



**BANK ĊENTRALI TA' MALTA**  
**EUROSISTEMA**  
**CENTRAL BANK OF MALTA**

**THE BANKING SECTOR EXTENSION  
TO THE BANK'S  
MACRO-ECONOMETRIC MODEL**

## **BOX 6: THE BANKING SECTOR EXTENSION TO THE BANK'S MACRO-ECONOMETRIC MODEL<sup>1</sup>**

The role undertaken by financial intermediaries in the latest economic crisis has highlighted the need for a more comprehensive quantitative analysis of the relationship between the liquidity and solvency positions of such organisations and the real economy. This is particularly relevant to the Maltese economy, which is characterised by the absence of a highly developed and liquid financial market, implying that SMEs operating in Malta mainly finance their investment through bank loans. A change in the ability or willingness of banks to extend credit is likely to have a significant effect on real economic activity. In this context, the second version of the Bank's macro-econometric model has introduced improvements that seek to model some of the macro-financial linkages existing in the Maltese economy.<sup>2</sup> While these modifications have certainly improved the fit and simulation properties of the model, they cannot explicitly account for the effects which changes in the health of financial intermediaries are likely to have on the supply of credit, and therefore on the real economy.

The third version of the Bank's model proposes an extension that features an aggregate, yet sufficiently detailed, framework of the Maltese banking system. In contrast with the majority of banking sector models found in literature, this extension is modelled using an error-correction framework, which allows it to be integrated with a fully fledged macro-econometric model. When compared with other more stylised representations aimed at modelling financial frictions, this set-up is more flexible and allows the model to explain a larger number of relationships. Also, such a framework caters for a less stringent theoretical framework that takes into consideration relationships and properties that are specific to the Maltese banking system.

This banking sector extension targets two main objectives. First, it helps to improve the modelling of credit supply constraints by taking into account the health of Maltese financial intermediaries and the link that exists between savings generated by the economy and credit developments. Second, the endogenous determination of the banks' balance sheets allows for a simultaneous response between developments in the real economy and the banks' ability or willingness to extend credit, allowing the model to be used for financial stability and macro-prudential purposes.

### **The banking sector block**

This extension to the Bank's core macro-econometric model allows for a two-way feedback to exist between the real and the financial blocks of the model. The feedback from the real side of the model to the banking sector is modelled via two transmission channels, the Indirect Interest Rate and the Probability of Default (PD) channels. The financial sector

<sup>1</sup> Prepared by Noel Rapa, Senior Research Economist at the Economic Research Department. The views expressed in this article are the author's own and do not necessarily represent the views of the Bank. The author would like to thank Professor Josef Bonnici, Mr Alfred Mifsud, Mr Alexander Demarco, Dr Aaron G. Grech, Mr Alfred DeMarco and colleagues for valuable comments and suggestions during an internal presentation.

<sup>2</sup> See Grech, O. and Micallef, B., "A structural macro-econometric model of the Maltese economy", *Working Paper WP07/2014* available at <http://www.centralbankmalta.org/macro-econometric-model>.

is affected by the real part of the economy through the endogenous determination of the banks' profits or losses and balance sheets.

### *The transmission channels*

The banking sector extension makes use of two main channels that are used to model the interactions between financial intermediaries and the real economy. The first channel taken into consideration is the *interest rate channel*, which predicts that credit developments are affected by the policy stance of the monetary authority.<sup>3</sup> A monetary tightening (easing) will directly increase (reduce) bank lending rates through the *direct interest rate channel*, thereby leading to a reduction (increase) in the credit extended by financial intermediaries. However, the extent of the pass-through between the policy relevant rate of interest and the lending rates charged by banks is likely to depend on specific bank characteristics that can increase or decrease the costs of financing of banks, a channel which will be labelled as the *indirect interest rate channel*. There are two alternative theories, which can explain a varying degree of pass-through owing to changes in the cost of financing of banks, the Bank Lending Channel and the Bank Capital Channel.<sup>4</sup>

According to the bank lending channel thesis, an exogenous drop in bank deposits cannot be completely offset by the issue of other forms of finance, such as bonds. Since these types of liabilities are uninsured and are subject to asymmetric information issues, the interest rates of such financial assets carry a premium to compensate investors for the higher risk. Therefore, following a negative shock to their deposits, banks will usually find it cheaper to restore their liquidity position by increasing deposit rates to attract new depositors than to issue new bank debt. Moreover, following a negative liquidity shock, the ability of banks to issue new debt is likely to decrease as investors demand higher risk premiums to account for greater risks faced by the banks.

