This is based on BCBS (2013a, 2013b, 2013c), Schmieder et al. (2012), and Schmitz (2015).

- *In 10 days*, withdrawal of 8.5 percent of customer deposits from Washington Mutual (United States) in September 2008;
- *In 12 days*, withdrawal of 30 percent of customer deposits from DSB Bank (Netherlands) in 2009;
- *In 3 months*, withdrawal of 25 percent of customer deposits from Parex Bank (Latvia) in 2008;
- *In 9 months*, withdrawal of 30 percent of customer deposits from the Argentinian banking system in 2001; and
- *In 1 year*, withdrawal of 57 percent of customer deposits from Northern Rock (United Kingdom) in 2007.

The details of the liquidity stress test parameters for Malta–run-off, roll-off, and the market value haircut–are presented in Appendix VI. The market value decline assumption is consistent with solvency-based stress testing and referred to the haircut in LCR-based stress testing.

83. To account for uncertainty, which is an integral part of liquidity stress testing, a cash-flow-based test was conducted for two scenarios for different time horizons. Two time horizons were used: one month and three months. The difference between the two time horizons is in the run-off of non-resident deposits. To test the resilience of the banking system liquidity under severe conditions, a test over 5 days was also conducted. This assumed that banks will rely more on liquid assets to meet the deposit run-off. The scenarios are differentiated by the severity of the stress test:

- Scenario 1 assumed large withdrawals of retail and wholesale deposits. It includes an additional run-off for non-resident deposits and assumes a decline in market value of liquid assets. An ECB haircut was also assumed on top of the market value decline.
- Scenario 2 makes the same assumptions, but also assumes that the counterbalancing capacity excludes committed lines from intragroup or other counterparty, and only includes cash, reserves in the central bank, and debt securities.

84. The results of the cash-flow-based test suggest that most banks are resilient to net funding gaps, but several small banks show vulnerabilities.

- For the 1-month time horizon under scenario 1, all banks except two would be able to meet cumulative funding gaps. The total liquidity shortfall of the two banks would be 0.7 percent of total sample bank assets, or 1.8 percent of GDP. Under scenario 2, no additional banks would fail the test, and the total liquidity shortfall of the two banks would be 0.8 percent of total sample bank assets, or 1.9 percent of GDP.
- For the 3-month time horizon under scenario 1, all banks except two would be able to meet cumulative funding gaps. The total liquidity shortfall of the two banks would be 1.1 percent of total sample bank assets, or 2.7 percent of total GDP. Under scenario 2, the two banks would still

fail the test, with total liquidity shortfall increasing to 1.2 percent of total sample bank assets or, 2.8 percent of GDP.

- An analysis of the 5-day horizon of scenario 1 would see three banks failing the test. The total shortfall of the three banks would be 0.4 percent of total sample bank assets, or 0.9 percent of GDP. Under scenario 2, the total shortfall of the three banks would be 0.4 percent of total funding assets, or 1.0 percent of GDP.

85. The cash flow-based test confirmed the LCR-based stress test results. The stress tests based on cash-flow and LCR point to the banking system's vulnerability to the substantial shares of short-term deposits, including deposits with open maturity. Some banks that rely on wholesale funding and non-resident deposits would be vulnerable under this stress scenario.

86. The robustness of the liquidity stress test relies on data reported by banks. The reporting of resident and non-resident deposits is currently based on the residency of the depositors. There are also cases when depositors are domestic legal entities but owned by non-resident counterparts. This type of depositor is excluded from non-resident deposits, which means they are not captured in the stress test. Importantly, the quality of data reporting for liquidity risk should be continually reviewed by the authorities. With the NSFR about to be implemented, and maturity ladder reporting underway since March 2018, the authorities should start to regularly verify the quality of bank reporting, including cross-checking with the other reporting templates.

F. Funding Concentration

87. A separate test of sensitivity to funding concentration was conducted. This test aimed to test for bank sensitivity to concentration of large depositors and concentration of deposits from certain sectors of economy.

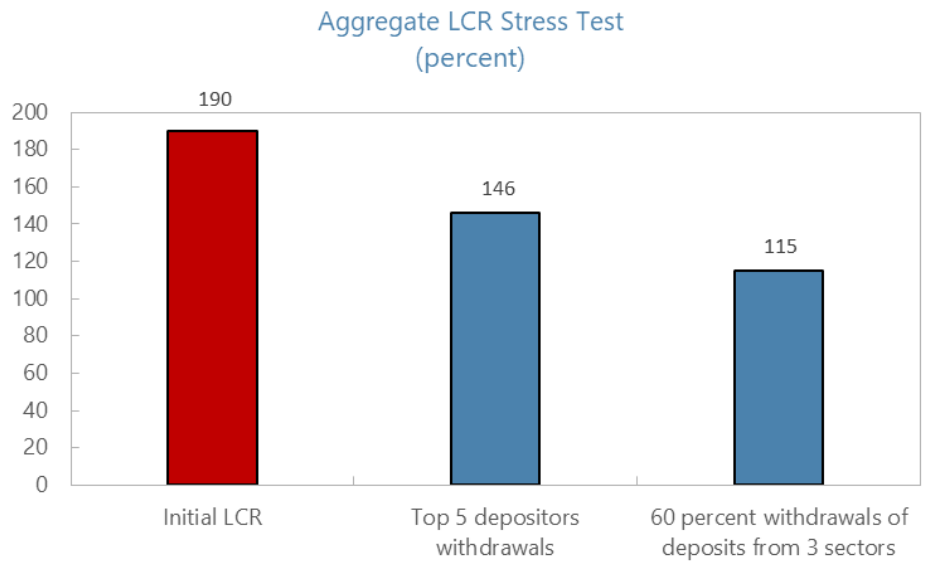
88. The sensitivity test to large depositors assumed simultaneous funding withdrawals of the top five depositors, which include household and nonfinancial corporates.

- The deposits from credit institutions were excluded and were analyzed separately in the interconnectedness and contagion analysis. Intragroup funding was also excluded on the assumption that such funds are controllable at the group level.
- The sensitivity results show that banking sector LCR would decline from 190 percent to 146 percent due to the withdrawal of the top five depositors (Figure 14). Three small banks would see their LCRs fall below the regulatory minimum of 80 percent, implying their high concentration of funding. The total liquidity shortfall of the three banks is estimated at 3 percent of GDP.

89. The sensitivity test also looked at 60 percent withdrawals of deposits from three important sectors of the economy. To determine banking system resilience to sudden withdrawals of such deposits, three sectors were selected for the test: (i) arts, entertainment, and recreation (including the gaming sector), (ii) accommodation and food service, and (iii) the financial sector. A funding shock of 60 percent of total deposits from these sectors was assumed. The results showed that the aggregate LCR of sample banks would still exceed the threshold of 80 percent, even though

it would decline significantly by 75 percentage points from 190 percent to 115 percent. Three banks would see their LCR below the threshold, with liquidity shortfalls totaling 0.9 percent of GDP.

Figure 14. Malta: Funding Concentration Sensitivity Test



Sources: CBM, MFSA, and IMF staff calculations.

G. Summary and Policy Implications

90. The liquidity stress test suggests that most sample banks are resilient to short-term liquidity pressures, but some banks showed vulnerabilities. At the aggregate level, excess liquidity in the banking system helps the sample banks remain resilient to liquidity shocks. However, the reliance of some banks on wholesale deposits of residents and retail and wholesale deposits of non-residents becomes the vulnerability point of these banks. An adverse event that combines large withdrawals of wholesale and non-resident deposits would cause some small banks to fail both LCR and cash flow-based stress tests. The LCR-based stress test for foreign currency also shows some banks fail the test, even under the baseline scenario.

91. A NSFR-based liquidity stress test showed that most sample banks do not have structural longer-term liquidity risk. Among the reasons are the relatively high capital and share of retail deposits (a more stable funding source under the NSFR regulatory framework) of Maltese banks. On the required stable funding side (including the assets and off-balance sheet items), the high share of HQLA explained the low requirement for stable funding. Only few small banks would struggle to meet the requirement, which is partly due to their high share of mortgage and long-term corporate loans that required high stable funding.

92. Some banks rely heavily on funding from a few large depositors. This leads to a high risk of funding concentration. The sensitivity test for the funding withdrawals of the five largest household and corporate depositors would cause the LCR of three banks to fall below the 80 percent threshold. A similar test for large withdrawals of depositors from certain economic sectors would also result in the failure of three banks.

93. To address the vulnerabilities in the banking system, this technical note provides some policy recommendations. The recommendations below are based on the findings in the liquidity stress tests and risk analysis and are aimed to strengthen the resilience of Malta's banking system.

- *Strengthen the liquidity stress test framework by incorporating some additional features, e.g., different run-off rates for resident and non-resident deposits, liquidity tests by currencies, and liquidity tests for longer-time horizons*. The liquidity stress test that applies different run-offs for resident and non-resident deposits would better capture the vulnerabilities from non-resident deposits, which are naturally less stable than resident deposits. Liquidity stress tests by each major currency is also needed to measure the adequacy of liquid buffers to meet funding withdrawals in certain currencies under FX market illiquidity. Finally, liquidity stress tests for a longer time horizon (e.g., using maturity ladders) could be useful to identify vulnerabilities in liquidity risk under severe conditions.

- *Conduct regular sensitivity tests for certain vulnerabilities in liquidity.* The reliance on large depositors could cause severe liquidity pressure for some banks. A regular sensitivity test could be useful to gauge and detect potential shifts in systemic risk, e.g., an early identification of the increase in deposit concentration risk in the banking system.

- *Enhance the data management system for liquidity stress-testing and prepare for the implementation of NSFR*. The quality of data on liquidity risk is crucial to the liquidity stress test. Regular checks on bank liquidity reports – for example, the LCR, NSFR, and the maturity ladder, including cross-checking among other reports (FINREP, COREP, and MFSA Banking Rule 06) – could be a good starting point to maintain the quality of liquidity stress tests. Authorities should also ensure bank readiness for the upcoming NSFR implementation, particularly for banks identified as vulnerable in the NSFR-based stress test.

INTERCONNECTEDNESS ANALYSIS

94. Spillover and contagion risks are examined from both a cross-sectoral and cross-border perspective, based on supervisory and market information. The impact of international shocks on financial stability in Malta is considered by mapping cross-border exposures of banks with their banking counterparts outside Malta. At the domestic level, the analysis focuses exclusively on cross-sectoral interconnectedness among banks, domestically-relevant insurers, and domestically-relevant funds.

95. The assessment of contagion risks is conducted mainly using model-based simulations applied to bilateral exposures. The balance sheet-based network analysis follows the CoMap framework (Covi, Gorpe, and Kok 2019), which extends the simple bank network model of Espinosa-Vega and Sole (2011) using granular supervisory data. It advances the simple interbank exposure model with credit and funding shocks by incorporating bank and exposure-specific parameters and liquidity dynamics that reflect heterogeneity across entities. These features make the framework adaptable to assessing the interlinkages between different sector players as their heterogeneities can be accounted for. In addition, a complementary market-based analysis employs the Diebold-Yilmaz (2014) methodology, deriving pair-wise net spillovers on equity returns to capture market perception of risks. It is important to note that the market-based analysis covers only four Maltese banks that are listed on the stock exchange and could be affected by low market activity.

96. The rest of the chapter is organized along these complementarities. The first section centers on bank-to-bank bilateral exposures while expanding the scope to cross-border linkages with non-Maltese banks. The next section adds insurers and funds to the banking network while limiting the focus to the domestic financial system. The third section complements these analyses with a market-based approach aimed at net spillovers to Malta. After performing robustness checks and discussing important caveats, the chapter concludes with a summary and policy recommendations.

A. Network Analysis of Interbank Exposures and Contagion Risk

97. The balance sheet-based network analysis first focuses on the interbank exposures within Malta and with non-Maltese entities. The bilateral linkages between banks can lead to widespread contagion originating from a shock on a single entity (e.g., from a tail event). For a banking system with the presence of both primarily domestically-oriented banks and more diversified internationally-oriented banks, it is important to understand whether the interaction of bank business models may lead to propagation of shocks with repercussions for financial stability. In particular, incorporating cross-border exposures can shed light onto whether systemic events in Malta have a domestic or international origin.

98. Contagion risks are appraised using the CoMap framework (see Appendix VII). It includes a stylized credit shock simulation, where one credit counterparty defaults at a time, and a funding shock, where a counterparty default may induce a liquidity shortfall. It incorporates liquidity dynamics by considering each entity's liquidity surplus, liquidity constraint, and quality of assets to determine the most appropriate "fire sale" discount rate. It captures the contagion risks to the rest of the network through the hypothetical default of each bank – both in terms of contagion defaults, driven either by insolvency or illiquidity, and in terms of losses across the network. The model informs about potential cascading defaults and amplification effects. Detailed counterparty-level exposure data reported by 21 Maltese banks (6 core and 15 other) as of December 2018 allow for a coverage of total 78 banks, of which 58 are significant banking counterparts domiciled outside Malta. Since the construction of the matrix of bilateral exposures is limited to the supervisory data provided only by Maltese banks, its focus is Malta-centric.

99. The network analysis is comprehensive. It makes extensive use of supervisory data – large exposures and additional liquidity monitoring metrics and other granular supervisory data – to capture various bank characteristics for parameter calibration. It expands the coverage of interbank networks to incorporate bilateral cross-border linkages vis-à-vis non-Maltese banks. Finally, it maps contagion based on an advanced analytical framework that is tailored for EU supervisory reporting requirements and introduces two highly-sought features: bank- and exposure-specific model parametrization and liquidity dynamics.

Stylized Facts

100. Aggregated credit and funding exposures reveal different patterns in cross-border linkages for core and other banks. A panel of heatmaps illustrates the relative importance of large exposures by geography and by sector as well as their concentration (Figure 15).

- Other banks report large exposures to the tune of about 83 percent of their total assets. For core *banks*, the concentration of large exposures is much lower, constituting only about 43 percent of total assets. Although the decomposition of their large exposures varies across sectors, interbank exposures represent similar shares for core and other banks (21 and 24 percent, respectively). While the majority interbank credit exposures for core banks is domestic (10 percent), exposures to non-Maltese euro area banks for other banks dominate (16 percent), followed by those vis-à-vis non-euro area banks (7 percent).

- On the liabilities side, the contribution of large funding sources is significantly lower (10 and 42 percent of the liabilities of core and other banks, respectively). However, of the funding *exposures*, interbank linkages make up the largest share, reaching 45 and 44 percent, respectively. On the funding side, the largest funding sources for core domestic banks are from within the euro area (39 percent) while other banks mostly rely on non-euro area banks (31 percent).

- These aggregate patterns signal potential sources and channels of contagion risk for Maltese banks. Other banks are likely to face more contagion risks compared to core banks given their significantly higher concentration of large exposures. Credit shocks seem to dominate funding shocks as the main transmission channel of potential contagion. Last, but not least, cross-border *exposures* are expected to play a critical role for other banks. From a systemic perspective, this risk might be moderated given that total assets of other banks are about one-fourth of the total assets of core banks.

Figure 15. Malta: Decomposition of Bank Credit and Funding Exposures

Large credit exposures by orientation and sector

(percent of total large exposures in respective group)

Core banks

	Banks	CB	Other FIN	GOV	NFC	total
Domestic	10%	36%	0%	25%	9%	81%
Intra-EA	6%	0%	0%	5%	1%	12%
RoW	4%	0%	0%	1%	0%	6%
total	21%	36%	1%	32%	11%	

Coverage: 43% of total assets of core banks

Other banks

	Banks	CB	Other FIN	GOV	NFC	total
Domestic	1%	14%	0%	9%	0%	25%
Intra-EA	16%	0%	10%	3%	12%	41%
RoW	7%	0%	4%	5%	17%	34%
total	24%	14%	14%	17%	30%	

Coverage: 83% of total assets of other banks

Large funding exposures by origin and sector

(percent of total large funding sources in respective group)

Core banks

	Banks	CB	Other FIN	NFC	total
Domestic	6%	5%	19%	23%	52%
Intra-EA	39%	0%	8%	0%	48%
RoW	0%	0%	0%	0%	0%
total	45%	5%	28%	23%	

Coverage: 10% of total liabilities of core banks

Other banks

	Banks	CB	Other FIN	NFC	total
Domestic	0%	1%	11%	3%	16%
Intra-EA	13%	0%	7%	16%	37%
RoW	31%	0%	8%	9%	48%
total	44%	1%	26%	29%	

Coverage: 42% of total liabilities of core banks

Sources: Maltese authorities and IMF staff estimates.

