Date: 20.03.2015
Number: 14-40b

RISK CONTROL

Stress Testing for an Asset Manager-Private Bank

A Case Study

www.riskcontrollimited.com

Contents

1. Executive Summary

This note presents an illustrative case study of stress testing for an asset manager accomplished using Risk Control's *Stress Controller™* software. The calculations are performed for a notional UK asset manager that is also engaged in private banking operations.

We show how the AUM (Assets under Management), balance sheet, P&L and key capital planning ratios of the private bank-asset manager group are affected by scenarios involving (i) customer loss and (ii) a UK recession. A set of equations is constructed to describe the evolution of the asset manager's financial statements.

The AUM is modelled in a region- and asset-class-specific fashion. This permits the user to calibrate the distributions of the AUM across regions and to employ appropriate sensitivities of the AUM in each region to appropriate geographically specific market variables (equity indices, interest rates, exchange rates and commodity prices).

The growth of each AUM class is forecast by taking into account (i) changes in relevant market prices and (ii) user-specified additional growth reflecting, for example, past trends in AUL market growth or anticipated marketing activities by the asset manager. The model allows the user to override forecasts by directly assuming particular levels of AUL growth for different components of the AUL asset class-region breakdown.

Revenue in the form of fees depends on the AUM forecasts described above. Users are able also to specify fee rate dynamics directly if they wish, calibrating either the relative growth or the absolute level of the future fee rate.

The results show how the asset manager's AUM size, revenue growth, loan impairment provisions and capital are boosted or depressed by the different stress scenarios.

Note that the framework described here may be used either with coarse, public data to perform high level, top down stress testing or with highly granular internal data for bottom-up stress testing purposes. Financial statement modelling is highly flexible since equations may be written first in Excel, before being converted into scripts and then imported into the software for use at run-time to perform calculations.

2. Generating Consistent Macroeconomic Scenarios

The stress tests considered in this note include what one might term "parametric stresses" such as assumed changes in fee rates, for example, and also more economically based stress scenarios in which the consequences for the business of changes in the macroeconomic environment are traced through.

To devise economic stress tests of this latter type, one must first accomplish the (often challenging) task of generating consistent time paths for multiple macroeconomic variables. For example, one may wish to consider the impact of a recession in the US affecting, say, US GDP. However, this raises the issue of what the impact on European or Asian GDP should be and also what should happen to commodity prices and interest rates, exchange rates, inflation and in the different regions?

Risk Control's *Stress Controller™* software employs an embedded macroeconomic model which permits the user to specify shocks to a particular variable and then calculate conditional forecasts of this and other variables stretching into the future. The macroeconomic model employed is a statistical model commonly referred to as a Global Vector Autoregressive or GVAR model. Such models have been extensively used by central banks, government agencies and private sector analysts in economic forecasting and stress testing applications.

It is important to allow for contagion between regions in the propagation of macroeconomic scenarios. GVAR models suppose that for each geographical region there exists a vector of macroeconomic variables which evolve linearly over time as non-stationary but co-integrated time series. The variables in each region are affected by their own lagged values as well as by weighted sums of variables from other regions.

The GVAR model included in *Stress Controller™* is highly flexible in that one may readily change the countries and regions used. In the exercise reported in this note, we adopt a set of regions consistent with the bank's approach to categorizing its loan exposures. Specifically, we suppose that the regions comprise: (a) UK, (b) Europe (excluding the UK), (c) the Americas (comprising South, Central and North American countries), (d) the Middle East and Africa, and (e) Asia.

To set up scenarios within *Stress Controller™*, one operates through the web-based interface. Scenarios are stored within an underlying relational database and repeated calculations may be performed for a given scenario after amendments have been made to the scenario itself or after the underlying data has been updated. Figure 1 shows the list of scenarios within the *Stress Controller™* web-based interface.

Figure 2 provides a screenshot of the software illustrating how one may edit a scenario. In this case, the scenario consists of a sequence of period-by-period shocks to macroeconomic variables. Non-interest-rate macro time series are stored in log form times 100. Hence, a shock of negative one unit in a given quarter to a scenario variable such as GDP corresponds to a minus 1% innovation.