The effects of the bank lending channel are amplified in the case of banks operating in relatively less developed financial systems. In such instances, the ability of banks to finance their assets through the issue of longer-term financial instruments is substantially undermined, implying that banks' financing needs will be heavily dependent on deposits. Deposits are usually re-negotiated more frequently than loans, forcing these banks to keep a low loan-to-deposit ratio (LDR) to account for higher maturity mismatch risks. Following negative deposit shocks, such banks will be required to increase interest rates on deposits to compensate deposit holders for higher maturity mismatch risks, as well as to reduce their credit exposure, either directly via credit rationing or indirectly by raising lending rates.

The bank lending proposition is introduced by augmenting the commercial interest rate pass-through equations with a cost of funding indicator.<sup>5</sup> Despite recent trends of deregulation

<sup>3</sup> Gambacorta, L., "How do Banks set Interest Rates?" *European Economic Review*, 52(5), 2008, pp. 792-819.

<sup>4</sup> These two theories provide two different propositions of how the indirect interest rate channel works. Therefore, they can be seen as two mutually exclusive ways of how to model the cost of funding channels of commercial banks. Despite the fact that only one theory can be operative at each point in time, both theories are retained in the extension to the core model. Indeed, despite the similarity in the way these two theories work within the model, as well as in the final simulation results, both theories can provide unique interpretations of the manner in which some shocks are transmitted to the economy.

<sup>5</sup> This study augments simple pass-through equations as discussed in Gauci, T. and Micallef, B., "Interest rate pass-through in Malta", *Quarterly Review*, 2014:1, Central Bank of Malta, pp. 71-82.

and liberalisation that have shaped the global financial system in the last two decades, Maltese banks can still be regarded as operating a fairly traditional banking model. Indeed, by 2014 more than 70% of core banks' assets consisted of credit issued to the private sector and government bonds. Also, 85% of the funding needs of these banks were financed by attracting deposits from the private sector. Given these characteristics, the LDR is a good gauge for the maturity transformation risk faced by banks and can thus be used as a cost of funding indicator that allows for the simultaneous analysis of both asset and liability sides of Maltese banks. The sign and magnitude of the LDR in the pass-through equations is according to a priori expectations, implying that a fall in deposits (which increases the maturity mismatch risk of the banking sector) prompts banks to increase deposit and lending rates in an attempt to raise deposits and restrict credit growth, thereby pushing the LDR to safer levels.

The bank capital channel theory is based on two hypotheses. First, the market for bank equity is imperfect and, therefore, banks cannot issue new capital without incurring costs. Second, commercial banks are subject to risk-based regulatory capital requirements that limit the supply of credit. These two conditions imply the failure of the Modigliani-Miller theorem for bank lending, suggesting that bank credit will depend on the financial structure of the bank.<sup>6</sup> When capital is sufficiently low, either due to credit defaults or other losses, banks will find it too costly to recapitalise through the issue of new shares.<sup>7</sup> Therefore, they will opt to reduce credit either directly through credit rationing or by increasing bank lending rates.

In line with literature, the bank capital channel is captured by introducing the amount of bank capitalisation relative to its risk-weighted-assets (RWA) or the Capital Adequacy Ratio (CAR), held in excess of an exogenously set minimum requirement.<sup>8</sup> The estimated sign and magnitude of the excess CAR variables are also according to theory and predict that a fall in the CAR causes banks to raise lending rates (and to a lesser extent deposit rates), resulting in an increase in net lending margins. This helps to raise bank profits (and therefore capital accumulation) and reduce credit growth, pushing up the CAR to target levels.