Note: CB: Central Bank; GOV: Government; Other FIN: Non-bank financial entities; NFC = non-financial corporations. The percent shares in these tables are rounded up and thus the subtotals may not add up to 100 percent, exactly.

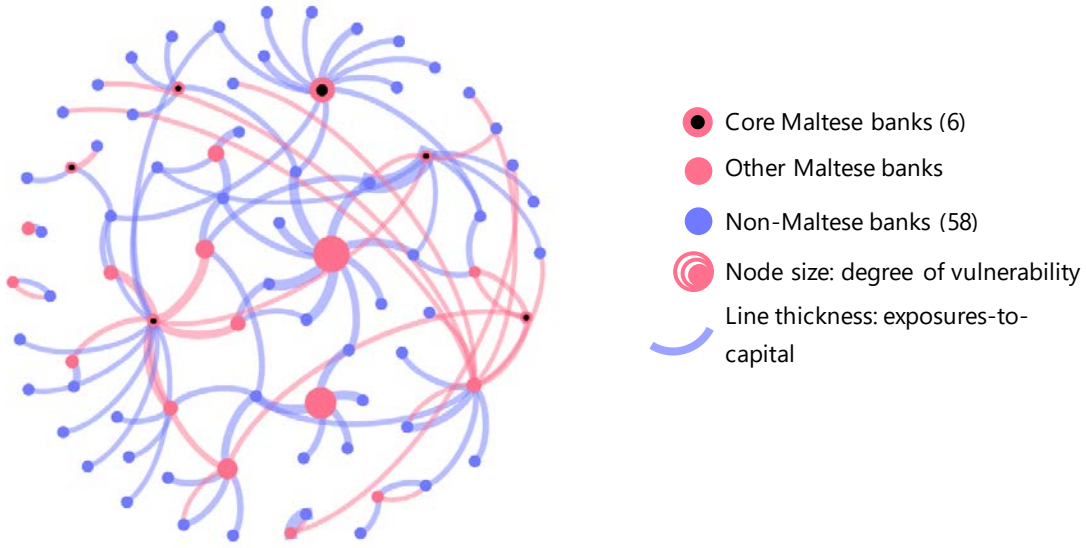
101. The topography of interbank exposures provides a visual map of the relationships and the network structure. In Figure 16, banks are arranged according to the degree of their vulnerability (indicated by node size) and clustered together based on the strength of their bilateral connections (indicated by line thickness).[54] The colors of the nodes distinguish Maltese from non-Maltese banks; the line color between any given pair of nodes denotes the source of the contagion.

- As aggregate figures alluded to, other banks seem to be overall more vulnerable to contagion risk, with the main source of contagion coming from non-Maltese banks. This graph also shows that there are a handful of shared connections – banks in the network to which multiple Maltese banks are exposed to. To the extent that these exposures are material, the sources of contagion might be concentrated on a few entities.

[54] Degree of vulnerability is measured by the number of connections weighted by the strength of the connections, which is proportional to the relative size of exposures with respect to the exposed bank's capital. Node location in the network graph (Figure 16) is derived using the ForceAtlas2 algorithm (Jacomy et al. 2014), a network spatialization tool. It is based on nodes repulsing each other like magnets, while edges attract their nodes, like springs, with these forces creating a movement that converges to a balanced state.

Figure 16. Malta: Topography of Malta-Centric Interbank Exposures

Cross-border banking network



Sources: Maltese authorities' data and IMF staff estimates.
Note: The cross-border banking network comprise 21 Maltese banks (red nodes) and 58 non-Maltese banks (blue) nodes. Nodes indicate the degree of vulnerability and lines are proportional to relative size of large exposures with respect to capital.

Appraisal of Contagion Risks

102. The analysis points to higher contagion risks originating from cross-border exposures concentrated in a few banks.

- Of the top 20 most contagious banks, 18 are non-Maltese, highlighting the importance of cross-*border* exposures (Figure 17, upper panel). Of the two Maltese banks, one is a core bank with an above-average contagion index (see Appendix VII), while the other belongs to the other bank category and has an index below the average. It is important to note that individual bank index values seem to be evenly dispersed around the average index of 2.6.

- The hypothetical default of the most contagious bank (Bank 1) results in the average losses to Maltese banks of close to 5 percent of their capital buffers (Figure 17, upper panel). While this indicates a mild system-wide impact, given the high level of market concentration in the Maltese banking system, the impact could be disproportionately weighing on banks with relatively smaller market share. This can be observed on the scatterplot that shows the induced distress on *individual* banks (Figure 17, upper panel). Bank 1 causes contagion to six Maltese banks, with individual losses ranging between 20 and 140 percent of their capital buffers. Of the six, two experience default with losses leading to undercapitalization (diamond symbols overlapping due to similar losses). While some triggered defaults impact a single bank, some others bring about multiple distresses in the system to varying degrees. Overall, there is a total of 12 contagion defaults associated with losses in the default zone.

- Focusing on the fragilities in the system, the vulnerability scores of all Maltese banks are ranked (Figure 17, lower panel). The most vulnerable bank, also labeled Bank 1, incurs average losses of about 13 percent of its capital buffer. This is appreciably greater than an average index *reading* of 2.5. Of the 13 percent losses for this bank, nearly 9 percentage points can be attributed to losses caused by euro area banks, while the rest by other European banks. In fact, the top three most vulnerable banks are exposed only to cross-border contagion, highlighting once more the role of external spill-overs, most of which can be attributed to euro area banks. Of the 12 contagion defaults, 9 are associated with the top three banks, which includes one core bank. The remaining core banks are all in the bottom half of the distribution.

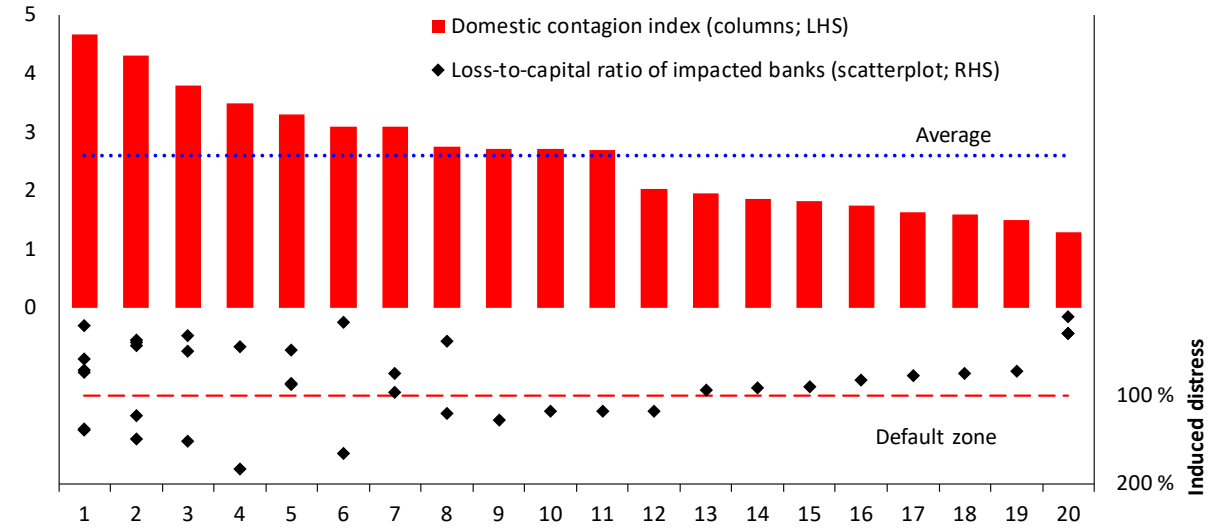
- Most contagion can be attributed to credit risk. For most banks, their liquidity positions help to absorb funding risk from their counterparts. There are four banks with limited space on the liquidity *front* that face distress due to funding risk while remaining sufficiently capitalized (Figure 17, lower panel).

- Amplification effects, as captured by the ratio of contagion losses in subsequent rounds over those in the immediate round, are limited. Furthermore, all contagion defaults, when induced, take place in the immediate round with no cascade defaults.

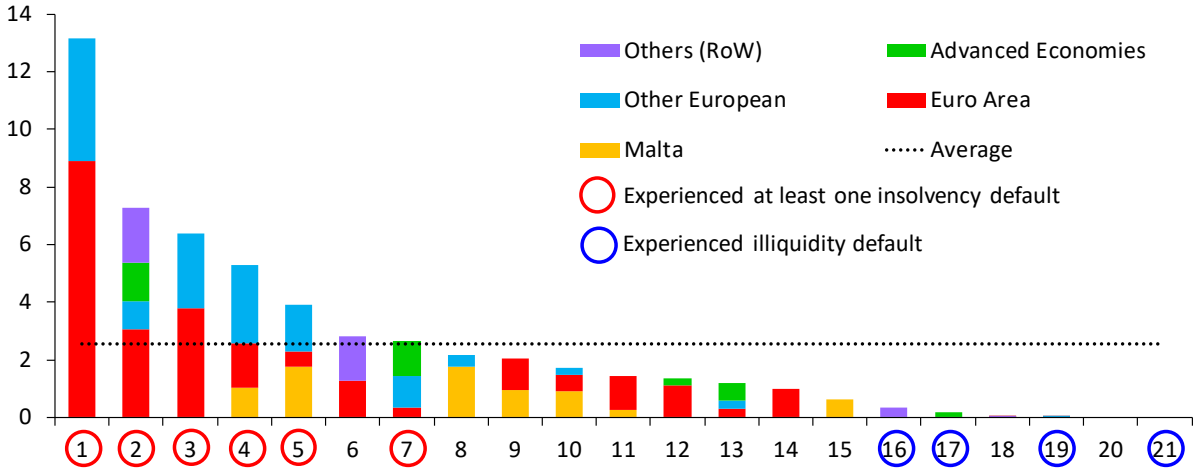
- Therefore, within this cross-border network, the diffusion of contagion is highly concentrated and largely direct. Most contagion is attributed to credit risk from non-Maltese euro area banks with *no* single bank as the key transmitter.

Figure 17. Malta: Contagion Mapping of Cross-Border Exposures 1/

Top 20 contagious banks and their impact on Maltese banks



Vulnerability scores of Maltese banks by source



Sources: ECB, MFSA, and IMF Staff calculations.

1/ The cross-border contagion mapping is based on a sample of 21 Maltese banks with large exposures to a total of 58 outside banks. The numbering of columns indicates only the respective ranking in each chart. For example, the hypothetical default of the most contagious bank, Bank 1, results in the average losses to the Maltese banks of close to 5 percent of their capital buffer (columns in the upper panel). There number of impacted entities may appear fewer than actual because of overlapping diamond symbols when losses are of similar magnitude. The most vulnerable bank, also labeled Bank 1, incurs average losses of about 13 percent of its capital buffer (lower panel).

B. Network Analysis of Domestic Financial System and Contagion Risk

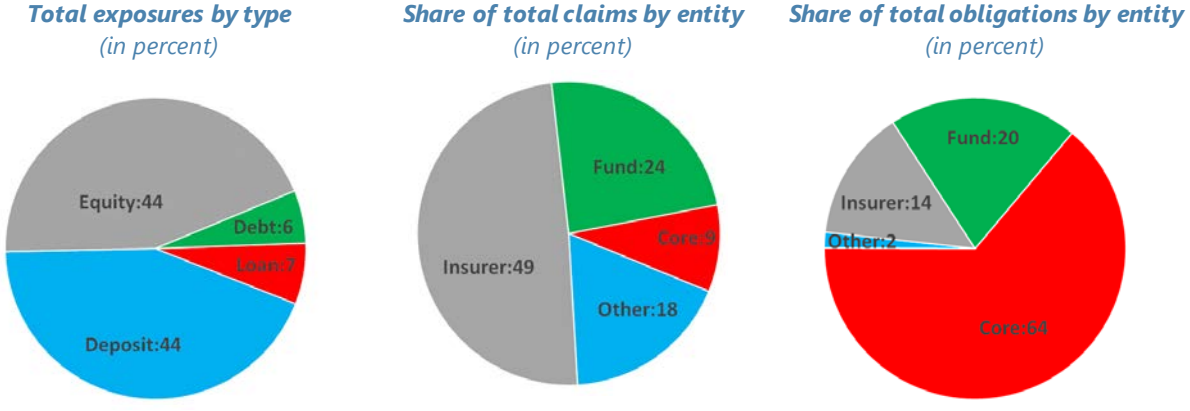
103. This section presents contagion risks arising from cross-sectoral interlinkages within the domestic financial system. This contagion analysis combines the interbank network of Maltese banks with insurers and funds based on supervisory data on bilateral exposures among them. It is important to incorporate other financial entities to study whether there are more complex interactions due to interlinkages between sectors that might lead to further contagion.

104. It was necessary to tailor the framework to incorporate insurers and funds in the implementation of the cross-sectoral network (see Appendix VII). For the most part, the important elements of the CoMap framework remain in the adapted version. While bank parameters could be fully calibrated as before, some assumptions had to be made for insurers and funds when granular data was limited. The construction of the bilateral exposures in the cross-sectoral network relied mostly on a unique dataset provided by MFSA (as of June 2017).[55] Accordingly, the analysis focused on domestically-relevant entities from the insurance (8) and investment fund (8) sectors while encompassing the entire banking sector (24), including foreign branches but excluding one bank with no exposures to financial institutions.[56]

Stylized Facts

105. Aggregated bilateral exposures reveal several trends in the cross-sectoral financial network (Figure 18). The breakdown of exposures by instrument type shows the equally dominant role of equity holdings and deposits, pointing to cross-ownership as a possible source of interconnectedness. Insurers as a group have the largest exposure within this network, with almost half the share of total bilateral claims. On the flipside, core banks have the overwhelming majority of total obligations, with a two-thirds share.

Figure 18. Malta: Decomposition of Bank Credit and Funding Exposures



Sources: Maltese authorities' data and IMF staff estimates.

[55] This analysis was made possible with the use of a unique dataset of inter-sectoral exposures constructed by MFSA staff, who generously shared it with the FSAP team.

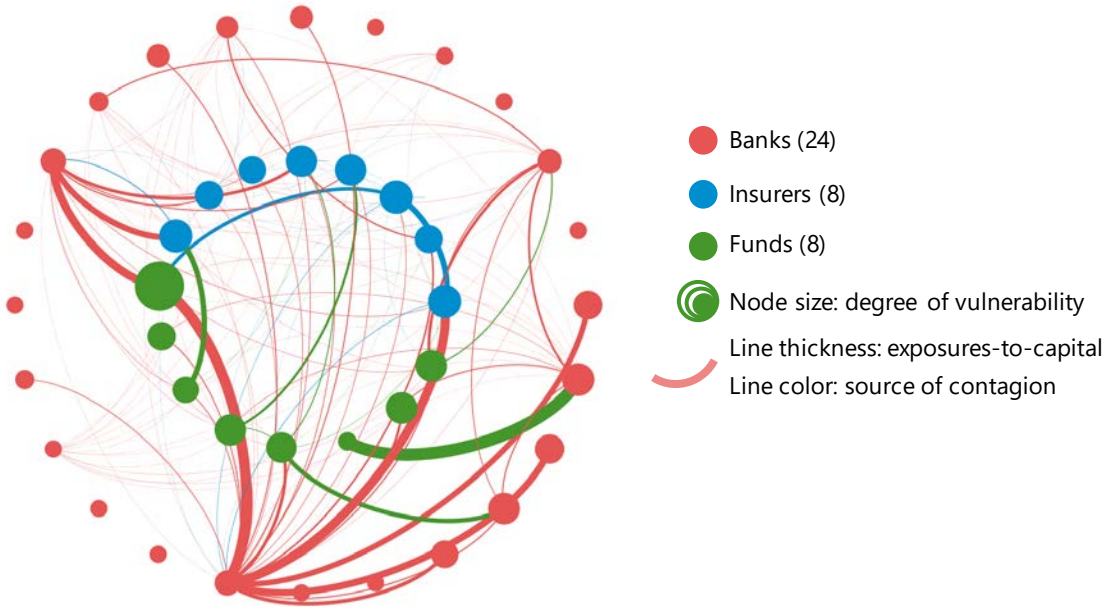
[56] For classifications of insurers and investment funds, see Technical Note – Insurance and Securities Markets Supervision.