Stress Controller™ produces time paths of macroeconomic variables such as those shown in Figure 3. These time series are the mean values of the variables in question conditional on the assumed shocks to the scenario variables.
Note that, as an alternative to generating macroeconomic scenarios within *Stress Controller™* one may import a scenario in the form of a set of time series for different macroeconomic variables. Hence, one may work with scenarios generated by regulators or a bank economics department, importing the scenario time series into the application and then performing additional calculations with them.

Figure 1: The Stress ControllerTM Web Application

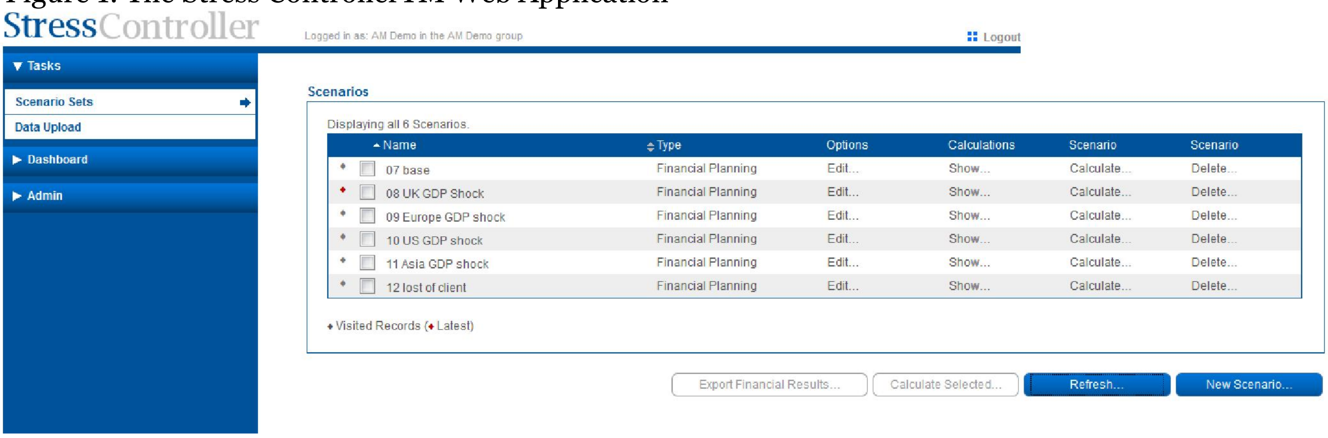


Figure 2: Editing Scenarios - Shocks to GDP

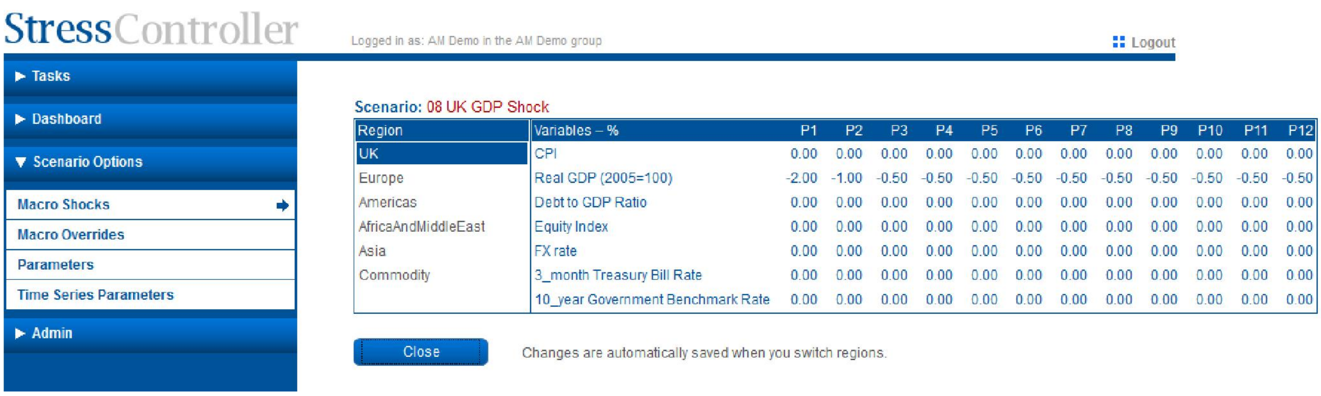
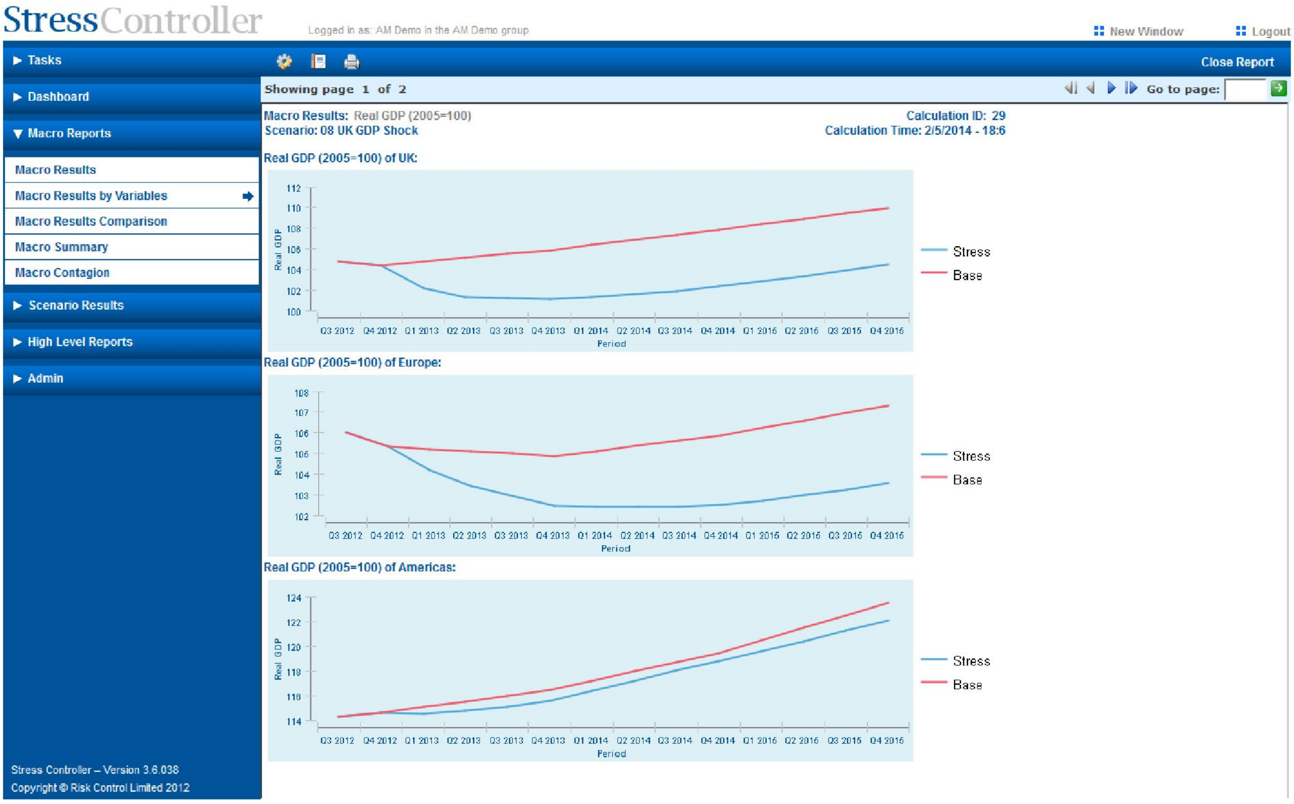


Figure 3: Results on GDP time paths for different regions



3. The AUM of the Asset Manager

The current size of AUM for the asset manager in this case study is around £106 billion, about 40 times the asset manager's total assets and about 80 times the total shareholders' equity. Breakdowns of the region- and asset-class-weights for the current AUM are displayed in Table 1.