The second channel used to enhance the macro-financial linkages in the Maltese economy is the PD channel. This channel predicts that an increase in the credit risk of some classes of assets will prompt banks to re-allocate their portfolio towards less risky assets. In the case of increases in the PDs of credit, banks will either seek to reduce their credit exposure by shifting their portfolio to less risky alternatives (such as government or corporate bonds),

<sup>6</sup> Modigliani, F. and Miller, M., "The Cost of Capital, Corporation Finance and the Theory of Investment", *American Economic Review* 48 (3), 1958, pp. 261–297.

<sup>7</sup> Literature shows that even if the capital requirement is not binding at a specific point in time, low capitalised banks may find it optimal to forgo profitable lending to lower the risk of future capital inadequacy. Therefore, banks will seek to retain some optimal level of CAR, which is above the minimum required by regulatory bodies. For a more in-depth discussion, see Van den Heuvel, S. "Does bank capital matter for monetary transmission?" *Economic Policy Review* 8, 259265, FED, 2002.

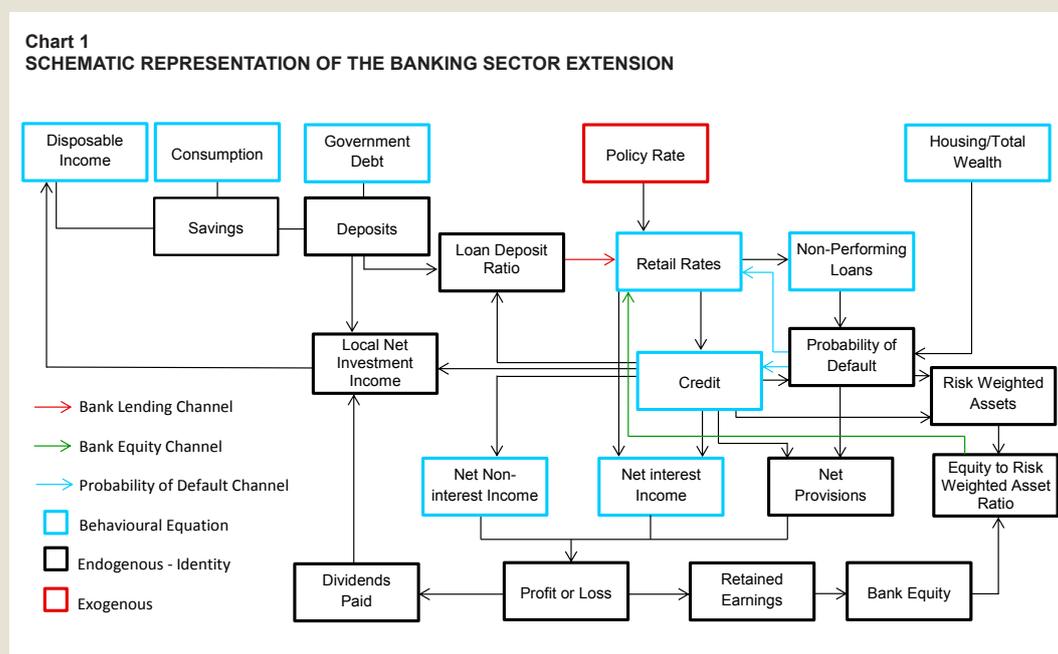
<sup>8</sup> In studies, such as Gambacorta, L. and Mistrulli, P., "Does bank capital affect lending behaviour?" *Journal of Financial Intermediation*, 13(4), 2004, pp. 436–457, the measure of excess bank capitalisation used is the total CAR held in excess of a minimum of 8% as required by the Capital Requirement Directive IV of the European Commission. Other studies, such as Miani, C., Nicoletti, G., Notarpietro, A. and Pisani M., "Banks' balance sheets and the macro-economy in the Bank of Italy Quarterly Model", *Occasional papers (Questioni di Economia e Finanza)*, 64, Banca d'Italia, 2012, suggest using the CAR held in excess of an endogenous minimum requirement that takes in consideration the overall risk of the bank's portfolio.

in effect rationing credit supply to the private sector, or else continue extending credit, although at higher interest rates, as a compensation for the higher credit risk exposure. This channel was introduced in the model in two ways. First, the pass-through equations were augmented with PDs, allowing bank lending rates to respond positively following higher credit risks faced by banks. Second, the credit demand equations were extended to allow for direct supply-side rationing whenever banks face higher probabilities of default.