106. Network depiction of interlinkages displays a significant degree of connectivity between groups of entities within the financial system (Figure 19). As in the cross-border network, node size and line thickness indicate a bank's degree of vulnerability and strength of bilateral exposures, respectively. However, for a clearer exposition of intersectoral linkages, nodes are selectively arranged with banks in the outer circle and funds and insurers in the inner circle. Colors are used to distinguish sectors of the nodes and the source of contagion between pairs of nodes.

- As indicated by node size, the highest concentration of contagion is on a fund with exposures mainly *to* two banks and an insurer. Overall, red lines dominate in terms of both the number and strength of connections. This indicates that banks are the main source of contagion. While much fewer in number, several green lines also appear to be significant in size, underlining the interconnectedness of the funds sector with banks as well as insurers. Insurers seem to be well interconnected, albeit mainly as a receiver driven by exposures. The majority of banks either have connections only within the banking sector or remain sparsely connected to the domestic system.

Figure 19. Malta: Topography of Financial Sector's Domestic Interlinkages

Cross-Sectoral domestic network (40 financial entities)



Sources: Maltese authorities' data and IMF staff estimates.

Note: The cross-sectoral network comprises 24 banks (red), 8 insurers (blue), and 8 funds (green). Nodes indicate vulnerability to contagion and lines reflect the prominence of large exposures normalized by loss absorption capacity (excess capital) of financial entities.

Appraisal of Cross-Sectoral Contagion

107. The analysis points to higher contagion risks to the domestic financial system emanating from core banks.

- Core banks, on average, cause contagion losses equaling almost 10 percent of the capital buffer of the domestic financial system (Figure 20). This is significantly greater than the industry average index value of 2.1 highlighting the systemic importance of core banks domestically. The distribution of index values among these banks is highly skewed, with a single bank as the key transmitter of contagion risk. Funds and insurers remain close to the industry average, with contagion indexes of 2.1 and 1.5, respectively. Both have skewed distributions, pointing to concentration in these sectors as well.

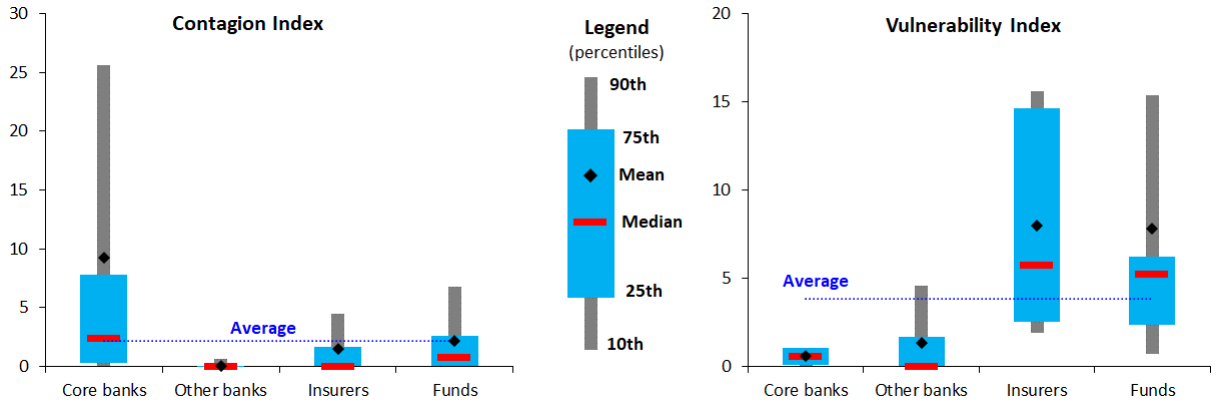
- In fact, the concentration of contagion risks is also evident at the overall level. Only 6 entities—a mix of core banks, insurers, and funds—are above the industry average. The top three among them cause 14 out of the total 18 contagion defaults.

- In terms of fragilities in the system, insurers seem to be the most vulnerable to contagion risks (Figure 21). As a group, they have an average "vulnerability index" (see Appendix VII) of 8 percent in relation to their capital buffer, with individual indices evenly dispersed around the mean. While funds have almost the same average (7.8), it is mainly driven by a single entity with a high index value.

- There seems to be potential for cascade defaults. Under two simulations, an initial shock leads to further second-round contagion defaults. Relatedly, there are some amplification effects as indicated by an *average* ratio of about 1-to-6 (losses in subsequent rounds versus in the initial round).

Figure 20. Malta: Cross-Sectoral Domestic Network: Contagion and Vulnerability by Groups

Distribution of contagion and vulnerability indices in each group (40 financial entities)



Sources: Maltese authorities' data and IMF staff estimates.

108. A deeper dive reveals potential for cascade effects and spillovers mainly from core banks to insurers and, to a lesser degree, funds.

- Distress matrices break down system-wide losses by source and target of contagion to shed more light onto how *contagion* spreads (Figure 21). The top panel shows that the highest share (38 percent) of total losses across simulations can be attributed to those caused by core banks toward insurers, followed by those toward funds (18 percent). It also shows that, to a lesser degree, insurers and other banks are exposed to contagion from funds. On the other hand, insurers can induce losses to core banks as well as to other insurers.

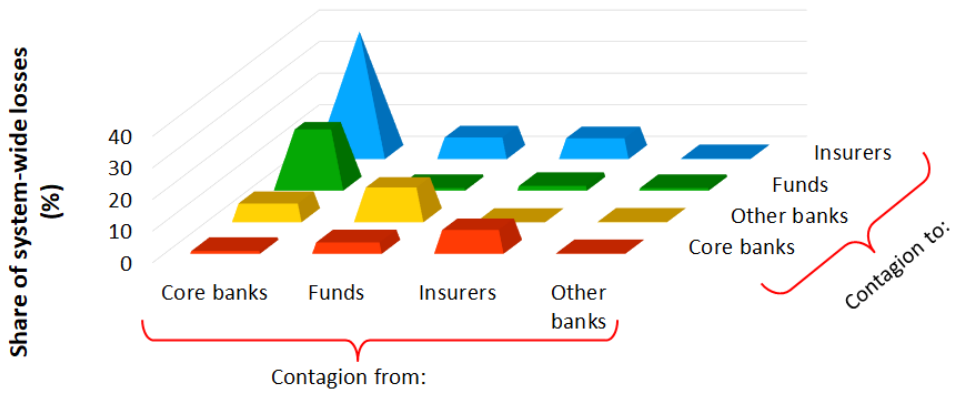
- When these losses are normalized by capital buffers (middle panel), the contagion experienced by insurers and funds takes even higher prominence. Core banks induce normalized losses of 55 percent to insurers and *25* percent to funds, on average. In contrast, the losses experienced by core and other banks can be absorbed by their capital buffers, resulting in very low average figures.

- In terms of default frequency (bottom panel), funds lead insurers, accounting for 8 out of 18 total defaults across simulations. Insurers and other banks absorb the rest with a 6-to-4 split. Other banks cause no *contagion* to the domestic system, both in terms of losses and defaults.

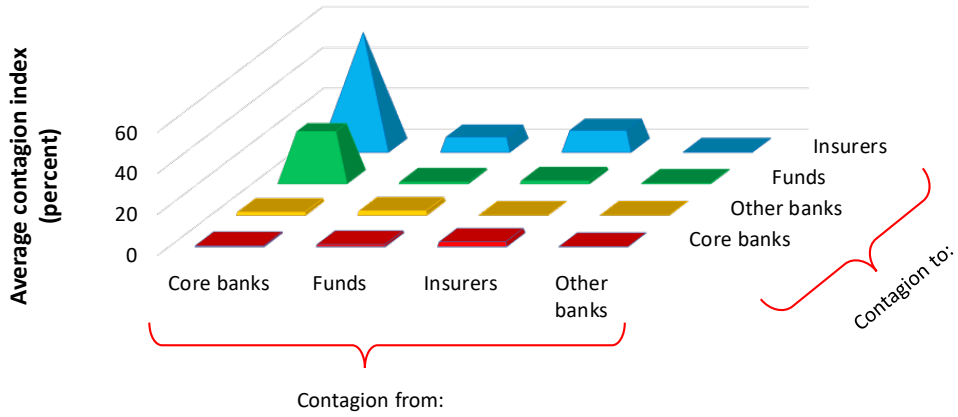
- Overall, insurers are the most affected group primarily because of their deposits and equity exposures, making them vulnerable to large-exposure counterparties through multiple channels. Though high capital can help alleviate contagion risks to some financial sector players, the domestic focus of insurers also implies increased fragility towards domestic-born risks, if tail events were to materialize.

Figure 21. Malta: Distress Matrices

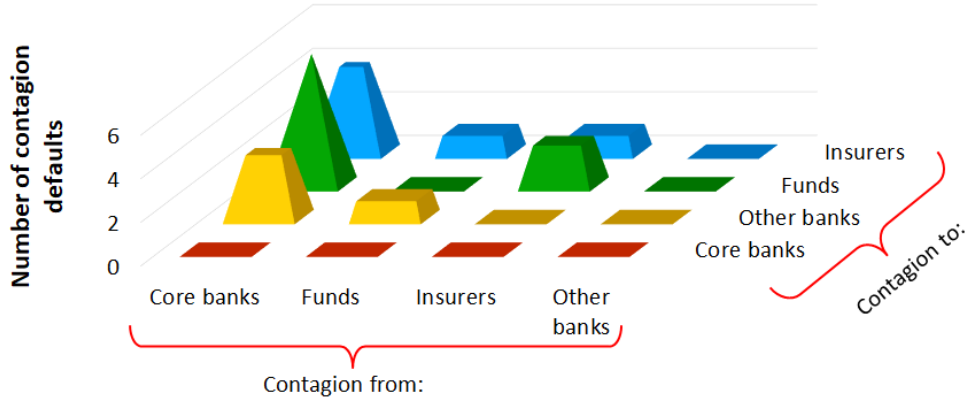
Shares of system-wide losses (in percent of total losses)



Default frequency (number of entities)



Average contagion index (percent of capital buffers)



Sources: ECB, MFSA, and IMF staff calculations.

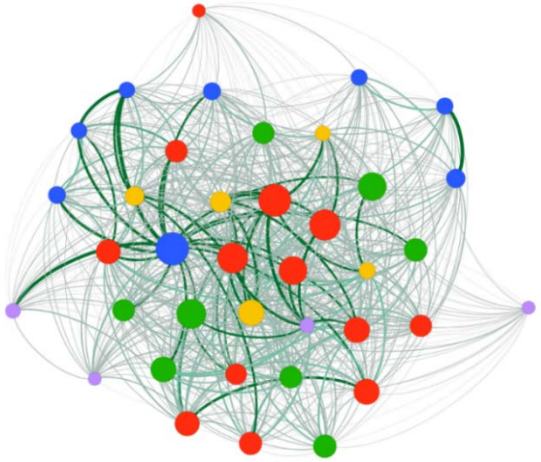
C. Market-Based Interconnectedness Analysis

109. In this section, market-based spillover measures are used to assess interconnectedness between Maltese and foreign banks.[57] The methodological approach offered by Diebold and Yilmaz (2014, 2015) is used, as it aims to quantify strength and direction of spillovers within the network. Using daily equity returns for a selected set of listed banks, it estimates a spillover metric using a vector autoregressive model (VAR).[58] This metric, directionally defined between each pair in the network, is based on how much of the return variability for a given bank can be attributed to shocks to returns of every other bank in the network. Consequently, a net spillover measure can be constructed for each bank.

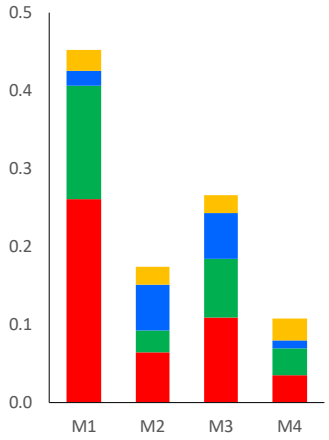
110. Market-based network analysis highlights inward spillovers from the euro area and other European banks. Three of the four Maltese banks (in light purple) appear on the periphery of the global network of banks because of their relatively lower degree of connectivity with the rest of the network (light and thin lines) for the most part (Figure 22, left). One Maltese bank is more centrally located, a reflection of significant common underlying factors with other banks as captured in market pricing of its equities. Overall, the prominence of euro area and other European banks account for the large portion of net inward spillovers to Maltese banks and is consistent with the result of the balance sheet-based analysis (Figure 22, right).

Figure 22. Malta: Market-Based Spillovers Using Diebold-Yilmaz Methodology

Network map of net spillovers 1/ (percent)



Net inward spillovers to Malta 2/ (Contribution by region to total)



Sources: Bloomberg and IMF staff estimates.
1/ Node size indicates relative size of inward spillover to Maltese institutions. Color and thickness of lines indicate "total connectedness to others," with darker and thick lines indicating stronger pairwise relationships. Node location is derived using the ForceAtlas2 algorithm (Jacomy et al. 2014), a network spatialization tool. It is based on nodes repulsing each other like magnets, while edges attract their nodes, like springs, with these forces creating a movement that converges to a balanced state.
2/ M1, M2, M3, M4 indicate the four Maltese banks (in no specific order) listed in the Malta Stock Exchange.

[57] Tadeusz Galeza (IMF, Monetary and Capital Markets Department) provided the results of the Diebold-Yilmaz analysis.

[58] See Appendix VIII for more details on data and implementation.

D. Robustness Analysis

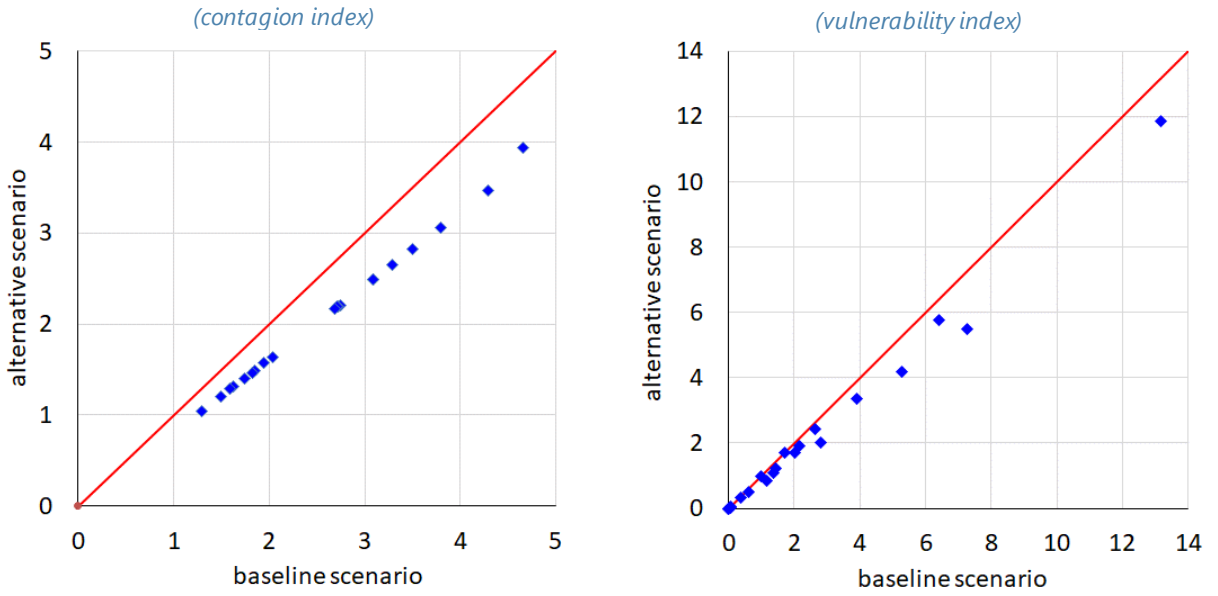
111. The findings are broadly robust to several alternative assumptions. As most model inputs are calibrated at entity or exposure level, the findings are based on most granular information to minimize misestimations. There are several assumptions with regards to default thresholds that can be tested with less conservative alternatives.