Table 1: Region and asset class breakdowns

AUM class/weight by region	UK	Europe	Asia	America
Equity	40%	20%	20%	20%
Fixed Income	40%	20%	20%	20%
Multi Assets	40%	20%	20%	20%

4. Modeling Financial Planning

In Figures 4 and 5, the historical consolidated summary financial statements of the asset manager are presented for the past 6 years. These historical financial statements, invented for the purpose of this exercise, are imported into *Stress Controller™* and serve as the starting point for forecasts of future financial statements conditional on macroeconomic scenarios.[1]

Figure 4: Historical Consolidated Statements of Financial Position and Assets under Management

As at 31 December	2007 £'000	2008 £'000	2009 £'000	2010 £'000	2011 £'000	2012 £'000
Assets						
Cash, balances at central banks and items in the course of collection	822,771	741,238	794,683	872,990	952,274	1,036,715
Gross loans and advances to banks	80,336	95,510	82,366	75,694	94,982	81,878
Less: bank allowance for impairment	96	96	96	96	90	82
Loans and advances to banks	80,240	95,414	82,270	75,598	94,892	81,796
Gross loans and advances to customers	715,564	948,398	865,216	880,652	884,972	870,728
Less: customers allowance for impairment	24,768	24,768	24,768	24,768	21,104	19,270
Loans and advances to customers	690,796	923,630	840,448	855,884	863,868	851,458
Other assets	37,600	49,552	47,706	46,674	50,378	48,326
Total assets	**1,631,407**	**1,809,834**	**1,765,107**	**1,851,146**	**1,961,412**	**2,018,295**
Liabilities						
Deposits and items in the course of collection due to banks	184,676	233,090	155,824	158,592	184,170	157,166
Customer accounts	589,974	671,010	644,858	691,576	732,064	771,592
Other liabilities	37,870	36,408	34,124	31,410	33,044	33,174
Total liabilities	**812,520**	**940,508**	**834,806**	**881,578**	**949,278**	**961,932**
Shareholders equity						
Shareholders equity excluding noncontrolling interests	587,286	623,460	667,189	695,350	725,878	757,598
Noncontrolling interests	231,601	245,867	263,112	274,217	286,256	298,765
Total shareholders equity	**818,887**	**869,326**	**930,301**	**969,568**	**1,012,134**	**1,056,363**
Total liabilities and shareholders equity	**1,631,407**	**1,809,834**	**1,765,107**	**1,851,146**	**1,961,412**	**2,018,295**
Assets under management						
Total AUM	**81,888,737**	**86,932,628**	**93,030,117**	**96,956,772**	**101,213,369**	**105,636,254**
AUM equity	40,944,368	43,466,314	46,515,058	48,478,386	50,606,684	52,818,127
AUM fixed income	20,472,184	21,733,157	23,257,529	24,239,193	25,303,342	26,409,063
AUM multi asset	20,472,184	21,733,157	23,257,529	24,239,193	25,303,342	26,409,063

Figure 5: Historical Consolidated Income Statement

For the year ended 31 December	2007 £'000	2008 £'000	2009 £'000	2010 £'000	2011 £'000	2012 £'000
Continuing operations						
Revenue	612,143	643,972	691,891	725,486	756,823	790,442
Net interest income	19,196	22,938	23,836	25,046	24,402	23,270
Total income	**631,339**	**666,910**	**715,727**	**750,532**	**781,225**	**813,712**
Credit impairment charges and other provisions	(5,590)	(5,590)	(5,590)	(5,590)	(5,590)	(5,590)
Impairment of investment	-	-	-	-	-	-
Operating expenses	(280,522)	(280,522)	(280,522)	(280,522)	(280,522)	(280,522)
Other	-	-	-	-	-	-
Profit before tax	345,227	380,798	429,615	464,420	495,113	527,600
Taxation	(69,045)	(76,160)	(85,923)	(92,884)	(99,023)	(105,520)
Profit after tax from continuing operations	276,182	304,639	343,692	371,536	396,090	422,080
Profit for the year from discontinued operations, including gain on disposal	-	-	-	-	-	-
Profit after tax	**276,182**	**304,639**	**343,692**	**371,536**	**396,090**	**422,080**

[1]The calculations are performed on a quarterly basis so the data is imported after converting the annual reports into quarterly data.

