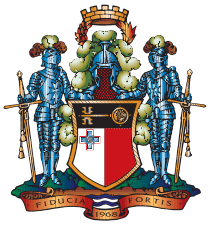

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# THE CENTRAL BANK OF MALTA'S MACRO STRESS TESTING FRAMEWORK

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## BOX 3: THE CENTRAL BANK OF MALTA'S MACRO STRESS TESTING FRAMEWORK[1]

This box presents details of the improvements carried out to the Central Bank of Malta's macro stress testing framework (MST), focusing particularly on the macroeconomic scenario designed specifically for this exercise and revisions to the credit risk module. See Section 3.1.

The macroeconomic scenario draws on the risk assessment presented in Chapter 1. Two scenarios are considered: a baseline based on the Central Bank of Malta's Economic Projections and an adverse scenario designed via the Bank's structural macro-econometric model (STREAM).[2] Relevant exogenous shocks are calibrated following a statistical approach and a consistent scenario is generated by means of STREAM.

The revision of the MST framework also concerned the quantification of credit risk, particularly the projections of the non-performing loan (NPL) ratio for mortgages and loans to NFCs under the baseline and the adverse scenarios. Similar to the IMF's models utilised during the 2018 MT FSAP, the credit risk satellite panel models are developed in a manner to capture the developments in NPL ratios in relation to the main macroeconomic and financial variables under both the baseline and adverse scenario. Further details on the approach followed are presented in the second sub-section of this Box.

### Scenario narrative and calibration

According to the overarching principle of stress testing, a scenario *"should be designed to capture material and relevant risks identified in the risk identification process and key variables should be internally consistent"* and *"a narrative should articulate how the scenario captures the risks".* Moreover, so that the stress test represents *"a meaningful test of banks' resilience"*, the designed scenarios *"should be sufficiently severe but plausible"*.[3]

These principles are embedded in the baseline and adverse scenarios designed to assess core and non-core domestic banks' resilience over a three-year period. The baseline scenario is based on the Central Bank of Malta's Economic Projections, whilst the adverse scenario was designed to capture the systemic risks identified and assessed for the domestic economy as presented in Chapter 1 complemented by the risk drivers identified for the euro area systemic institutions.[4] Particularly, the narrative of the adverse scenario reflects the risk drivers potentially affecting the Maltese economy, namely a growing risk from the external environment stemming from geopolitical uncertainty and concerns about rising protectionism posing downside risk to the domestic economy and triggering repricing in global financial markets in a low interest rate environment.[5]

In the adverse scenario, the domestic economy will experience a severe downturn originating from an external demand shock due to weak economic growth in some trading partners that will affect Malta's export performance and, in turn, domestic GDP. Moreover, uncertainty linked to geopolitical tensions triggers global markets repricing of risk premia spurred by market participants' expectations and the

[1] Prepared by Dr Alessandra Donini, Senior Economist within the Stress Testing and Risk Models Office of the Central Bank of Malta. The author would like to thank Noel Rapa for valuable comments and suggestions.

[2] For further methodological details on the Bank's macroeconometric model, see O. Grech and N. Rapa (2016), "STREAM: A Structural Macro-Econometric Model of the Maltese Economy – Version 3.0", Central Bank of Malta WP/01/2016.

[3] Basel Committee on Banking Supervision, *"Stress testing principles"*, October 2018, available at https://www.bis.org/bcbs/publ/d450.pdf

[4] *"ECB Banking Supervision: Risk Assessment for 2019"*, available at https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ra/ssm.ra2019.en.pdf

[5] Including cybercrime and IT disruptions in the adverse scenario proved to be challenging given that it is difficult to quantify these risks at the current juncture. However, given the recent events affecting domestic banks, and thus the relevance of assessing such risk, the materialisation of this risk, although not included in the scenario, was taken into consideration when quantifying banks' provisions for operational risk.

ensuing interest rate hike in major economies. Such events lead to a worsening in financial market conditions resulting in asset prices falling and steepening of the yield curve which in turn affect bond market valuations.