### *The link between macroeconomic and banking sector conditions*

The link between developments in the real economy and banking sector conditions is modelled by introducing a stylised framework for the Maltese banking system. The approach used is similar to the one recently used by the Banca d'Italia in the extension to its macro-econometric model and allows for the determination of a number of important banking variables, such as RWAs, PDs, bank profits, bank equity and deposits.<sup>9</sup>

The schematic diagram in Chart 1 shows the structure of the banking sector block, the relations that exist between the real economy and the banking sector (shown in black arrows) and the transmission mechanism of banking sector conditions to the real economy through the bank lending thesis (shown in red arrows), the bank equity channel (shown in green arrows), and the PD channel (shown in blue arrows). The banking sector framework consists of seven behavioural equations (which determine the variables encircled in blue) and 13 identities (determining the variables encircled in black).



<sup>9</sup> Miani, C., Nicoletti, G., Notarpietro, A. and Pisani, M., "Banks' balance sheets and the macro-economy in the Bank of Italy Quarterly Model", *Occasional papers (Questioni di Economia e Finanza)*, 64, Banca d'Italia, 2012.

On the profit and loss side of the block, the most significant variable is net interest income, which is assumed to grow in line with total credit and the net interest rate spread between lending and deposit rates. Given that government debt makes up the majority of the non-credit assets of Maltese banks, non-interest income is assumed to grow proportionally with government debt outstanding, and to be positively related to government bond yields. Operating expenses are assumed to grow in line with total credit, while net provisions are assumed to grow in line with non-performing loans (NPL), assuming a constant coverage ratio.

The law of motion for capital assumes that equity accumulates with profits after tax and distribution of dividends, both of which are assumed as a fixed proportion of profits before tax.<sup>10</sup> The PDs necessary for the evaluation of RWAs, as well as for the PD transmission channel, are determined via an identity, in line with the study of Buncic and Melecky.<sup>11</sup>

Deposits are determined as the difference between total private savings generated by the economy and the change in general government debt. This assumes that the economy's private savings can be either used to finance government debt or deposited with the local banking sector, and that economic agents will always demand enough government bonds to cover the financing needs of the public sector. This simple framework allows for a direct link to exist between savings, deposits and ultimately private sector credit via the transmission channels explained above. Also, it introduces an element of crowding out effect, through which extra credit demanded by Government will adversely affect bank deposits and, eventually, bank lending via the indirect interest rate channel.

The banking sector extension also allows for the partial modelling of local household investment income. The Bank's current econometric model assumes that household investment income moves in line with household financial wealth. Such an assumption ignores the fact that investment income generally depends on prevailing commercial interest rates. The endogenous determination of deposits and banks' profits or losses allows for net investment income to depend on the amount of net household deposits, commercial lending and deposit rates, and bank dividends earned.

### **Simulation results**

To illustrate the properties of the banking sector block, this section presents the results of two shocks: a permanent upward shock to NPLs and a temporary shock to bank profits resulting from a deterioration in the credit quality of core banks' securities portfolio.

Table 1 shows a 20% permanent increase in NPLs of both household and NFCs. This shock emanates from the real side of the economy and affects the financial sector, and its willingness to extend credit via both bank capital and PD channels.

Following the shock in NPLs, total PD is pushed up, causing an increase in RWAs. Together with a fall in bank equity, caused by a rise in net provisions, the increase in RWAs reduces

<sup>10</sup> In the event of losses incurred by banks, dividends and taxes paid are assumed to be zero.

<sup>11</sup> Buncic, D. and Melecky, M., "Macro-prudential stress testing of credit risk: A practical approach for policy makers", *Policy Research Working Paper*, 5936, WPS5936, The World Bank, 2012.

the CAR of the banking system. In an effort to address a deterioration in their solvency position, banks seek to raise net profits – thereby improving capital accumulation – by increasing their net interest margin. Also, the increase in bank lending rates helps reduce the demand for credit, causing downward pressures on credit extended by banks, which partly offsets the rises in RWAs caused by higher PDs. The volume of credit extended by financial institutions is also affected by the PD channel. Higher PDs attached to bank lending will prompt banks to re-allocate their asset portfolio towards less risky assets, thereby reducing their exposure to bank credit both by increasing lending rates, as well as through direct credit rationing.