112. For the cross-border interbank network, the sensitivity test involves considering bank excess capital based on the minimum CET1 requirement. While this change reduces the average losses somewhat, it is linear for the most part with limited change in the ranking of banks and number of defaults (Figure 23, top panel). On the contagion side, banks are ranked exactly in the same order, with contagion indexes declining in the 15–20 percent range. The variations are slightly greater on the vulnerability side, with ranking changes limited to moving up/down by one place and indexes declining in the 5–30 percent range. Overall, there are three less insolvency defaults across all simulations. As expected, the change in the default threshold does not affect the number of illiquidity-driven defaults, which remain at three.

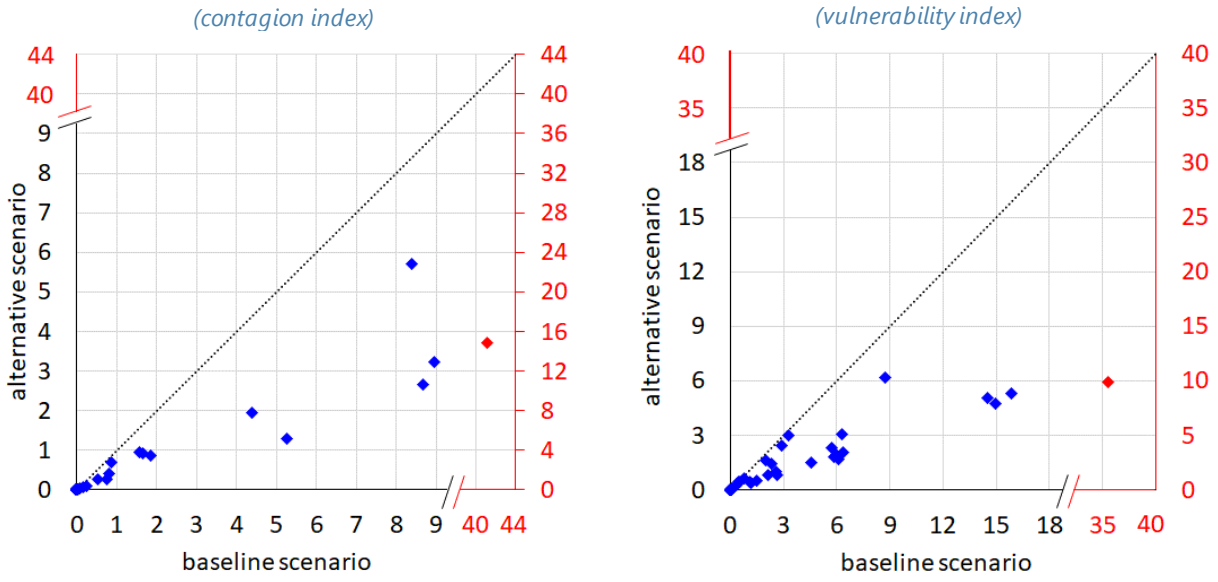
113. Both liquidity and solvency assumptions for the cross-sectoral domestic financial network analysis are tested. An alternative scenario with less conservative assumptions considers a larger capital surplus to absorb contagion losses. This implies using: (i) excess capital based on minimum CET1 ratio for banks; (ii) tier 1 capital for insurers; and (iii) a redemption shock of 20 percent as the default trigger for funds. Furthermore, the calculation of liquidity surplus for funds incorporates sovereign holdings and short-term debt securities (both with 50 percent risk weight). Both contagion and vulnerability index averages decline by about 60 percent in the alternative scenario with less conservative assumptions (Figure 23, bottom panel). There is a wide variation across individual entity indexes, which results in several changes in the ranking of entities. One significant change is in the number of contagion defaults, which declines from 18 to 7. While the contagion and vulnerability indicators decline in degree, the main patterns at the group level remain the same, highlighting the vulnerability of insurers to contagion risk and the role of core banks in perpetuating these risks.

Figure 23. Malta: Sensitivity Tests

Cross-border interbank network: distribution of individual indexes
(in percent of capital buffers)



Cross-sectoral domestic financial network: distribution of individual indexes
(in percent of capital buffers)



Sources: Maltese authorities' data and IMF staff estimates.

E. Caveats

114. Both the balance sheet-based and market-based interconnectedness analyses are subject to potential misestimation of contagion risks, which can be summarized:

- On the modeling side, while the CoMap framework addresses several shortcomings associated with *network* analysis by incorporating liquidity dynamics and bank-specific parameter calibration, it fails to account for market perceptions to exposures. For example, the contagion could spread faster and wider if the model considered additional losses due to common exposures. Furthermore, by assuming a single solvency threshold, which triggers an outright default, the model could be missing the dynamics related to the ability of banks to react to depleting capital bases. The effects of such dynamics could either decrease or increase contagion risk depending on bank characteristics and network topology.

- On the data side, a key limitation is that the analysis was based on a specific point in time (2017Q2 and 2017Q4). Furthermore, limited counterparty-level data on funding sources and lack of information on foreign counterpart balance sheets only allow for partial analysis of outward spillovers from Maltese entities. However, Maltese entities are less likely to be a significant source of contagion to foreign entities, as also confirmed by the market-based analysis. While granularity of bank-level data allows for full calibration of model parameters, the adaptation of the framework for the domestic financial system, including insurers and funds, is subject to misestimations due to several assumptions made on non-bank financial entities. To mitigate, robustness tests were performed with less-conservative assumptions. The market-based analysis covered only four banks that are listed in the Maltese Stock Exchange (*Figure* 22, right panel). Given the limited coverage and low level of market activity at the Maltese Stock Exchange, the analysis is subject to significant data limitations and individual results should be interpreted with caution.

F. Summary and Policy Implications

115. Taken together, the results suggest that the risk of contagion through the interlinkages within the financial sector is currently higher and more widespread relative to cross-border interbank exposures. Within the cross-border network, while the contagion index produces mild readings, evidence points to concentrated distresses in smaller banks. At the domestic level, expanding the analysis from interbank networks to include funds and insurers would have implications for the health of the financial institutions. Analysis points to the vulnerability of insurers to contagion risk and the key role of core banks in perpetuating these risks. Market-based analysis confirms the level of interconnectivity particularly with euro area and other European banks, to which Malta is a net recipient of cross-border spillovers.

116. Monitoring and conducting periodic analysis of both cross-border and inter-sectoral linkages would provide an early warning before contagion risks accumulate. Even though the Maltese financial system is currently in good health, addressing certain structural challenges related to concentration of large exposures could further reduce vulnerabilities that arise from within the

domestic financial system as well as those that spill over from the outside. Several recommendations follow:

- Expand the scope of the interbank analysis based on large exposures and funding concentration to capture cross-*border* bilateral exposures;
- Continue to enhance network analysis of interlinkages within the financial sector to fully incorporate risks due to various transmission channels;
- Integrate contagion risks into the overall macroeconomic stress-testing framework driven by macro scenarios to inform the *calibration* of macroprudential tools.

HOUSEHOLD STRESS TESTS

117. The analysis suggests that Maltese households are resilient against shocks under the adverse scenario and that systemic risk in the sector is unlikely at this juncture. While prolonged economic shocks could impact the solvency risk of low-income households, reflecting their relative thin financial buffers, the overall impact appears to be manageable both in terms of outstanding debt held by distressed households and their share of the population.

Key Trends

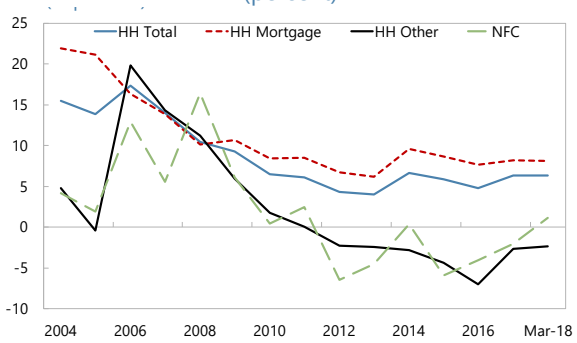
118. The household stress test aims to shed light on bank credit risk exposure in the fast-growing mortgage segment. Mortgage lending has been growing at nearly 10 percent annually in recent years, resulting in a rising concentration of mortgages in bank loan portfolios (Figure 24, left). At the same time, indebtedness of Maltese households picked up quickly and stabilized at about 110 percent of gross disposable income in recent years, around 10 percentage points above the euro area average (Figure 24, right).[59]

119. Strong demand pressures continue to drive property prices up. Residential property prices have been on an upward trend, exceeding that of the euro area average in recent years (Figure 25, left). Strong employment growth, higher disposable incomes, a large influx of foreign workers, and portfolio rebalancing toward property investments have supported property prices and rents. Combined with relatively high home ownership, Maltese household balance sheets have significant exposure to real estate market developments (Figure 25, right).

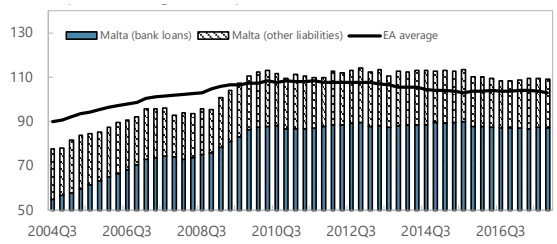
[59] It is worth noting that the difference could partly reflect potential coverage of household debt data. The household debt data for Malta covers bank loans as well as other accounts payable and loans, while the euro area average covers household debt arising from loans.

Figure 24. Malta: Household Credit and Debt in Malta

Credit growth rate
(percent)



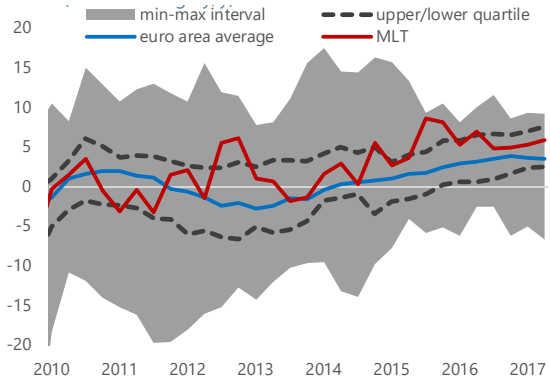
Household debt
(percent of gross disposable income)



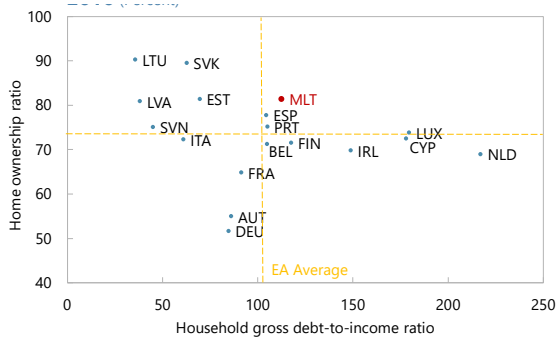
Sources: CBM, Haver Analytics, and IMF staff calculations.

Figure 25. Malta: Housing Market Developments in Malta versus Euro Area

Dispersion of nominal house price growth in the EA
(percent change y/y)



Household debt-to-income, home ownership, 2016
(percent)



Sources: ECB, Eurostat, Haver Analytics, and Maltese authorities.

Data and Methodology

120. Maltese banks do not have internal models to estimate probabilities of default and loss given default in the housing loan segment. A household stress test based on micro data and household characteristics can provide a useful assessment of household solvency risks, the probability of default. The exercise can also help detect distributional and non-linear effects of shocks related to household financial conditions.

121. The micro household survey has recently been updated. The 2017 Eurosystem Household Finance and Consumption Survey sample for Malta contains detailed data of 1,004 households, including their income, financial and non-financial assets, as well as monthly repayments of total debt, including mortgage debt. Expenditure data is sourced from survey variables on consumption of food, goods and services, and expenses on utilities. Data is based on the information from 2016. To approximate the financial situation of households in 2017, income and expenditure data was updated using the latest available figures on wages, prices, and national

accounts.[60] Lastly, assets and liabilities are updated based on the aggregate data from financial accounts. Projections for the stress period (2018–20), are based on the adverse scenario developed by the FSAP team, including estimates for mortgage lending rates and household consumption growth in the stress period (Table 7).

122. The analysis of initial data reveals that 28 percent of households had debt, of which about 59 percent receive some social transfers and 9 percent have negative extended financial margin (Table 8).

Table 7. Malta: Dynamics of the Household Stress Test Parameters Before and After Stress, 2018–20
(percent)

	Stress test scenario		
	2018	2019	2020
Output Growth	-2.3	-1.0	2.9
Inflation	-0.1	-0.6	-0.2
Growth in expenditure	1.3	1.3	2.3
Growth in wages	-2.8	-4.7	-2.9
Changes in Mortgage rate (in ppts)	1.9	0.4	-0.1
Growth in house prices	-18.2	-14.1	-0.4
Growth in equities	-28.6	-1.8	8.3

Sources: Maltese authorities and IMF staff calculations.

Table 8. Malta: Descriptive Characteristics of Households with Debt
(2016, percent)

Households received no wage income	8.5
Households received social transfers	59.4
Households had negative financial margin	8.9

Sources: Maltese authorities and IMF staff calculations.

[60] The updating could have implications on income distribution, as income growth of a household depends on its income composition (e.g., wages, social benefits).

123. Households having both negative extended financial margin and negative assets were those deemed most likely to face financial difficulties in repaying their debt. The extended financial margin was calculated as follows:

$$EFM_t = \{wage\ income_{t-1} \times (1 + g_t^w) \times (1 + \alpha_t) + social\ transfer_{t-1} \times (1 + g_t^t) \times (1 + \beta_t) + otherincome_{t-1} \times (1 + g_t^o) \times (1 + \gamma_t)\} - expenditure_{t-1} \times (1 + g_t^e) \times (1 + \delta_t) - mortgage\ payments_t \times (1 + \epsilon_t) - other\ debt\ payments_t \times (1 + \psi_t) + total\ financial\ assets_{t-1} \times (1 + \eta_t)$$

124. All income and expenditure data were annualized. Regular social transfers exclude pensions, and current expenditures exclude mortgage and other debt payments (to avoid double counting). $\alpha_t, \beta_t, \gamma_t, \delta_t, \epsilon_t, \psi_t, \eta_t$ are respective shock parameters; and g is the growth rate. If the extended financial margin (EFM) is negative, we can assume that such a household would use other real assets to avoid default (e.g., sell real estate). Then we calculated net assets by assuming:

$$NA_t = total\ real\ assets_{t-1} \times (1 + \mu_t) + EFM_t - total\ outstanding\ balance\ of\ household\ liabilities_t$$

where μ_t is the growth rate of real estate prices under the stress scenario.