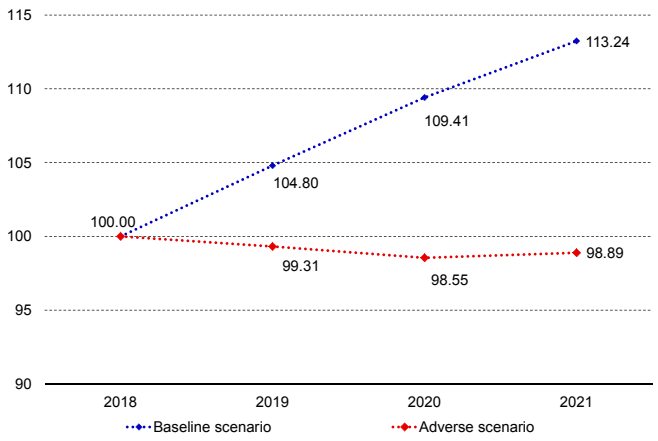
On the one hand, as Malta is a small open economy in a monetary union, a significant drop in external demand would lead to a slowdown in the domestic economy via lower exports. This, in turn, would drive up unemployment with adverse implications on wages and incomes, hence affecting private consumption. Subdued economic activity will also be reflected in a drop in government consumption due to a reduction in public compensation per employees and public consumption, which would dampen investment and consequently, contract GDP further. Moreover, the slowdown of the economy would put downward pressure on property prices, further exacerbated by the existing misalignment from their fundamental values. Owing to the high rate of home ownership, the drop in house prices will affect households' wealth leading to a further fall in private consumption.

On the other hand, the increased risk premia would negatively affect households' and NFCs' creditworthiness, which in turn, would cause an increase in banks' NPLs coupled with forgone interest income. Domestic banks would then face an increase in credit risk arising from borrowers' credit losses which would prompt banks to decrease the volume of loans to the private sector, both directly via credit rationing, as well as indirectly through an increase in lending rates. At the same time, banks would also suffer market losses owing to lower yields on their holdings of debt securities and falling equity prices. Moreover, falling asset prices would affect households' financial wealth, further worsening their ability to repay and constrain their consumption, whilst higher corporate bond yields would increase credit risk of NFCs and affect investment expenditure negatively. All this would lead to higher banks' funding costs as conditions tighten in the market and, consequently, credit would be rationed further.

The baseline scenario is aligned with the Central Bank of Malta's Economic Projections for 2019-2021 integrated with the ECB's Staff Macroeconomic Projections for the euro area.[6] These baseline projections foresee economic growth to remain strong, though at a slower pace, and unemployment is expected to rise slightly though still remaining low from a historical perspective.

Under the adverse scenario, permanent shocks to STREAM's exogenous macroeconomic factors relevant in the scenario narrative are calibrated statistically on the basis of their respective historical developments and serve as an input to the model to generate an internally consistent adverse scenario. Particularly, the geopolitical uncertainty described in the narrative of the adverse scenario is translated in terms of a world demand shock of -10% in year 1, -7% in year 2

**Chart 1A**
**REAL GDP**
*(index)*

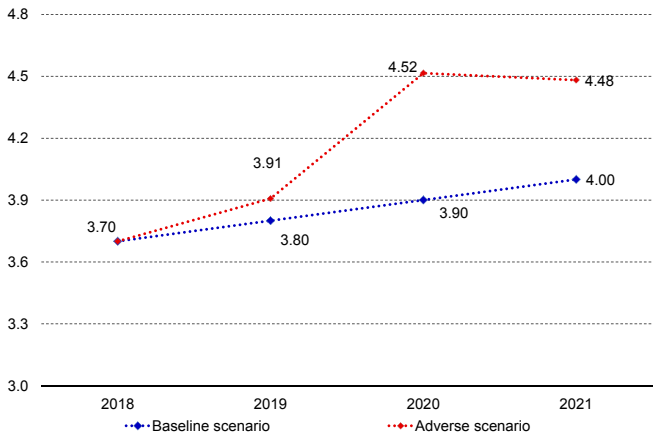



Source: Central Bank of Malta calculations.

[6] For the purpose of this exercise, the baseline scenario is defined based on the Central Bank of Malta's Economic Projections published in 2019:1, integrated, where necessary, with ECB's Staff macroeconomic projections at the same cut-off date.

and -5% in year 3 of the scenario. The increase in the risk premia is calibrated taking into account STREAM's pass-through rates and translated in a permanent shock to the short term rate of +212bps, whilst equity prices are calibrated exogenously on the basis of the MSE stock market index with a drop of 24%, which affected directly households' financial wealth. The resulting adverse scenario featured a V-shape profile of real domestic GDP similar to the one experienced in 2009 during the financial crisis (see Chart 1A) and a slow reaction of the unemployment rate consistent with it being close to the non-accelerating inflation rate of unemployment (see Chart 1B).

**Chart 1B**
**UNEMPLOYMENT RATE**
*(per cent)*




Source: Central Bank of Malta calculations.

Given the slow reaction of house prices to changes in macroeconomic and financial variables in the scenario, the magnitude of the shock to house prices is calibrated based on two components: a model-implied reaction driven by adverse demand factors and an exogenous component increasing the overall magnitude of the house price shock. The latter reflects the fact that in the first year of the scenario, property prices are brought to their equilibrium level by removing the mild sign of overvaluation as at the reference date. As a result, real estate prices would fall from their baseline level by around 9% in each year of the scenario.