The aggregate effect of bank capital and PD channels leads to a fall in private credit in the first year of 1.73% – mainly driven by falls in credit to NFCs – and an increase in total real lending rates of around 0.07 percentage point. This helps banks reduce losses caused by greater risks of default that lead to higher net provisions. These measures aid banks to limit the fall in their CAR from 0.95 percentage point (registered on impact with no changes in bank asset allocation and net interest profit), to less than 0.1 percentage point by the first

**Table 1**  
**RESPONSES TO NON-PERFORMING LOANS SHOCK**

*Percentage changes from baseline levels unless otherwise specified*

	Year 1	Year 2	Year 3
<b>Economic Activity</b>			
Real GDP	-0.05	-0.08	-0.09
<b>Contributions to Real GDP Growth<sup>(1)</sup></b>			
Domestic Demand	-0.21	-0.33	-0.32
Net exports	0.16	0.26	0.23
<b>Prices</b>			
GDP deflator	-0.01	-0.03	-0.06
<b>Labour Market</b>			
Unemployment rate <sup>(1)</sup>	0.00	0.01	0.01
<b>Credit Developments</b>			
Total Credit to Private Sector	-1.73	-2.62	-3.33
Credit to Households	-1.01	-1.95	-2.82
Mortgages	-0.96	-1.84	-2.68
Credit to Consumers	-1.26	-2.53	-3.54
Credit to NFCs	-2.67	-3.49	-3.97
Deposits	-0.03	0.22	0.48
<b>Retail Rates<sup>(1)</sup></b>			
Real Mortgage Rates	0.09	0.15	0.13
Real NFC Rates	0.05	0.13	0.13
Real Rates on Other Household credit	0.10	0.18	0.15
<b>Banks' Balance Sheets</b>			
Interest Rate Margin <sup>(1)</sup>	0.05	0.05	0.02
Loan Deposit Ratio <sup>(1)</sup>	-0.53	-1.87	-2.47
Capital Adequacy Ratio <sup>(1)</sup>	-0.07	0.12	0.27

<sup>(1)</sup> Absolute changes from baseline in percentage points.

Source: Author's calculations.

year.<sup>12</sup> Driven entirely by the PD channel, private credit falls by around 2.6% in the second year, allowing banks to cut their RWAs by almost 1%, and driving the CAR to levels higher than the baseline scenario. At this point the bank capital channel starts to exert negative pressures on bank lending rates, slightly outweighing the positive pressures exerted by the PD channel. Still, private credit and RWAs continue to fall in the third year after the shock, pushing the banking sector CAR further up, as the effects of the PD channel dominate those of the bank capital channel. From these results one can conclude that, when faced by a heightened degree of uncertainty in the economy, banks will seek to increase their capital buffers in the medium term so as to be able to sustain adverse solvency shocks.<sup>13</sup>

Turning to developments in economic activity, the falls in private credit cause marginal reductions in real GDP. The reductions are mainly driven by decreases in both private consumption and private gross fixed capital formation. The slowdown in economic activity generates some slack in the economy, causing the GDP deflator to fall and the unemployment rate to marginally climb up.

Table 2 shows the responses of the main variables of interest to a temporary shock to bank profits, following a deterioration in the credit quality of core banks' asset portfolio.<sup>14</sup> This shock negatively affects bank equity, causing a fall in the CAR. This brings about a raise in bank lending rates as banks try to increase capital accumulation and reduce RWAs. Indeed, credit to the private sector falls substantially by 1.00% in the first year, while the increases in bank lending rates outstrip those of deposits rates, leading to a rise in interest rate margins of 0.09 percentage point. These measures help improve bank profitability and reduce the impact of this shock on the solvency of the banking system.