125. If a household has negative EFM and negative net assets (NA) (i.e., higher total liabilities than the value of real assets and the surplus left to the household after satisfying its expenses and financial commitments), we assume that such a household is at risk of financial distress. We calculated implied PD using the following formula:

$$PD_t = \begin{cases} 1, if\ EFM_t < 0\ and\ NA_t < 0 \\ 0, \quad otherwise \end{cases}$$

Appraisal of Risks

126. The distribution of household debt varies significantly across income deciles (Figure 26, top panel). For example, an analysis found that the share of households with debt is much lower among the three lowest income deciles (below 10 percent). Beyond the 4th income decile, the proportion of households with debt broadly increases with income. More than half of the households have debt in the top two income deciles.

127. Pre-shock data analysis shows that there are about 3.7 percent of households in distress (i.e., PD equaling 1) in the sample. Household analysis by income level and PD (i.e., negative assets and negative financial margin) shows that, as expected, households with lower income have higher risks financial distress. At the same time, PDs are highest in the 1st, 2nd, and 3rd

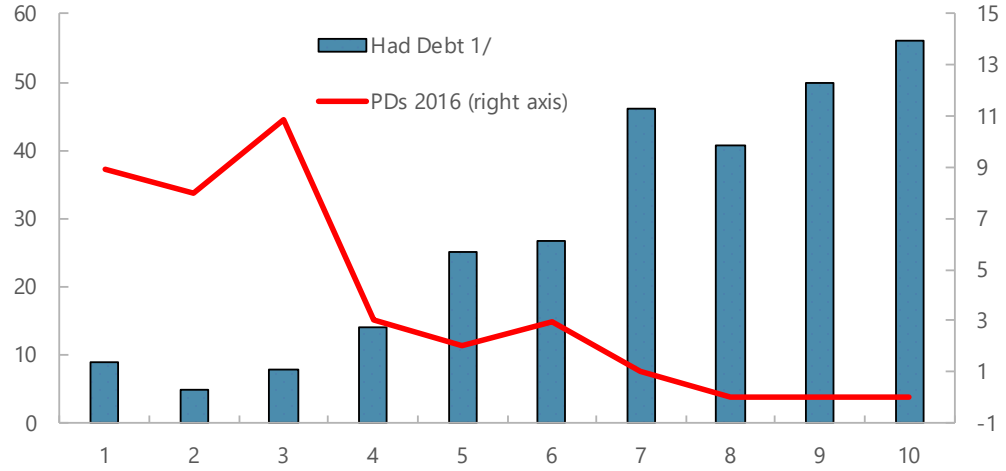
deciles, which is hardly surprising. As expected, households in the highest income deciles have the highest proportion of households with debt and the lowest PDs. In our sample, households in the top three income deciles did not default.

128. Household stress test results suggest that low-income households are more vulnerable to a drop of income and house prices, and rising finance costs, especially when facing prolonged adverse shocks. The distribution of PDs in the stress test scenario is shown in Figure 26 (bottom panel). While the average implied PD for household loans increases from 3.7 to 8.9 percent over the stress period under the adverse scenario (reflecting a multiplier of 2.4), the average PD ratio only increases to 5.8 percent in 2018, the first year of the stress period. The low share of households in distress reflect strong balance sheets as more than 91 percent of indebted households have sufficient liquid assets to cover at least 12 months of income shortages (i.e., debt service payments and living expense larger than their income). Nevertheless, a prolonged economic recession could exhaust financial buffers and put more households in distress. There are noticeable jumps in PDs in the second year of the stress period, averaging 10.4 percent. The increase is mostly driven by a higher share of distressed households among the low-income deciles, reflecting their relatively thin financial buffers against the shocks. As shocks dissipate in the final year of the stress period, the PDs stabilize and average 10.5 percent for the whole sample.

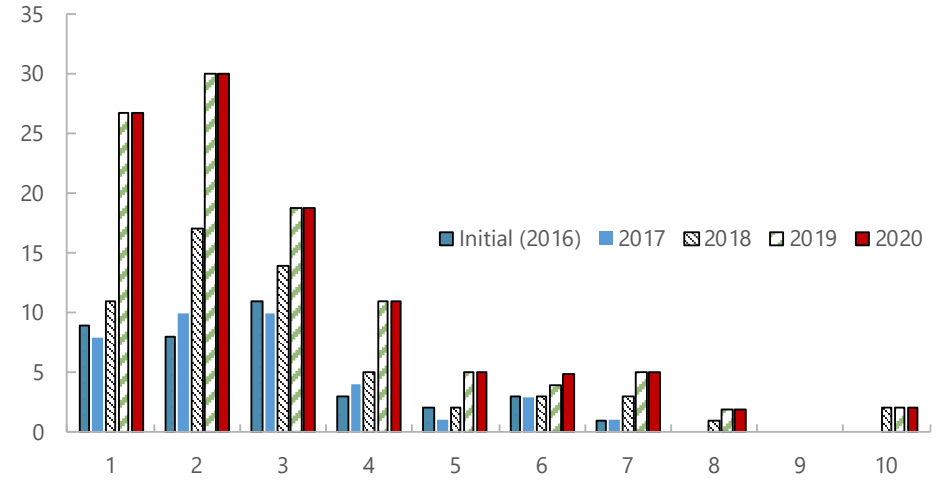
129. The credit loss associated with distressed households would likely remain manageable. It should be noted that the debt burden of the bottom four deciles (households with highest PD and most affected by the adverse scenario) accounted for only about 6.4 percent of total mortgage debt, or less than 6.3 percent of total household debt in the sample

Figure 26. Malta: Household Stress-Test Results

Distribution of household debt and implied PDs by income decile, pre-stress period
(percent)



Distribution of household PDs by income decile, before and after shocks
(percent)



Sources: IMF staff calculations.

1/ Share of households with debt outstanding in 2016.

Appendix I. Risk Assessment Matrix[1]

Source of risks	Relative likelihood and transmission channels	Impact if realized
Weaker-than-expected growth	Medium The Maltese economy is highly open with exports standing at about 150 percent of GDP in 2017. A secular weak external demand would have an adverse effect on domestic confidence and growth prospects. Cross border spillovers could also impact growth and employment through FDI channel, an important source of funding to nonfinancial corporates. Rising unemployment among residents and outflow of foreign workers could amplify the housing price correction, worsening the downward spiral.	Medium The external shocks would be transmitted through international macroeconomic spillovers (adverse impact on exports and GDP growth) and financial channels, including banks' foreign exposures. Slower growth and higher unemployment could increase NPLs and lead to higher loan loss impairment impacting bank profitability. Erosion in corporate profits from lower domestic and external demand may further increase distress in the corporate sector due to the large share of intercompany lending. This could lead to cascading defaults among NFCs, which could subsequently spread into the banking system. Internationally active banks could suffer credit losses on their cross-border exposures. Higher-than-envisaged gains from recent large-scale infrastructure projects and labor market reforms may mitigate the impact.
Rising protectionism and retreat from multilateralism	High Heightened uncertainty regarding Brexit, trade tensions, and policymaking in the U.S. may weigh on confidence and adversely affect growth prospects through lower investment and trade. Disruption to passporting arrangements into the U.K. for insurance and investment firms could be costly.	Medium Weaker GDP growth and higher unemployment in the euro area and U.K. would adversely impact export and GDP growth. The impact of Brexit on certain financial sector participants either through loss of business or direct exposures could spread to the rest of the system through interlinkages and cross-holding relationships. Some effects could be mitigated given Malta's trade diversification and excess demand in tourism sector, and possible relocation of firms that service the EU from the U.K. to Malta. Loss of market confidence and a reduction in market prices of securities held by banks could have negative implications on banks' balance sheets and capital.

[1] The RAM shows events that could materially alter the baseline path (the scenario most likely to materialize in the view of IMF staff). The relative likelihood is the staff's subjective assessment of the risks surrounding the baseline ("low" is meant to indicate a probability below 10 percent, "medium" a probability between 10 percent and 30 percent, and "high" a probability between 30 percent and 50 percent. The RAM reflects staff views on the source of risks and overall level of concern as of the time of discussions with the authorities. Non-mutually exclusive risks may interact and materialize jointly.

Source of risks	Relative likelihood and transmission channels	Impact if realized
A sharp tightening of global financial conditions	High Despite being relatively insulated from financial market contagion, Malta is vulnerable to weak external demand and lower FDI inflows. In the context of continued monetary policy normalization and increasingly stretched valuation across asset classes, an abrupt change in global risk appetite could lead to sudden, sharp increases in interest rates as term premia decompress, and associated tightening of financial conditions. Financial stress from continuous confidence shocks would exacerbate the fall in asset prices and result in a credit crunch.	Medium/Low Higher debt service and refinancing risks could stress household and firms. Loss of market confidence and increases in risk premia would lead to declines in assets prices, and cause valuation losses and higher funding cost for banks and could affect insurers/funds. A global financial cycle downturn could trigger further reduction in housing prices due to interest rate increases and a drop-in income growth.
A sharp correction in historically high housing prices	Medium After a period of price increases, coupled with a strong growth in mortgage lending in a low interest rate environment, a downturn in housing market poses significant risks to domestically oriented banks given their high and rising exposure to property-related loans. While currently strong household balance sheets could provide cushion, the pressure could be intensified if accompanied by broader economic slowdown—an increase in unemployment and/or interest rates, limiting the recovery.	Medium The significant drop in housing prices would reduce the value of collateral and result in lower recoveries in default cases. Erosion in profits and capital adequacy at the core of the banking system could cause wide-spread distress with tightening in lending conditions. Credit crunch could trigger a negative spiral of low investment and adverse effects on financial stability and growth. The combination of adverse wealth effects and income effects through the households could create negative feedback loops to the economy.

Source of risks	Relative likelihood and transmission channels	Impact if realized
Possible changes in international taxation	Medium/Low Malta's attractiveness as a financial and business location supports its fiscal revenues with about half of corporate tax base reliant on foreign-owned companies. Changes in Malta' comparative tax advantage could impact corporates and demand for its IIP and result in the shrinkage of the international sector, including within the financial system.	High/Medium Together with contribution from ancillary professions, financial sector accounts for about 10 percent of Malta's GDP. Remote gaming sector generates an estimated 10 percent gross value added to the economy. Businesses exits from these sectors would erode the tax base significantly, increase unemployment, and suppress economic growth. Stress in public finances would spill over into the banking system given the strong home bias. Deposit outflows from retrenchment could reduce banks' liquidity and raise funding costs, and, subsequently, lending rates.
Slow progress in effectively implementing the AML/CFT framework	Medium The banking sector's large exposures to nonresident customers, internationally-oriented resident companies, and to new technologies (e.g., VFA, and e-gaming), and investments from the IIP pose ML/TF risks, creating challenges through reputational risks, pressure on CBRs, and growing compliance costs. These would weaken Malta's attractiveness as a financial and business location. Exit of domestically oriented banks and de-risking would reduce the system's overall capacity to support financial intermediation.	Medium Heightened risks would lead to outflows from financial and remote gaming sectors. Materialization of reputational risks could trigger large withdrawals of wholesale and nonresident deposits, as well as deposits of internationally oriented resident companies. Deposit outflows from retrenchment could reduce banks' liquidity and raise funding costs. The high liquidity of banks is a mitigating factor

Appendix II. Stress Test Matrix

Banking Sector: Solvency Risk		
Domain	**Assumption**	
1. Institutional perimeter	Exercise	• Top-down by FSAP team.
	Institutions included	• The top 11 banks by share of assets.
	Market share	• 93 percent of total assets in the banking system (excluding foreign bank branches).
	Data and baseline date	• Latest data: December 2017 • Supervisory data: balance sheet information, COREP and FINREP, and large exposure (LE) templates provided by the authorities. Also provided was further supervisory information, among others, non-performing loans by portfolio, and details of funding by type of depositor. • Market and publicly-available data. • Scope of consolidation: banking activities of the consolidated banking group for banks having their headquarters in Malta and sub-consolidated level data for the subsidiaries of foreign banks. • Coverage of sovereign and non-sovereign securities exposures: held to maturity, available for sale, and fair value accounts, valued respectively at amortized cost, MTM, or fair-value at starting point.
2. Channels of risk propagation	Methodology	• In general, the solvency stress test is based on International Accounting Standard (IAS) 39 principles, particularly for the provisioning approach. • FSAP team satellite models and methodologies. • Balance-sheet regulatory approach. • Market data-based approach.
	Satellite models for macrofinancial linkages	• FSAP team's own model and expert judgment for balance-sheet and credit growth, pre-impairment net income as sum of net interest income, and non-interest income. No accrued income on NPL loans. • FSAP team's own model for credit losses from bank lending portfolios. Due to unavailability of consistent NPL data series for consumer loans (non-mortgage), the credit risk for this category was estimated by benchmark PD and LGD provided by ECB. • Credit estimation of loan to credit and financial institutions are proxied by Moody's Expected Default Frequency (EDF). • Methodology to calculate losses from sovereign debt holdings: Haircuts are calculated based on a modified duration approach and historical distributions of changes in yield.

Banking Sector: Solvency Risk		
Domain	**Assumption**	
		• Methodology to calculate losses from bonds and money market instruments: Haircuts are calculated based on a modified duration approach and historical distributions of changes in yield. • Methodology to calculate losses from bonds and money market instruments (HTM portfolios): losses from credit-rating migration approach.
	Stress test horizon	• 2017Q4–2020Q4 (3 years)
3. Tail shocks	Scenario analysis	• Macrofinancial scenario analysis, agreed with the authorities. • Baseline scenario based on 2018 *World Economic Outlook* projections, CBM and ECB projections. • The adverse macro scenario is informed by the IMF's Flexible System of Global Models (FSGM).
	Sensitivity analysis	• Sensitivity tests to various shocks: concentration and interest risks. • Interest rate increase and decrease by 200 and 100 bps respectively. • Failure of the largest 1, 3, and 5 non-financial corporate exposures.
4. Risks and buffers	Risks/factors assessed (How each element is derived, assumptions)	• Credit losses for lending and investment exposures, including indirect risk from foreign exchange books. • Losses from debt instruments (sovereign and other issuers) in the trading and banking books. • Market risk, including foreign exchange risk. • Interest rate risk on banking book. • Counterparty concentration risk.
	Behavioral adjustments	• Quasi-static balance sheet assumption: (i) balance sheet growth is in line with nominal GDP growth, with a floor set at zero, and accounting for foreign exchange movement and triggered off-balance sheet items (credit lines and guarantees). (ii) Risk weighted assets change due to change in the requirement for newly non-performing loan, triggered off-balance sheet items, and new loans granted during the stress test horizon; (iii) the balance sheet composition/structure remains constant throughout the stress test horizon; (iv) banks build capital only through retained earnings; and (v) maturing capital instruments (AT1 and Tier 2) are not renewed. • For comparison, a static balance sheet assumption is also conducted: (i) balance sheet growth is assumed to zero; (ii) maturing assets are replaced by exposures of the same type and risk. • Dividends can only be paid out by banks that remain adequately capitalized and have positive profits.
5. Regulatory and market-based	Calibration of risk parameters	• Based on credit models estimated by IMF staff. • The stress test made use of satellite models to project credit risk by sector. Given that all sample banks fall under the

Banking Sector: Solvency Risk		
Domain	**Assumption**	
standards and parameters		standardized regulatory framework, calculations for PD and LGD are not readily available. Instead, NPL ratios were projected using panel regression techniques for two exposure classes: corporate and household mortgages. Credit risk estimations of are proxied by Moody's EDF series and projected using a panel regression model. Due to the unavailability of consistent NPL data series for consumer loans (non-mortgage), the credit risk for this category was estimated by benchmark PDs and LGDs provided by ECB.
	Regulatory/ accounting and market-based standards	• National regulatory framework. • Capital metrics: Basel II standardized approach and fully loaded Basel III definition. • The hurdle rate based on capital requirements for CET1, T1, Total Capital, and Leverage ratio. • Capital conservation buffer is allowed to be used under adverse scenario.
6. Reporting format for results	Output presentation	• Capital ratio decline of the banking system. • Number of banks and the percentage of banking assets (or GDP) in the system that fall below a hurdle rate. •

Banking Sector: Liquidity Risk		
Domain	**Assumption**	
1. Institutional perimeter	Exercise	• Top-down by FSAP team.
	Institutions included	• The top 11 banks by share of assets.
	Market share	• 93 percent of total assets in the banking system (excluding foreign bank branches).
	Debt and baseline date	• Latest data: - December 2017 (LCR and NSFR approaches) - March 2018 (Cash-flow based liquidity stress test approach) • Source: supervisory data (COREP: LCR, NSFR and ALMM Maturity Ladder template) • Scope of consolidation: consolidated banking group.
2. Channels of risk propagation	Methodology	• Basel III LCR and NSFR type proxies, cash-flow based liquidity stress test using maturity buckets by banks, incorporating both contractual and behavioral (where available) with assumption about combined interaction of funding and market liquidity and difference levels of the central bank support. • Liquidity test in total currency and major foreign currencies. • Liquidity test for large depositor withdrawals. • Liquidity test for certain industry concentration risk for funding.