## Credit risk satellite models

Following the IMF 2018 MT FSAP, the credit risk module of the Central Bank of Malta's MST framework has been revised on the basis of newly-developed specifications for the projections of the NPL ratio for core and non-core domestic banks.[7] Given that domestic banks follow the Standardised Approach, probability of default (PD) and loss given default (LGD) are not part of banks' regulatory reporting requirements. Instead, the NPL ratio is projected at bank level based on a set of macroeconomic and financial variables, both under the baseline and the adverse scenarios defined earlier. Moreover, considering that the NPL ratio at portfolio level would react to different macroeconomic and financial variables, credit risk is estimated separately for mortgages and loans to NFCs.[8]

In both cases, the estimation is based on quarterly bank-by-bank NPL ratios computed from FINREP reporting and back-casted on the basis of previous regulatory reporting, whilst the macroeconomic and financial variables are sourced from the National Statistics Office. The sample considered in the analysis spans from 2004Q3 till 2017Q4.

The NPL ratio is transformed using a logistic transformation to ensure that the projected NPL ratios at the bank level fall in the zero-to-one range for both mortgages and NFCs. This ensures that potential

[7] Banks in the sample that have limited credit intermediation functions would be excluded for the purpose of credit risk determination.
[8] The model being presented is developed for the projections of the NPL ratio (IFRS9 stage 3 loans) and it does not cater for transition to or from other stages. Extension of the module to consider transitions to other stages will be considered in the future.

non-linear relationships between the dependent variable (NPL ratio) and the independent variables (macroeconomic and financial variables) in the specifications are captured.

The NPL ratio is projected as a linear function of exogenous macroeconomic and financial variables using fixed effects panel regression for mortgages and loans to NFC as follows:

$$Y_{j,i,t} = \alpha_j + \beta_{j,i} + \gamma Y_{j,i,t-1} + \delta' X_{j,t} + \varepsilon_{i,j,t}$$

Where:
$Y_{j,i,t}$ refers to the logistic transformation of the NPL ratio of bank i, for the exposure class j at time t, with $j = \{\text{mortgages}, \text{NFCs}\}$;
$\beta_{j,i}$ indicates the fixed effect at bank level i in model specification j;
$Y_{j,i,t-1}$ is the vector of lags of the dependent variables in model specification j, with $\gamma$ being the vector of coefficients;
$X_{j,t}$ represents a vector of macroeconomic and financial variables in model specification j with $\delta'$ being the transposed vector of coefficients; and
$\varepsilon_{i,j,t}$ is a vector of independently and identically-distributed error terms in model specification j.

The panel is estimated via least squares method constraining the coefficient of the annual change in the unemployment rate in the mortgage specification to be in line with *a priori* expectations. To correct for individual-level cross-sectional correlation in the residuals both for mortgages and loans to NFCs, standard errors are clustered at bank level. Generally, the credit risk specifications suggest that the NPL ratios are sensitive to changes in their past values owing to the autoregressive component, the annual growth of real GDP, changes in real house prices and unemployment rate, amongst others.

Specifically, in the case of mortgages, NPLs could increase due to negative movements in households' income, adverse labour market dynamics as well as price pressures arising in the property markets. All these dynamics were considered when choosing the final specification for the mortgage NPL ratio projections, however, the income channel was not found to be statistically robust and it is not included in the final specification reported in Table 1.

The logistic transformation of the non-performing mortgage ratio is sensitive to changes in its first lag, the year-on-year growth of the transacted property price index, changes in the unemployment rate and bank-specific fixed effects capturing the different dynamics of the NPL ratio by bank related to bank-specific levels of legacy mortgage NPLs. Specifically, mortgage NPLs would depend on their

**Table 1**
**CREDIT RISK SATELLITE FOR MORTGAGES**

| | Coefficient | Standard Error | P-value |
|---|---|---|---|
| Constant | -0.5130 | 0.1343 | 0.0002 |
| L1 dependent variable | 0.8315 | 0.0406 | 0.0000 |
| L1 year-on-year growth of domestic house prices | -0.3986 | 0.2242 | 0.0766 |
| L4 annual change in unemployment rate[(1)] | 0.0704 | | |
| Durbin-Watson | 2.11 | | |
| Adjusted R-squared | 0.92 | | |
| Observations | 260 | | |

[(1)] Constrained coefficient. Note: the dependent variable (logistic transformation of the NPL ratio for mortgages) is regressed on its first lag, first lag of the year-on-year growth rate of the transacted property price index and fourth lag of the annual change of the unemployment rate considering bank-specific fixed effect. Reported standard errors are clustered at bank level.

lagged values, as well as the annual changes in the domestic real estate prices and bank-specific factors. In other words, in line with economic theory a borrower is more likely to experience difficulties in the repayment of a mortgage in the event of becoming unemployed or should property prices decrease though with a one-year lag.