Real economic activity is affected in three ways. First, the reduction in private lending causes a slowdown in private consumption and in gross fixed capital formation, and therefore in real GDP. Second, the slowdown in economic activity causes an increase in NPLs and PDs, which cause additional upward pressures on bank lending rates and downward pressures on real credit via the PD channel. This result also implies that there is an element of contagion between the banking sector's and the private non-banking sector's solvency. Third, household investment income is reduced immediately after the shock owing to the suspension of banks' dividend pay-outs, as well as to increases in net interest rates, further contributing to reductions in private consumption. One can note that the impact of this shock on economic activity is quite different from the result of a shock to NPLs. Indeed, while the latter causes a gradual but prolonged fall in economic activity, the former has a more immediate but short-lived effect on real GDP, suggesting that shocks that directly affect bank's willingness to extend credit (especially through the PD channel) have a long-term effect on economic activity.

<sup>12</sup> The reduction in the capital adequacy ratio following a 20% increase in NPLs under a static environment, whereby banks are not allowed to reduce or re-allocate the size of their portfolio, is in line with the Central Bank of Malta *Financial Stability Report*, which performs stress tests on core Maltese banks under these conditions.

<sup>13</sup> This result is in line with conclusions put forward by McShane R.W. and Sharpe, G., "A time series/cross section analysis of the determinants of Australian trading bank loan/deposit interest margins: 1962-1981", *Journal of Banking & Finance*, Vol. 9, issue 1, 1985, pp. 115-136.

<sup>14</sup> In line with the stress tests performed in the *Financial Stability Report*, a three-notch downgrade for securities held to maturity was assumed. The losses from these downgrades are then charged to the profit and loss figure of banks, resulting in a reduction in equity.

**Table 2**  
**RESPONSES TO ASSET QUALITY DETERIORATION SHOCK**

*Percentage changes from baseline levels unless otherwise specified*

	Year 1	Year 2	Year 3
<b>Economic Activity</b>			
Real GDP	-0.09	-0.15	-0.07
<b>Contributions to Real GDP Growth<sup>(1)</sup></b>			
Domestic Demand	-0.44	-0.45	-0.29
Net exports	0.34	0.30	0.21
<b>Prices</b>			
GDP deflator	-0.01	-0.05	-0.11
<b>Labour Market</b>			
Unemployment rate <sup>(1)</sup>	0.00	0.02	0.01
<b>Credit Developments</b>			
Total Credit to Private Sector	-1.00	-1.81	-2.34
Credit to Households	-1.51	-2.29	-2.86
Mortgages	-1.63	-2.46	-3.06
Credit to Consumers	-0.89	-1.41	-1.80
Credit to NFCs	-0.34	-1.17	-1.70
Deposits	-0.10	0.26	0.61
<b>Retail Rates<sup>(1)</sup></b>			
Real Mortgage Rates	0.14	0.26	0.28
Real NFC Rates	0.12	0.30	0.36
Real Rates on Other Household credit	0.20	0.41	0.44
<b>Banks' Balance Sheets</b>			
Interest Rate Margin <sup>(1)</sup>	0.09	0.13	0.08
Loan Deposit Ratio <sup>(1)</sup>	-0.38	-1.23	-1.87
Capital Adequacy Ratio <sup>(1)</sup>	-2.26	-2.17	-2.05

<sup>(1)</sup> Absolute changes from baseline in percentage points.

Source: Author's calculations.

## Conclusion

This article presents the development of a banking sector extension to the bank's macro-econometric model. This block includes a detailed framework of the banking sector linking the real economy with the profit and loss, and balance sheet accounts of banks. It also introduces two new channels that link the liquidity and solvency of the banking sector with the real economy through the determination of bank lending and deposit rates.

Simulations show that when faced with real economic shocks that impact their solvency position, banks react in an attempt to improve their capital accumulation. These studies show that shocks that directly impact the credit disintermediation function of banks have a more prolonged impact on real output. Results also suggest that when banks operate in a riskier environment, they will try to increase their capital adequacy in an attempt to improve their capital buffers. These indications are in line with empirical studies that suggest a positive correlation between banks' risk averseness and CAR. The simulations presented in this article also indicate that real economic activity can be substantially affected from a purely financial shock that threatens the financial viability of the Maltese banking system.