Banking Sector: Liquidity Risk		
Domain	**Assumption**	
3. Risks and buffers	Risks	• Funding liquidity. • Market liquidity. • Counterparty/depositor concentration risk, i.e., withdrawal of top 1, 3, and 5 depositors. • Industry concentration risk, i.e., withdrawal of depositor for certain industries (namely the financial and insurance activities sector; accommodation and food service activities; and arts, entertainment, and recreation (including gaming). • ECB haircuts for Eurosystem monetary policy implementation as applicable at the reference date.
	Buffer	• The counterbalancing capacity, including liquidity obtained from markets and/or central bank facilities. • Expected cash inflows are also included in the cash-flow based and LCR-based analysis.
4. Tail shocks	Size of the shock	• The run-off rates are calibrated to reflect scenarios of system-wide deposit runs and dry-up unsecured wholesale and retail funding, with additional run-off for non-resident deposits on top of the retail and wholesale run-off, which is calibrated following historical events and IMF expert judgment. • For LCR-based liquidity stress tests, total run-off rates of non-resident deposits range from 33 to 46 percent, depending on the type of deposits (current, saving, and time). • The scenario will provide a combination of assumed deposits run-off and approaches to CBC: - Withdrawal of unsecured wholesale deposits, with CBC valuation at market price. - Withdrawal of unsecured wholesale and retail deposits. Market liquidity shock will reduce the CBC value and will incorporate the central bank haircut. - Withdrawal of unsecured wholesale and retail deposits, with additional run-off for non-resident deposits. Market liquidity shock will reduce the CBC value and will incorporate the central bank haircut. • The liquidity shocks will be simulated for 1-month for both LCR and cash-flow based approaches, and 5-day and 3-months for cash-flow based approach. • The haircut of high-quality liquid assets (HQLA) are calibrated consistent with market shock for investment securities and money market instruments in solvency stress test.
5. Regulatory and market-based standards and parameters	Regulatory standards	• Consistent with Basel III regulatory framework (LCR and NSFR). • Liquidity shortfall by bank.
6. Reporting format for results	Output presentation	• Liquidity ratio or shortfall by groups of banks and aggregated (system wide). • Number of banks that can still meet their obligations.

Financial Sector: Contagion Risk		
Domain	**Assumption**	
1. Institutional perimeter	Exercise	• Top-down by FSAP team.
	Institutions included	• Three networks: - Cross-border: 21 Maltese banks and 58 non-Maltese banks. - Cross-sectoral (domestic): 24 banks, 8 insurers, and 8 funds. - Market-based global: 4 listed Maltese banks, 34 global banks.
	Market share	• Cross-border: 99 percent of banking system (excluding branches); • Cross-sectoral: 99 percent of total assets in the banking system (including foreign bank branches), 35 percent of total assets of the insurance industry (100 percent of domestic insurers), 17 percent of total net asset value of investment funds (100 percent of domestic funds). • Market-based global: 70 percent of banking system excluding branches (100 percent of market capitalization of listed banks).
	Data and baseline date	• December 2017 for cross-border, June 2017 for cross-sectoral, 2005-2018 for market-based. • Source: supervisory data (COREP: LE, AMM, LCR, FINREP: AE) for cross-border, proprietary MFSA dataset from various supervisory reports for cross-sectoral, Bloomberg for market-based. • Scope of consolidation: consolidated (sub-consolidated for subsidiaries) only within own sector.
2. Channels of risk Propagation	Methodology	• Cross-border and cross-sectoral: Espinosa-Vega and Sole Bank Network Model (2010) framework and calibrated based on Covi, Gorpe, and Kok (2018) CoMap methodology.
4. Tail shocks	Size of the shock	• Pure contagion: hypothetical default of institutions.
5. Reporting format for results	Output presentation	• Number of undercapitalized institutions in distress. • Capital shortfall systemwide, by bank, and by group (contagion and vulnerability scores). • Amplification and cascade effects, and direction and size of spillovers within the network. • Net spillovers due to interconnectivity (market-based).

Appendix III. Stress Test Macro Scenario Calibration – Technical Details

1. The adverse scenario projections were simulated using the Flexible System of Global Models (FSGM) developed by IMF's Research Department. The EUROMOD version of the FSGM was used to calibrate to Malta's macro conditions and to simulate global shocks and their transmission to Malta in tandem with Malta-specific shocks. FSGM is a semi-structural model combining both micro-founded and reduced-form formulations of various economic sectors (Andrle et al. 2015). In this version of the FSGM, Malta is represented in a "Other EA countries block," where it is incorporated based on its weight in this aggregate block for all the data used for calibration (trade relationships; great ratios in GDP such as investment and consumption shares of GDP, etc.). The historical data is used to pin down initial model parameters based on pooled estimation (advanced, emerging countries, etc.), which are then fine-tuned to generate plausible global model parameters. The scenario targets Malta-specific characteristics by shocking the relevant parameters.

The country-specific layer associated with a shock to Malta's attractiveness as a business and financial hub was implemented in the form of a synchronized hit to financial and remote gaming sectors. Emanating from structural challenges or a retrenchment of the multinationals, the shocks to these sectors have been considered as tail events resulting in a contraction of -9.6 percent and -11.2 percent, respectively, corresponding to 95th percentile of yearly declines in their gross value added (1995-2017). The magnitude of the combined impact on Malta's GDP was estimated at -2.4 percentage points, using sector-specific multipliers recently estimated in Rapa (2017[1]This shock was then incorporated as an additional layer in the FSGM model.

2. Historical data formed the basis for calibrating market shocks as tail events. The shock to the Malta sovereign interest rate has been aligned with historical data placing it in the middle between low-spread (core) and high-spread (periphery) euro area countries, deviating by 122 bps from the baseline in the second year. The calibration of investment and sub-investment grade corporate spreads were done exogenously based on the 95th percentile of the historical annual changes using daily iTraxx euro 5 year and iTraxx cross-over data (2004-2017), leading to a widening of spreads by 80.8 and 295.0 bps, respectively, in relation to 2017 levels. Likewise, the projection of equity prices was based on the historical distribution of MALTEX index by taking the 95th percentile of annual declines (2004-2017), leading to 28.6 percent drop in the first year. In all cases, the prominent shock takes place in the first year, continues to worsen slightly into the second year, and eases somewhat in the third year.

3. The FSAP team, in collaboration with the Maltese authorities, made exogenous adjustments to house prices under the adverse scenario: House prices were assumed to decline

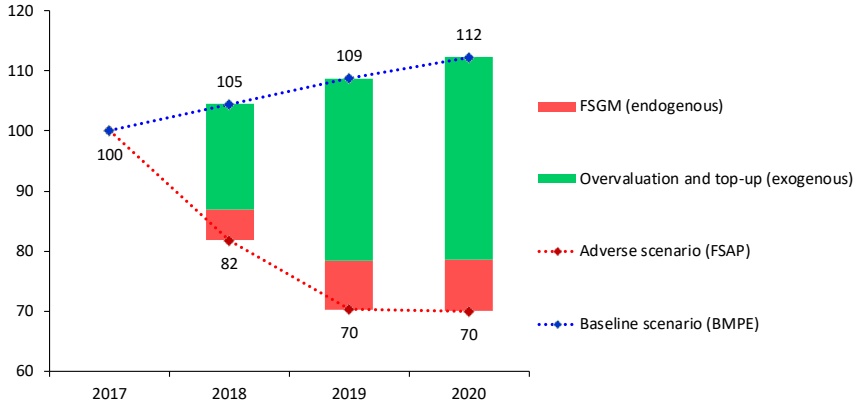
[1] A similar application was used in Cassar (2017). One caveat of this approach is the treatment of a sectoral contraction as a demand-driven shock rather than a supply shock. However, there are two mitigating factors. Firstly, the supply side would adjust to the changes in demand since this is a structural shock considered to be long-term in nature. Secondly, the demand for the services of the remote gaming sector and some segments of the financial sector have a large external component. It is important to note that these studies have not been used by the Maltese authorities to estimate the impact of a similar tax-harmonization shock.

by 30 percent in cumulative terms over the 3-year stress horizon. Such a drop would be in line with international experience during financial crisis periods (e.g., Hong Kong, Ireland, Spain) and would be comparable with the assumptions made in recent European and other advanced country FSAPs (e.g., Luxembourg, New Zealand, Sweden). The calibration of the house price correction incorporated both endogenous and exogenous factors, resulting in a 1-to-4 proportion (see Figure 1). The endogenous component is model-driven associated with global shocks and the Malta-specific shocks. The exogenous component comprises a correction due to overvaluation of prices estimated at end-2017 (including the removal of the cumulative growth in prices under the baseline) as well as the additional top-up consistent with a total cumulative decline of 30 percent in prices[2]

Figure 1. Malta: House Prices—Adverse Scenario Calibration

Contribution to deviation from baseline

(in percentage points)



Sources: BMPE and IMF staff calculations.

4. The unemployment rate was adjusted downward to better reflect the labor market dynamics in Malta, which has one of the lowest unemployment rates amongst EU countries. The model considers the weaker relationship between output and unemployment in Malta compared with other EU economies, as documented in Micallef (2017). Malta-specific coefficients were used to recalibrate the impact of the adverse scenario on the unemployment rate. Using dynamic specification accounting for asymmetric relationship during economic contractions, the deviation of unemployment rate from baseline peaked at 1.5 percentage points in 2020 under the adverse scenario

[2] Econometric analyses of equilibrium house prices conducted by the IMF staff suggest some overvaluation, although the estimated size of overvaluation varies, depending on the choice of house price index. Authorities' econometric models also hint at some overvaluations, but they are currently small in size. See the Technical Note on Macroprudential Policy Framework and Tools for details.

Appendix IV. Solvency Stress Test – Credit Risk Estimations

This appendix provides an overview of the methodology used to quantify credit risks, as well as further information on data and implementation.

1. For corporate and mortgage loans, the credit risk estimation used NPL-based projections for each bank. The bank-by-bank historical data was provided by CBM and MFSA on a quarterly basis from 2004Q3 to 2017Q4, while the macroeconomic data were taken from Bloomberg, Haver Analytics, IMF's International Financial Statistics, and the IMF's *World Economic Outlook* database. The macroeconomic series for adverse scenario follows the scenario set for this stress test.

2. The NPL ratios were transformed using logistic transformation to ensure the models only produce NPL predictions between 0 and 1 (or, equivalently, between 0 and 100 percent) and to capture nonlinearities. This logistic transformation captured non-linearities between the NPL ratios (dependent variable) and macro-financial variables (explanatory variables). The following logistic transformations were applied to the original NPL ratios:

$$Y_{k,j,t} = \ln\left(\frac{NPL_{k,j,t}}{1 - NPL_{k,j,t}}\right),$$

where $NPL_{k,j,t}$ denotes the NPL ratio for bank *k*, exposure class *j,* at time *t*.

3. The fixed-effect panel regression was used to project the NPL ratio, both for the baseline and adverse scenario. To estimate the impact of shocks of macrofinancial variables on NPL, the logit-transformed NPL was modeled as a linear function of different exogenous macroeconomic and financial variables. The model is expressed in the following equation:

$$Y_{k,j,t} = \alpha + \vartheta_k + \delta Y_{k,j,t-1} + \phi' X_t + \varepsilon_{k,j,t} \qquad (1)$$

where $Y_{k,j,t}$ captures the logit transformation of the NPL ratio for bank *k,* exposure class *j,* at time *t*, and X_t is a vector of macro-financial variables specified in the stress testing scenarios. $Y_{k,j,t-1}$ is the vector of lagged dependent variables, ϑ_k represents a bank-specific fixed effect term, and $\varepsilon_{k,j,t}$ represents an independently and identically distributed error term.

4. Due to some banks operating in different countries, models for corporate loans were conducted separately for these banks. Some banks in the sample have exposures outside Malta, which are quite different with the other sample banks. Therefore, to capture the specific macro variables relevant to these banks, the credit risk estimation for these banks was conducted separately using time-series regression. The time series model follows the following equation:

$$Y_t = \alpha + \delta Y_{t-1} + \phi' X_t + \varepsilon_t \qquad (2)$$

where $Y_{j,t}$ captures the logistic transformation of the NPL ratio for corporate loans at time *t*, and X_t is a vector of macro-financial variables specified in the stress testing scenarios. Y_{t-1} is the vector of

lagged dependent variables and $\varepsilon_{k,j,t}$ represents an independently and identically distributed error term.

5. The projected logit NPLs under the baseline and adverse scenarios were then transformed to get the NPL ratios projection. The projected logit NPLs based on the credit satellite model were then transformed to derive the NPL ratios projection using the following formula:

$$NPL_{k,j,t}^{Proj} = \frac{1}{1+\exp(-Y_{k,j,t}^{Proj})}$$

6. For loans to both credit and other financial institutions, the credit risk estimation uses Moody's Expected Default Frequencies for PD-based projections. The projection covers 10 countries where sample banks have significant exposures to credit and other financial institutions. The average EDF dataset was taken from 2004Q1 to 2017Q4, while the macroeconomic data were taken from Bloomberg, Haver Analytics, IMF's International Financial Statistics, and the IMF *World Economic Outlook* database and. The macroeconomic series under the adverse scenario followed the scenario set for this stress test.

7. Similar with the NPL-based approach, the PDs were transformed using logistic transformation to ensure the models only produce PDs predictions between 0 and 1 (or, equivalently, between 0 and 100 percent) and to capture nonlinearities. This logistic transformation captured non-linearities between the PDs (dependent variable) and macro-financial variables (explanatory variables). The following logistic transformation was applied to the original PDs:

$$Y_{g,t} = \ln\left(\frac{PD_{g,t}}{1-PD_{g,t}}\right),$$

8. The fixed-effect panel regression was used to project the PDs, both for baseline and adverse scenarios. To estimate the impact of the shocks of macrofinancial variables on PDs, the logit-transformed PDs was modeled as a linear function of different exogenous macroeconomic and financial variables. The model could be expressed as follows:

$$Y_{g,t} = \alpha + \vartheta_g + \delta Y_{g,t-1} + \phi' X_t + \varepsilon_{g,t} \qquad (3)$$

where $Y_{g,t}$ captures the logistic transformation of PDs for region or country *g*, at time *t*, and X_t is a vector of macro-financial variables specified in the stress testing scenarios. $Y_{g,t-1}$ is the vector of lagged dependent variables, ϑ_g represents the region- or country-fixed effect term, and $\varepsilon_{g,t}$ represents the independently and identically distributed error term. For some countries, the projection of PDs was conducted separately using time-series regression.