The key assumptions we make in modeling the asset manager's financial statements and capital planning are as follows:

1. We view the asset manager's financial and capital planning as Income Statement driven.

2. The Income Statement is modeled mainly via the following three components: (i) size and rate of the AUM (which will be described in detail below), (ii) growth of the expenses and (iii) the dividend payout. The latter two components can be calibrated by the user via parameters and can differentiate between different forecasting periods.

3. AUM forecasting
The growth rate of each asset class is affected by (a) that asset class' historical performance and (b) the macroeconomic forecasts. The impact of the first element is calibrated by the user purely via time-series parameters. The impact of the second element is modeled as a weighted sum of sensitivity-adjusted regional macro variable growth rates, where the influencing macro variable is determined by scripting and the regional weight distributions and sensitivities to each regional macro-variable are calibrated via matrix type parameters. (Note that no time-series dimension is involved.)This is explained by the equations below:

$$AUM_{i,t+1} = AUM_{i,t}(1 + G_{i,t+1})$$
$$G_{i,t+1} = P_{i,t+1} + \sum_{r=1}^{R}(MG_{i,r,t+1}W_{i,r}S_{i,r})$$

Here:
i: the i^{th} AUM asset class;
r: the r^{th} macro region where r=1,2,...R;
$G_{i,t+1}$: the growth rate of the i^{th} AUM asset class in period t+1;
$P_{i,t+1}$: is a user defined adjustment to the growth rate of i^{th} AUM asset class in period t+1;
MG is a three-dimensional macro variable growth rate matrix in which the dimensions are (1) macro variables, (2) macro regions and (3) time horizon.
$MG_{i,r,t+1}$: the growth rate of the influencing macro variable from the r^{th} region of the i^{th} AUM asset class in period t+1;
$W_{i,r}$: the regional weight of the i^{th} AUM asset class in the r^{th} regional element of the influencing macro variable, it is constant over time;.
$S_{i,r}$: the sensitivity of the i^{th} AUM asset class to the r^{th} regional element of the influencing macro variable, it is constant over time;

4. AUM user override
As an alternative to the calculation above, the user can specify the growth rate for any asset class in any period, denoted $GOR_{i,t+1}$. This specification will override the above calculation.
The comprehensive modeling of AUM size can be summarized as:
If $GOR_{i,t+1}$does not equal -999;

$$G_{i,t+1} = P_{i,t+1} + \sum_{r=1}^{R}(MG_{i,r,t+1}W_{i,r}S_{i,r})$$

Else;

$$G_{i,t+1} = GOR_{i,t+1}$$

End;

$$AUM_{i,t+1} = AUM_{i,t}(1 + G_{i,t+1})$$

5. Loans and deposits are assumed to be linked to (a) GDP growth in the relevant region, and (b) their own historical trend. The relative importance of (a) and (b) and the sensitivity to macro shocks vary for different loans and deposits.

6. The credit impairment charge is calculated as the expected losses of loans and advances to retail and wholesale customers, taking into account the lagged impact of macroeconomic variables on provisions. (Recall that loans are modeled as diversified pool exposures.)

7. The financial position statement is affected, apart from loans and deposits, by retained earnings calculated from Income Statement forecasts.
8. To balance the financial position statement at the end of each forecasting period, we adjust the gap between forecast 'Total Assets' and 'Total Liabilities and Shareholder Equities', allowing this gap to be absorbed by multiple items employing user-defined weights.

The equations for the financial statements analysis are treated in *Stress Controller™* as a part of the model's data. They are imported from a 'feeder' Excel workbook. A screenshot of the equations stored in such a workbook is provided in Figure 6.