In the case of non-performing loans of NFCs, banks are grouped according to their geographical risk exposures with reactions to different macroeconomic and financial variables. Based on this rationale, two models were developed for the projections of non-performing loans to NFCs: one considering banks providing lending to domestic NFCs and another for internationally-oriented banks.[9] In both cases, the NPL ratio for NFCs *a priori* would be expected to display persistence and relate to macroeconomic variables which are either affecting domestic or foreign lending.

In the case of domestically-oriented banks, the ratio of non-performing loans to NFCs is sensitive to changes in domestic GDP, changes in real property prices as well as sovereign spreads, as reported in Table 2. As expected, the variability in the NPL ratio for NFCs is largely explained by the lagged changes in domestic GDP. Owing to a large fraction of NFC loans that are collateralised by real estate, dynamics of the domestic real estate market are also positively related with the dependent variable. On the contrary, an increase in the 10-year sovereign spread, which is used as a proxy for investors' risk premium, leads to higher NPLs for NFC.

In the case of internationally-oriented banks, the variability in the ratio of NFC NPLs would mostly be explained by changes in the euro area GDP due to the cyclicality of the NFC lending by geographical exposure. A deterioration in interbank funding conditions will raise the cost of funding for banks which is passed on to NFCs in terms of higher interest rates. These higher costs will lead to an increase in the NPL ratio for NFCs for internationally-oriented banks, whilst annual changes in oil prices have a minor negative impact (see Table 3).

Once the models for mortgages and NFCs have been estimated, the NPL ratio is then projected over the stress test horizon (2019-2021) on the basis of the above-mentioned credit risk satellite models

**Table 2**
**CREDIT RISK SATELLITE FOR NFC LOANS (DOMESTICALLY-ORIENTED BANKS)**

| | Coefficient | Standard Error | P-value |
|---|---|---|---|
| Constant | -0.1764 | 0.0830 | 0.0349 |
| L1 dependent variable | 0.6908 | 0.0688 | 0.0000 |
| L2 dependent variable | 0.1997 | 0.0676 | 0.0035 |
| L5 domestic real GDP growth | -1.0613 | 0.3257 | 0.0013 |
| L5 year-on-year growth of domestic house prices | -0.3532 | 0.1418 | 0.0135 |
| L4 sovereign spread | 0.0396 | 0.0191 | 0.0389 |
| Durbin-Watson | 2.03 | | |
| Adjusted R-squared | 0.96 | | |
| Observations | 206 | | |

Note: The dependent variable (logistic transformation of the NFC NPL ratio) is regressed on its first two lags, fifth lag of real domestic GDP growth, fifth lag of the year-on-year growth rate of the transacted property price index and fourth lag of the sovereign spread (10-year MGS minus 10-year German Bund) considering bank-specific fixed effect. Reported standard errors are clustered at bank level.

[9] Owing to short time series for the NPL ratio for NFC for some internationally-oriented banks, the model was estimated using a time series approach and applied to bank-specific starting points. The model could be replaced by a panel regression similar to the one for domestically-oriented banks should data become available.

**Table 3**
**CREDIT RISK SATELLITE FOR NFC LOANS (INTERNATIONALLY-ORIENTED BANKS)**

| | Coefficient | Standard Error | P-value |
|---|---|---|---|
| Constant | -1.0121 | 0.2504 | 0.0002 |
| L1 dependent variable | 0.5410 | 0.1148 | 0.0000 |
| L1 USD Libor | 0.1162 | 0.0285 | 0.0002 |
| L3 EA GDP growth | -4.6716 | 1.5838 | 0.0051 |
| L1 oil price | -0.0031 | 0.0014 | 0.0374 |
| Durbin-Watson | 2.21 | | |
| Adjusted R-squared | 0.84 | | |
| Observations | 49 | | |

Note: The dependent variable (logistic transformation of the NFC NPL ratio) is regressed on a constant, its first lag, third lag of real euro area GDP growth and first lag of year-on-year oil prices. Reported standard errors are robust.

using an inverse exponential function. Hence, for each bank in the sample, an NPL ratio for mortgages and NFCs is determined under the baseline and the adverse scenarios, which are described in this Box under *"Scenatio narrative and calibration"*. Finally, the plausibility of these projections is assessed against the historical developments of the NPL ratio for each bank in the sample.

These projections form the basis for the quantification of credit risk in the loan book and together with the estimates of the LGD determine the loan loss provisions following an expected loss approach.