9. The projected logit PDs under baseline and adverse scenarios were then transformed to get the PDs projection. The projected logit PDs based on the credit satellite model were then transformed backed to get the PDs projection using the following formula:

$$PD_{g,t}^{Proj} = \frac{1}{1 + \exp(-Y_{g,t}^{Proj})}$$

The proxied PD was then mapped to each bank according to its geographical loan distribution and the type of financial institution it is lends to (credit or other financial institutions). Due to the unavailability of EDF for financial institutions in Malta, the PD projection for loans to credit and financial institutions in Malta was calculated as the median PD of euro area countries in the sample.

10. The credit risk estimations suggest the following results:

- For corporate loans, the increase in NPLs are mainly explained by the GDP growth in the respective geographical areas of bank exposures. However, there were exceptions. In one case, the price of oil was used to represent the GDP growth of a country where one sample bank operated. In another case, house prices were used in a country where another sample bank had significant exposure of real-estate corporate lending. These proxies proved to be significant factors in explaining the increase in the respective NPL ratios. For five banks concentrated in the domestic market, the decline in GDP growth due to external and domestic shocks was one of significant factors contributing to the increase of corporate NPL. In addition, the assumed decline in housing prices was also a large contributor, reflecting (i) the high share of lending to real estate and construction, and (ii) the nature of the corporate sector in Malta, which is dominated by small- and medium-sized enterprises, and where a major share of wealth is in property. Other factors contributing to the NPL ratio of corporate loans were interest rates (either annual change or level) and sovereign spreads.

- For mortgage loans, credit risk was sensitive to changes in housing prices, changes in the unemployment rate, and wage growth. The last two variables reflect the income effects that impact the repayment capacity of *households*.

  PDs of credit and other financial *institutions* were sensitive to GDP growth of each relevant geographical area, interest rates (either the level or changes), and the U.S. stock market volatility index

Table 1. Malta: MNPL Estimation Equation

Variables	Corporate (logit NPL)				Mortgage (logit NPL)
	5 banks	Bank A/B	Bank C	Bank D	6 banks
L1 dependent variable	0.7353***	0.7966***	0.5353***	0.7969***	0.6217***
	(0.0738)	(0.0734)	(0.1397)	(0.0679)	(0.0638)
L2 dependent variable	0.1802***		0.1047		0.1637***
	(0.0693)		(0.1298)		(0.0629)
L2 EA GDP growth		-7.6995*			
		(4.3255)			
L3 EA GDP growth			-3.2162*		
			(1.8475)		
L5 Malta GDP growth	-1.0885***				
	(0.3312)				
L3 Annual Change in Oil Price			-0.2122**		
			(0.0927)		
L1 YoY in Housing Price - other country				-3.7579**	-0.6506**
				(1.4097)	(0.3251)
L5 YoY in Housing Price - Malta	-0.3105**				
	(0.1552)				
L2 Wage growth					-1.3515*
					(0.6944)
L7 Annual Change in Unemployment rate					0.0924**
					(0.0394)
L1 Annual Change in GBP Libor		0.1008			
		(0.0657)			
L1 USD Libor			0.1054***		
			(0.0336)		
L1 Annual Change in LT rate - other country				0.0350*	
				(0.0196)	
L1 Sovereign Spread	0.0328*				
	(0.0181)				
Time dummy variable		0.5638**		0.7057***	
		(0.2206)		(0.2598)	
Constant	-0.1246*	-0.9658**	-1.0227***	-0.9353**	-0.6005***
	(0.0658)	(0.4038)	(0.2594)	(0.3522)	(0.1412)
Adjusted R-squared	0.94	0.94	0.84	0.96	0.90
Observations	210	48	49	44	252

Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Sources: CBM, MFSA, and IMF staff calculations.

Table 2. Malta: PDs Estimation Equation

Variables	Credit Institutions (logit PD)			Financial Institutions (logit PD)		
	G1	G2	G3	G1	G2	G3
L1 dependent variable	0.8639***	0.7704***	0.6218***	0.8619***	0.7984***	0.7182***
	(0.0485)	(0.0648)	(0.1714)	(0.0288)	(0.0553)	(0.1504)
L3 G1 GDP growth	-6.5896**					
	(3.3092)					
L4 G1 GDP growth				-1.8587**		
				(0.9148)		
L5 G2 GDP growth		-4.6376**				
		(1.8351)				
L0 G3 GDP growth (Contemporaneous)			-5.0924**			
			(2.1715)			
L2 G3 GDP growth						-2.9617*
						(1.5871)
L1 GBP Libor rate					0.0175*	
					(0.0103)	
L2 GBP Libor rate		0.0583**				
		(0.0276)				
L2 Annual Change in Long-term rate			0.0239			
			(0.0244)			
L1 Annual Change in Euribor rate				0.0372**		0.0469*
				(0.0167)		(0.0259)
L2 Annual Change in Euribor rate	0.1128**					
	(0.0540)					
L0 Volatility Index (Contemporaneous)	0.0103***			0.0122***	0.0134***	
	(0.0029)			(0.0021)	(0.0032)	
Constant	-0.7891***	-1.1445***	-1.2759**	-0.8268***	-1.2550***	-0.9646**
	(0.2686)	(0.3417)	(0.6256)	(0.1534)	(0.2969)	-0.478
Adjusted R-squared	0.80	0.75	0.77	0.84	0.88	0.77
Observations	196	47	47	336	55	50

Note: Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

G represents geographical area, i.e. region or country

Sources: CBM, MFSA, and IMF staff calculations.

Appendix V. Solvency Stress Test – Funding and Lending Rate Estimation

This appendix provides an overview of the methodology used to project funding and lending rates, as well as information on data and implementation.

1. Bank funding costs were estimated based on the effective funding rate for each bank. The effective funding rate was calculated from the ratio of interest expense to interest-bearing liabilities for each bank. The data was provided by the authorities on a quarterly basis from 2004Q3 to 2017Q4. The macroeconomic data was sourced from Bloomberg, Haver Analytics, IMF's International Financial Statistics, the IMF's *World Economic Outlook* database. The macroeconomic series for the adverse scenario followed the scenario set for this stress test.

2. The funding rate estimation was conducted using a fixed-effect panel regression. The fixed-effect panel regression was used to project funding rates for 11 sample banks using the following specification:

$$Y_{k,t} = \alpha + \vartheta_k + \delta Y_{k,t-1} + \phi' X_t + \varepsilon_{k,t}$$

where $Y_{k,t}$ captures the funding rate for bank *k,* at time *t,* and X_t is a vector of macro-financial variables specified in the stress testing scenarios. $Y_{k,t-1}$ is the vector of lagged dependent variables, ϑ_k represents the bank specific fixed-effect term, and $\varepsilon_{k,t}$ represents the independently and identically distributed error term.

3. The result suggests the funding rates were associated with short-term market funding rate movements. The most statistically significant factors were 3-months Euribor and U.S. dollar Libor, which represent the deposits structure of sample banks.

Table 1. Malta: Funding Rate Equation

Variables	Effective Funding Rate
L1 dependent variable	0.4385***
	(0.099)
L2 dependent variable	0.1388*
	(0.074)
L2 3-month Euribor	0.110***
	(0.047)
L1 USD Libor	0.168***
	(0.036)
Constant	0.0048***
	(0.0009)
Adjusted R-squared	0.76
Observations	509

Note: Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

4. The lending rate is projected based on its relationship with funding rates using quantile regression at the 90th percentile. This represents an imperfect pass-through of changes in the interest rate of liabilities to the interest rate of assets, leading to a shrinking in net interest margins under the adverse scenario[1] The sample was based on the interest rate on assets and liabilities of each sample bank sourced from FINREP from 2015Q3 to 2017Q4 (adjusted data sample).

Table 2. Malta: Quantile Regression Equation

Variables	Change in Effective Interest Rate on Assets
Change in Effective Interest Rate on Liabilities	0.7134***
	(0.036)
Constant	0.0086***
	(0.001)
Adjusted R-squared	0.25
Observations	487

Note: Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1
Method: Quantile regression (tau = 0.9)

[1] The assets and liabilities were limited to interest-bearing assets and liabilities.

Appendix VI. Liquidity Stress Test Parameters

Table 1. Malta: LCR-Based Test Parameters

(percent)

	Scenarios			
	CRR Weights	1	2	3
A. High Quality Liquid Assets				
Central government assets	100	100	**95**	**95**
Regional government / local authorities assets	100	100	**95**	**95**
Public Sector Entity assets	100	100	**95**	**95**
Recognisable domestic and foreign currency central government and central bank assets	100	100	**95**	**95**
Credit institution (protected by Member State government, promotional lender) assets	100	100	**95**	**95**
Multilateral development bank and international organisations assets	100	100	**95**	**95**
Qualifying CIU shares/units: underlying is coins/banknotes and/or central bank exposure	100	100	**95**	**95**
Qualifying CIU shares/units: underlying is Level 1 assets excluding extremely high quality covered bonds	95	95	**90**	**90**
B. Outflows				
Retail deposits				
Deposits subject to higher outflows				
category 1	15	15	15	15
category 2	20	20	20	20
Stable deposits	5	**11**	**11**	**11**
Derogated stable deposits	3	**6**	**6**	**6**
Other retail deposits	10	**21**	**21**	**21**
Operational deposits				
Maintained for clearing, custody, cash management or other comparable services in the context of an established operational relationship				
covered by DGS	5	**8**	**8**	**8**
not covered by DGS	25	**41**	**41**	**41**
Non-operational deposits				
Correspondent banking and provisions of prime brokerage deposits	100	100	100	100
Deposits by financial customers	100	100	100	100
Deposits by other customers				
covered by DGS	20	**25**	**25**	**25**
not covered by DGS	40	**51**	**51**	**51**
Run-off of non-resident deposits *				
Current deposits	0	0	0	**46**
Saving deposits	0	0	0	**36**
Time deposits	0	0	0	**33**

**Notes: To avoid double counting of outflows, the additional withdrawals of non-resident deposits is based on the difference between these rates and other retail deposits*

Sources: EU's Capital Requirements Regulation and IMF staff calculations.

Notes: CIU = collective investment undertaking; DGS = deposit guarantee scheme.

Table 2. Malta: NSFR-Based Test Parameters

(percent)

	Baseline	Adverse
ASF Factor 100percent		
(a) Tier 1 capital instruments	100	100
(b) Tier 2 capital instruments	100	100
ASF Factor 95percent		
Stable retail deposits	95	89
ASF Factor 95percent		
Less stable retail deposits	90	79
ASF Factor 50percent		
(a) Liabilities from secured lending and capital market driven, collateralized by HQLA	50	40
(b) Liabilities from secured lending and capital market driven, collateralized by other assets	50	40
(c) Liabilities from unsecured lending transaction	50	40
RSF Factor 0percent		
(a) Cash		
(b) Exposure to central bank		
RSF Factor 5percent		
Unencumbered level 1 assets - excluding cash and central bank reserves	5	10
RSF Factor 15percent		
(a) corporate bonds - extremely high liquidity and credit quality assets	15	20
(b) loan to borrower of which are financial customers other than credit institutions	15	25
RSF Factor 25percent		
corporate bonds - high liquidity and credit quality assets	25	30
RSF Factor 35percent		
corporate bonds - other assets	35	40
RSF Factor 50percent		
(a) loan to SME that qualify for the retail exposures	50	70
(b) loan to the borrowers other than financial customers	50	60
(c) loan to borrower of which are financial customers other than credit institutions	50	60
RFS Factor 65percent		
(a) Non-renewable loans that are collateralized by commercial real estate	65	80
(b) Non-renewable loans that are collateralized by residential real estate	65	80
RFS Factor 100percent		
(a) All assets unencumbered for a period of one year or more	100	100
(b) Derivative receivables	100	100

Sources: EU's Capital Requirements Regulation and IMF staff calculations.

Notes: ASF = available stable funding; RFS = required stable funding.

Table 3. Malta: Cash-flow-Based Test Parameters

(percent)

	4 weeks	3 months	5 days
A. Run-off and Roll-off Rates			
LT Unsecured issuance	50	50	50
Repo across all colateral classes	30-50	30-50	30-50
Stable retail deposits	6	7	6
Unstable retail deposits	13	15	13
Operational corporate deposits	30	35	30
Non-operational corporate deposits and other	50	55	50
Deposits FI	33	35	33
Other Outflows	100	100	100
FX-swap in/outflows	100	100	100
Derivative in/outflows	100	100	100
Repo across all colateral classes	100	100	100
Retail/Corporate inflows	50	50	95
FI Inflows	100	100	100
Central bank deposits inflows	100	100	100
Other Inflows	100	100	100
Additional run-off for non-resident deposits:			
- Current	25	37	10
- Saving	15	23	7
- Term	11	17	6
B. Counterbalancing Capacity			
Withdrawable central bank reserves	100	100	100
Level 1 tradable assets	90-100	90-100	90-100
Level 2A tradable assets	85	85	85
Level 2B tradable assets	50-75	50-75	50-75
Other tradable assets	50-95	50-95	50-95

Source: IMF staff calculations.

Note: In calculating LCR, there are three categories of liquid assets: Level 1 (highest level), Level 2A, and Level 2B (lowest level).

Appendix VII. Balance Sheet-Based Interconnectedness Analysis – Technical Details

This appendix provides an overview of the methodology used to quantify contagion risks, as well as further information on data and implementation.

Methodology

1. The balance sheet-based network analysis follows the CoMap framework (Covi, Gorpe, and Kok, 2019), which extends the simple bank network model of Espinosa-Vega and Sole (2011). The data requirements of the CoMap framework is fully consistent with the latest euro area supervisory reporting regimes. It advances the simple interbank exposure model with credit and funding shocks by incorporating bank and exposure-specific parameters and liquidity dynamics that reflect heterogeneity across entities.

Credit Shock

2. Credit shock captures the impact of a bank defaulting on its obligations to other banks. As a result, a bank incurs losses on a share of its claims depending on the nature and counterparty of its exposures. Exposure-specific loss-given default rates reflect the precise risk mitigation and collateralization that a bank has accounted for in its claims vis-à-vis each counterparty. Assume $\mathcal{Z}$ is the complete set of all banks in the network. Should a subset of banks ($\mathcal{Y} \subset \mathcal{Z}$) default on their obligations, *bank i*'s losses are summed across all banks $j \in \mathcal{Y}$ and claim types k using exposure-specific loss-given default rates, λ_{ij}^{k}, corresponding to its claim of *type k* on *bank j*, x_{ij}^{k}:

$$\sum_{j\in\mathcal{Y}}\sum_{k}\lambda_{ij}^{k}x_{ij}^{k}, where\ \lambda_{ij}^{k} \in [0,1]\ and\ i \notin \mathcal{Y} \qquad (2)$$

Funding Shock and Liquidity Dynamics

3. Funding shock represents how a bank's withdrawal of funding from other banks forces them to deleverage by selling assets at a "fire sale" discount. In response to a subset of banks defaulting or getting into distress ($\mathcal{Y} \subset \mathcal{Z}$), and thereby withdrawing funding from other counterparties, *bank i* faces a funding shortfall summed across all banks $j \in \mathcal{Y}$ using its specific funding shortfall rate, ρ_i:

$$\sum_{j\in\mathcal{Y}}\rho_i x_{ji}, where\ \rho_i \in [0,1] \qquad (5)$$

4. In practice, for immediate liquidity needs, banks can pledge HQLA as collateral to the central bank for overnight borrowing. From a modeling perspective, this implies that *bank i* can offset funding its shortfall with the new credit line up to its liquidity surplus (HQLA in excess of net liquidity outflows), γ_i, with the remaining liquidity shortage computed as:

$$max\left\{0, \sum_{j\in y} \rho_i x_{ji} - \gamma_i\right\} \qquad (7)$$

A constraint on the amount of remaining pool of assets available to the bank, θ_i, sets an upper threshold to how much of the remaining liquidity shortage can be sustained with the fire sale proceeds after accounting for haircuts proportional to a discount rate, δ_i. As a result, the deleveraging amounts to the sale of assets equivalent to:

$$min\left\{\frac{1}{1-\delta_i} max\left\{0, \sum_{j\in y} \rho_i x_{ji} - \gamma_i\right\}, \theta_i\right\}, where\ \delta_i \in [0,1] \qquad (8)$$

5. While credit shocks translate directly to a weakening of a bank's capital, funding shocks lead to depletion of its liquidity and to capital losses via fire sales. In a distress event, the capital of exposed counterparties, such as *bank i*, must absorb the losses on impact. Then, *bank i* is said to become insolvent if its capital falls below a certain threshold c_i^d, which may be defined as the bank's minimum capital requirements with or without capital buffers. In other words, *bank i* is said to fail if its capital surplus $(c_i - c_i^d)$ is insufficient to fully cover the combined credit and fire-sale losses:

$$c_i - c_i^d < \sum_{j\in y}\sum_k \lambda_{ij}^k x_{ij}^k + \delta_i min\left\{\frac{1}{1-\delta_i} max\left\{0, \sum_{j\in y} \rho_i x_{ji} - \gamma_i\right\}, \theta_i\right\} \qquad (12)$$

6. In terms of the impact through the liquidity channel, bank i's liquidity surplus serves as the first line of defense. However, the remaining liquidity shortages might require a large-scale fire sale operation relative to its financial assets. Having already exhausted its liquidity surplus, *bank i* becomes illiquid if its remaining assets are insufficient to match the liquidity shortage:

$$\theta_i < \frac{1}{1-\delta_i} max\left\{0, \sum_{j\in y} \rho_i x_{ji} - \gamma_i\right\} \qquad (13)$$

7. Bringing the full network of banks into the picture, in each simulation the exercise tests the system for a given bank's default. The initial default of bank 1 is triggered by design in order to study the cascade effects and contagion path it causes through the interbank network. The exercise moves to subsequent rounds if there are additional failures in the system and stops when there are no other failures. The exercise repeats this sequence to simulate for each bank as the trigger default event.