To take an example, the growth rate of the Fixed Income asset class of AUM is modeled as:

AUM_FixedIncome_growth=AUM_perf_growthaddon_fixedincome[0][period_count+1]+CustomMethods.SumCol(CustomMethods.VecCal(Vector_Int_change,CustomMethods.VecCal(CustomMethods.MtxVec(MTX_AUM_RegionWeight,1,1),CustomMethods.MtxVec(MTX_AUM_RegionSensitivity,1,1),3),3));

Before the above equation is executed, all the variables employed in the equation must be declared by importing a user workbook containing the definition of each variable.

Figure 6: Screen Shot of Financial Planning Equations in an Excel Workbook

1000	if (AUM_equity_OR[0][period_count+1]==-999) {	check if user has input override
3000	AUM_Equity_growth=AUM_perf_growthaddon_equity[0][period_count+1]+CustomMethods.SumCol(CustomMethods.VecCal(Vector_equity_growth,CustomMethods.VecCal(CustomMethods.MtxVec(MTX_AUM_RegionWeight,0,1),CustomMethods.MtxVec(MTX_AUM_RegionSensitivity,0,1),3),3));	equity class growth: performace linked change + macro linked change, where the latter is a weighted average of sensitivity adjusted regional macro growths.
1000	} else {	
1000	AUM_Equity_growth=AUM_equity_OR[0][period_count+1];	
1000	}	
1000	if (AUM_fixedincome_OR[0][period_count+1]==-999) {	check if user has input override
3000	AUM_FixedIncome_growth=AUM_perf_growthaddon_fixedincome[0][period_count+1]+CustomMethods.SumCol(CustomMethods.VecCal(Vector_Int_change,CustomMethods.VecCal(CustomMethods.MtxVec(MTX_AUM_RegionWeight,1,1),CustomMethods.MtxVec(MTX_AUM_RegionSensitivity,1,1),3),3));	performace linked change + macro linked change, where the latter is a weighted average of sensitivity adjusted regional macro growths.
1000	} else {	
1000	AUM_FixedIncome_growth=AUM_fixedincome_OR[0][period_count+1];	
1000	}	
1000	if (AUM_multiassets_OR[0][period_count+1]==-999) {	check if user has input override
3000	AUM_MultiAssets_growth=AUM_perf_growthaddon_multiassets[0][period_count+1]+CustomMethods.SumCol(CustomMethods.VecCal(Vector_GDP_growth,CustomMethods.VecCal(CustomMethods.MtxVec(MTX_AUM_RegionWeight,2,1),CustomMethods.MtxVec(MTX_AUM_RegionSensitivity,2,1),3),3));	performace linked change + macro linked change, where the latter is a weighted average of sensitivity adjusted regional macro growths.
1000	} else {	
1000	AUM_MultiAssets_growth=AUM_multiassets_OR[0][period_count+1];	
1000	}	
55	AUM_equity[0][period_count+1]=AUM_equity[0][period_count]*(1+AUM_Equity_growth);	
56	AUM_fixed_income[0][period_count+1]=AUM_fixed_income[0][period_count]*(1+AUM_FixedIncome_growth);	
57	AUM_multi_assets[0][period_count+1]=AUM_multi_assets[0][period_count]*(1+AUM_MultiAssets_growth);	
3000	Total_AUM[0][period_count+1]=AUM_equity[0][period_count+1]+AUM_fixed_income[0][period_count+1]+AUM_multi_assets[0][period_count+1];	
3000	AUM_growth=Total_AUM[0][period_count+1]/Total_AUM[0][period_count];	intermediate variable: growth of non-loan type assets

5. Modeling Pillar I Capital Planning

We model the Pillar I capital requirement and resources of the asset manager as follows:

1. Credit risk capital: 8% of the credit risk RWA. And the credit risk RWA is modeled as taking the trend of the provision results from the 'ICAAP module' of *Stress Controller™* and applying it on the historical credit risk RWA.
2. Market risk capital: this is modeled as taking the trend of the forecasted total assets and applying it to the historical market risk required capital.
3. Operational risk capital: the standard approach is implemented, i.e. 12% of the forecasted revenue.
4. Pillar I capital resources are modelled in a simple manner in that Tier 1 capitals assumed to equal forecast shareholder equity. Tier 2 capital and the capital reduction are supposed to be constant over time.

6. Results

Using the approach described above, we performed an analysis of the impact of several stress scenarios on the asset manager's AUM and financial and capital planning. We present below results for (i) a base case (i.e., an unconditional forecast), (ii) a UK recession and (iii) a customer loss scenario.

The recession scenarios assume a sequence of shocks to real GDP in the geographical region in question. In all cases, the shocks are -2% in Q1, -1% in Q2 and -0.5% in Q3, Q4, Q5 and Q6. These shocks sum to a cumulative negative shock of 5% over 1.5 years. The customer loss scenario assumes a 3% decline in AUM in each quarter for the first 4 quarters. These shocks sum to a cumulative reduction in AUM of 12% over 1 year.

Figure 7: 12 Month GDP Growth Rates under Base and UK Recession Scenarios

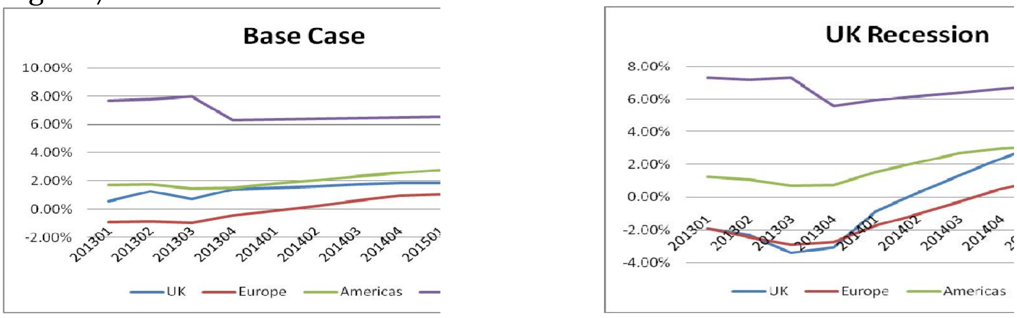
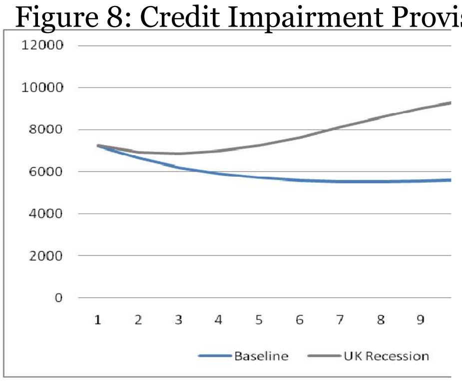


Figure 7 shows the effects of the base case and UK recession scenarios on GDP growth rates in different regions. Conditional on set of negative shocks to UK GDP, the model generates forecasts of all other macroeconomic variables including GDP in other regions and market prices including equity indices and interest rates by region. We perform the analysis from the perspective of information available at the end of 2012. Europe was still exhibiting a slight negative growth rate at that time which is then reflected in depressed growth in the first few periods of the projection.

Figure 8: Credit Impairment Provisions in a UK Recession



Within the model, the UK recession scenario has an impact on the ratings of the private bank's counter-parties and hence boosts credit impairment provisions as shown in Figure 8. This scenario also leads to a drop in equity indices with reduces AUM. The impact on is only partially compensated by a rise in the value of bond funds that occurs through lower interest rates. Figure 9 shows the forecast dynamics of AUM under the base case and the two scenarios of client loss and UK recession.

Figure 10 shows the impact of the scenarios on the asset manager's capital adequacy ratio. Customer loss leads to an immediate loss of revenue. This reduces capital requirements in the short run but subsequently generates a loss of income erodes which profitability. The plot therefore shows a short-term rise in the capital ratio followed by a relative decline to below the level of the base case projection.