8. In terms of results, this exercise generates a selection of outputs customized specifically for Malta:

- **Contagion index**: This indicator captures each bank's potential contagion (i.e., systemic impact) by taking a weighted average of losses of all other banks in percent of their capital;

$$CI_i = 100\frac{\sum_{j\neq i} L_{ji}}{\sum_{j\neq i} k_j},$$

where L_{ji} is the loss experienced by *bank j* due to the triggered default of *bank i*. This indicator then can be used to compare banks in the network in terms of how much contagion each bank causes to the system if it was to experience severe distress (a tail event).

- **Vulnerability index**: This indicator gauges each bank's degree of vulnerability, averaged across all individual default events with identical probability:

$$VI_i = 100\frac{\sum_{j\neq i} L_{ij}}{(N-1)k_i},$$

where L_{ij} is the loss experienced by *bank i* due to the triggered default of *bank j*. This indicator can be used to compare fragility of banks to systemic events. Banks that on average incur greater losses due to their exposures are deemed more vulnerable. The average losses take into account both the magnitude of a bank's losses (in response to each default event) and the frequency with which it experiences losses (by treating each default with equal probability).

These indicators can be further broken down into sub-indices based on the portion of losses that can be attributed to credit shocks versus funding shocks. They can also be decomposed based on a bank's geographical origins and business models to better map how contagion spreads.

- **Contagion default**: This indicator tracks the number of banks that experience severe distress associated with the triggered default of *bank i*. Whereas the contagion index measures the degree of losses within a continuous range associated with a default event, contagion default is a discreet indicator based on a binary "pass or fail" outcome. It gauges how many other banks in the network become undercapitalized.

- **Default frequency**: This indicator tallies the total number of simulations under which *bank i* falls below the capital distress threshold. Similarly, whereas the vulnerability index measures the degree of losses within a continuum, default frequency is a discreet indicator, gauging the binary outcomes.

- **Amplification ratio**: This metric compares the losses induced by a bank's simulated default in the initial round vis-à-vis those occurring in all successive rounds. From the perspective of a bank, *bank i*, triggering system-wide contagion:

$$AMP(C)_i = \frac{\sum_{j\neq i} L_{ji\,r_{0+t}}}{\sum_{j\neq i} L_{ji\,r_0}},$$

$$where\ r_0 = initial\ round;\ r_{0+t} = all\ successive\ rounds\ until\ termination.$$

This indicator complements the total number of rounds it takes for cascade defaults to subside. It measures how much of the system-wide impact from the failure of *bank i* is caused by the cascading of defaults rather than direct and immediate losses from *bank i*. Hence, the higher the ratio, the larger the amplification through the network, and a ratio greater than 1 indicates that losses due to cascade effects dominate direct losses. Conversely, bank susceptibility to systemic

events can be split into two similar components to distinguish how much of the losses experienced by *bank i* across all simulations were immediate losses as opposed to losses in successive rounds:

$$AMP(V)_i = \frac{\sum_{j \neq i} L_{ij}\, r_{0+t}}{\sum_{j \neq i} L_{ij}\, r_0}$$

Data Calibration and Implementation

9. Contagion analysis for both the cross-border interbank network and domestic cross-sectoral financial network relies on the CoMap methodology. Since both networks included Maltese *significant institutions*, the supervisory data was provided in a secure room at the ECB. While the analysis of interbank network follows precisely the guidelines in Covi, Gorpe, and Kok (2019), the framework had to be tailored to incorporate insurers and funds in the implementation of the cross-sectoral network.

Cross-Border Interbank Network

10. The data sources and calibration are briefly summarized here as detailed presentation can be found in the referenced study.

- **Scope**: All non-branch banks (22) in Malta report large exposures. However, one bank has no large exposures vis-à-vis other financial institutions, effectively reducing the main sample size to 21. Using the large credit and funding exposures reported by these 21 Maltese banks, the sample is expanded to incorporate significant foreign counterparties (58), increasing the full network size to 79 banks in total ($\mathcal{Z}$=79). Since the construction of the matrix of bilateral exposures is limited to the supervisory data provided only by Maltese banks, its focus is Malta-centric. This implies that the analysis is designed to capture inward spillovers from foreign entities toward Maltese banks. Furthermore, the limited granular data on foreign entities would make it challenging to accurately calibrate model *parameters* for those banks. Therefore, the model outputs in the cross-border analysis computes contagion to Maltese banks, whether the contagion comes from non-Maltese banks (inward spillover) or Maltese banks (domestic spillover).

- ***Large credit exposures*** (x_{ij}^k): COREP Large Exposures templates (C.27 and C.28) shows the breakdown of each bank's assets by counterparty and asset class, including associated credit risk mitigation, collateralization, and exemptions. A large exposure is defined as an exposure that is 10 percent or more of a bank's eligible *capital* base vis-à-vis a single borrower or a group of connected clients.

- ***Large funding exposures*** (x_{ji}): COREP Concentration of Funding templates (C.67.00.a) reports the top ten largest counterparties as a single creditor or a group of connected clients, where obtained funding exceeds 1 percent of the bank's total liabilities. In order to expand the scope to cross-border exposures, large exposures *reporting* on the asset side was complemented with the largest funding sources on the liabilities side of Maltese bank balance sheets.

- ***Loss-given-default rate*** (λ_{ij}^{k}) is calibrated at the exposure level using the ratio of net exposures to bank capital after accounting for credit risk *mitigation*, collaterals, and exemptions to gross exposures vis-à-vis each counterparty (C.28 and C.28).

- ***Funding shortfall rate*** (ρ_i) is calibrated at bank level using the share of obligations with maturities shorter than 30 days. It is estimated for each bank using maturity information of the largest funding sources (C.67.00.a) and large credit exposures (C.30).[1]

- ***Liquidity surplus*** (γ_i) is calculated as the stock of *HQLA* above the net funding outflows (NLO) over a 30-day liquidity distress scenario. Both HQLA and NLO are reported on Liquidity Coverage Ratio templates (C.72.00-C.76.00).

- ***Liquidity constraint*** (θ_i), or pool of financial assets available for fire-sale, is calibrated as the total amount of unencumbered non-central bank *eligible* assets reported in Asset Encumbrance templates (F.32.01).

- ***Fire-sale discount rate*** (δ_i) is estimated for each bank based on the portfolio of its assets classified under unencumbered non-central bank eligible assets weighted by relevant haircuts. Respective haircut rates for each asset class is based on ECB guidelines on haircuts after applying a lower bound haircut, which is the highest haircut used for central bank eligible instruments.[2]

- ***Default/distress threshold*** (c_i^d) is based on CET1 minimum requirement plus additional buffers. The additional buffers include the capital conservation buffer, a bank-specific buffer for *other systemically important institutions* (applicable to *significant institutions*), and countercyclical buffer. To be conservative, we consider depletion of capital enough to penetrate through the capital buffers, signaling acute distress for the bank that triggers it to default on its obligations and withdraw funding. A less conservative default threshold based on only the minimum CET1 requirement is considered for robustness.

Table 1. Malta: Summary Statistics of Calibrated Model Parameters

	Weighted average	Min	Max
Loss-given-default rate (λ_{ij}^{k})	0.65	0	1
Funding shortfall rate (ρ_i)	0.41	0.18	0.95
Fire-sale discount rate (δ_i)	0.55	0.46	0.68

[1] *Bank i*'s credit exposure to *bank j* can be equally thought of as the amount of funding provided by *bank i* to *bank j*.

[2] The ECB guidelines on valuation haircut levels are available at https://www.ecb.europa.eu/ecb/legal/pdf/celex_32018o0004_en_txt.pdf.

Table 2. Malta: Breakdown of Bank-Specific Default Thresholds (c_i^d)
(in percent of RWA)

Minimum CET1	Buffers:			Total
	Capital conservation buffer	O-SII[3]	Countercyclical buffer	
4.5	1.875	Ranging from 0.375 to 1.5 for *significant institutions*; 0 for *other banks*	0	Ranging from 6.75 to 7.875 for *significant institutions*; 6.375 for *other banks*

Note: O-SII = other systemically important institution

Cross-Sectoral Domestic Financial Network

11. The contagion analysis of the cross-sectoral linkages in the domestic financial system relied mostly on a unique dataset constructed by MFSA as of June 2017.

- **Scope**: The dataset encompassed the entire banking sector, including foreign branches (but *excluded* one bank with no exposures to financial institutions scope). It also included domestically-relevant entities from the insurance and investment fund sectors. This resulted in a full sample of 40 financial entities comprising 24 banks, 8 insurers, and 8 funds.

- **Bilateral credit and funding exposures**: The counterparty-level and by-instrument interfirm exposure data constructed by MFSA combines multiple supervisory reporting templates from different financial industries. These include MFSA Banking Rule 06 reports for banks, Investment Fund *reports*, and Solvency II Quantitative Reporting templates for insurers. Security-by-security reporting was fundamental to establish debt and equity interlinkages. The FSAP team used COREP Large Exposures templates (C.27 and C.28) to fill in the interbank loan exposures in this otherwise comprehensive dataset. The resulting dataset comprises a 40-by-40 matrix for each instrument: loans, deposits, debt, and equity.

- ***Loss-given-default* rate** (λ_{ij}^k) for interbank lending is calibrated as the ratio of net exposures to gross exposures vis-à-vis each counterparty (C.27 and C.28). As risk mitigation measures and collateral information wasn't available for other exposures, instrument-specific assumptions were made (Table x3).

- ***Funding shortfall rate*** (ρ_i) for interbank exposures is calibrated at bank level using the share of obligations with *maturities* shorter than 30 days using granular bank reporting templates. As

[3] The 2017 phased-in requirements in Table A.VII.2 are available at http://www.centralbankmalta.org/systemically-important-institutions.

detailed information wasn't available for other exposures, instrument-specific assumptions were made (Annex Table VII.3).

Table 3. Malta: Model Assumptions and Sample Averages

	Interbank loans	Other loans	Debt securities	Deposits	Equity	Sample average
Loss-given default	Calibrated	0.3	0.6	1	1	0.8
Funding shortfall	Calibrated	0.5	0.3	1	0	0.5

- ***Bank-level data:*** Bank-level model inputs (liquidity surplus, liquidity constraint, fires-sale discount rate, and default threshold) have been calibrated as described for the cross-border network analysis in the previous section.

- ***Insurer-level data***: The calibration of respective model inputs has been modified to reflect reporting regimes applicable to insurers. Insurer liquid assets were considered the liquidity surplus while total investment assets *remaining* were considered the liquidity constraint. The fire-sale discount rate was assumed as 0.7 as no granular data was provided on their portfolio composition.[4] For the default threshold, the solvency capital requirement was used as the benchmark, while Tier 1 capital as the less conservative alternative was used for robustness.

- ***Fund-level data***: Similarly, the model inputs had to be adapted to reflect balance-sheet structures of investment funds and their reporting templates. The baseline for liquidity surplus was limited to the amount of cash holdings. In addition to cash, the less conservative calculation considered government securities and short-term debt securities (1 year or less) with a risk weight of 50 percent. The liquidity constraint is equivalent to the sum of non-cash assets. Fire-sale discount rate was calibrated based on each fund's portfolio composition using different haircut assumptions for asset classes, resulting in a sample average of 0.7. Finally, as there is no capital requirement for funds, large *redemptions* were considered as a conceptual equivalent of the severe distress scenario for funds. Under the baseline, the amount is calibrated based on a redemption of 5 percent relative to total net assets, whereas the less conservative alternative is based on a much larger 20 percent redemption shock to trigger distress to the fund.

[4] This is consistent with the average discount rate for insurance companies estimated for contagion analysis in the 2017 Japan FSAP (IMF 2017b).

Appendix VIII. Market-Based Interconnectedness Analysis – Technical Details

This appendix provides an overview of the methodology used to quantify market-based net cross-border spillovers and how it was implemented.

Methodology

1. The market-based interconnectedness analysis follows the Diebold-Yilmaz (2014) approach with some enhancements adapted for the 2018 EA FSAP (IMF 2018b). This approach relies on estimating a vector autoregressive (VAR) model based on time-series data. Within the VAR framework, spillover metrics are derived via a forecast error variance decomposition.

2. Following Demirer et al. (2018), the elastic net estimator (Zou and Hastie 2005) is used to estimate the high-dimensional VAR. This blends shrinkage and selection to recover degrees of freedom, to deal with the "curse of dimensionality." Essentially, the elastic net estimator blends the lasso (Tibshirani 1996) and ridge regression. For the error variance decomposition, the Generalized Variance Decomposition (GVD) is applied (Koop, Pesaran, and Potter 1996; Pesaran and Shin 1998). Compared to the Cholesky decomposition proposed by Sims (1980) and related identification strategies, GVD is invariant to the ordering of variables, which offers more flexibility in modeling strategy without making any *a priori* assumption on the sequence of responses.

3. The estimated error variance decomposition quantifies the proportion of return variability (contemporaneous and H-steps ahead) of a particular bank i, that can be attributed to shocks to returns of another bank j, for instance. This quantity, $C^H_{i\leftarrow j}$ say, is taken to proxy the spillover from *bank j* to *bank i*. Conversely, the proportion of *bank j*'s return variability, given shocks to *bank i*'s returns can also be computed. This would correspond to spillover from *i* towards *j*, i.e., $C^H_{i\rightarrow j}$. It follows that a net spillover measure for bank *i* vis-à-vis *j* would simply be the difference:

$$netspillover_{i\leftrightarrow j} = C^H_{i\rightarrow j} - C^H_{i\leftarrow j}.$$

Data

4. The analysis, conducted at the individual bank level, is meant to capture linkages between Maltese banks and a selected sample of foreign banking counterparts across geographies that are relevant given exposures of Maltese banks. The spillovers are derived using daily returns from equity price data. The sample comprises banks with the following geographical decomposition: 4 from Malta, 13 from the euro area (7 *global systemically important banks*, 6 *significant institutions*), 8 from the rest of Europe (7 *global systemically important banks* and 1 other), 8 from other advanced economies (4 *global systemically important banks*), and 5 from emerging markets. The underlying equity price data for these 38 banks spans the period 2005–18.

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