Figure 9: AUM under Different Scenarios

Figure 10: Capital Adequacy Ratio under Different Scenarios

One may observe that the CAR ratio in the '03 customer loss' scenario remains higher than that of '01 base case' for the first 5 quarters. This is because the shock to AUM reduces revenue and hence the Pillar 1 operational risk capital required. This leads to a quasi-linear reduction in capital required (recall that the shock reduce in customer is about 12% for the first 4 quarters) whereas the capital available reduces at a much slower speed. Figures 11 and 12 show time paths of the numerator and denominator of the CAR ratio.

Figure 11: Forecasted Pillar I Capital Requirement under Different Scenarios

Figure 12: Forecasted Pillar I Capital Resources under Different Scenarios

7. Conclusion

The analysis in this note is illustrative of how *Stress ControllerTM* may be used to perform stress testing of asset managers and private banks. It is straightforward to change the logic of the modelling to accommodate quite different forms of analysis.
To illustrate, one may as an input to the calculations a central-case projection of the financial statements of an asset manager and model deviations from that base case as driven by shocks to market variables. Such an approach renders the analysis consistent with a set of forecasts generated by, for example, a Treasury function within an asset manager while permitting the risk function to investigate the impact on the business of a set of stress scenarios.

To this extent, *Stress ControllerTM* is an environment within which a wide range of company specific financial statement and capital projections may be performed.

Appendix

1.Controls

```
hist_len=24;
print(period_count+1);
```

2. Macro variables

```
UK_GDP_current=CustomMethods.Exp(UK_GDP_log[0][period_count+1]);
Europe_GDP_current=CustomMethods.Exp(Europe_GDP_log[0][period_count+1]);
Americas_GDP_current=CustomMethods.Exp(Americas_GDP_log[0][period_count+1]);
AfricaAndMiddleEast_GDP_current=CustomMethods.Exp(AfricaAndMiddleEast_GDP_log[0][period_count+1]);
Asia_GDP_current=CustomMethods.Exp(Asia_GDP_log[0][period_count+1]);
UK_Equity_current=CustomMethods.Exp(UK_Equity_log[0][period_count+1]);
Europe_Equity_current=CustomMethods.Exp(Europe_Equity_log[0][period_count+1]);
Americas_Equity_current=CustomMethods.Exp(Americas_Equity_log[0][period_count+1]);
AfricaAndMiddleEast_Equity_current=CustomMethods.Exp(AfricaAndMiddleEast_Equity_log[0][period_count+1]);
Asia_Equity_current=CustomMethods.Exp(Asia_Equity_log[0][period_count+1]);
UK_GDP_previous=CustomMethods.Exp(UK_GDP_log[0][period_count]);
Europe_GDP_previous=CustomMethods.Exp(Europe_GDP_log[0][period_count]);
Americas_GDP_previous=CustomMethods.Exp(Americas_GDP_log[0][period_count]);
AfricaAndMiddleEast_GDP_previous=CustomMethods.Exp(AfricaAndMiddleEast_GDP_log[0][period_count]);
Asia_GDP_previous=CustomMethods.Exp(Asia_GDP_log[0][period_count]);
UK_Equity_previous=CustomMethods.Exp(UK_Equity_log[0][period_count]);
Europe_Equity_previous=CustomMethods.Exp(Europe_Equity_log[0][period_count]);
Americas_Equity_previous=CustomMethods.Exp(Americas_Equity_log[0][period_count]);
AfricaAndMiddleEast_Equity_previous=CustomMethods.Exp(AfricaAndMiddleEast_Equity_log[0][period_count]);
Asia_Equity_previous=CustomMethods.Exp(Asia_Equity_log[0][period_count]);
```

3. BS model round 1

```
BS_Cash[0][period_count+1]=CustomMethods.MovAve(BS_Cash[0],period_count,8);
Europe_CPI_growth=CustomMethods.Exp(Europe_CPI_log[0][period_count+1])/CustomMethods.Exp(Europe_CPI_log[0][period_count])-1;
Americas_CPI_growth=CustomMethods.Exp(Americas_CPI_log[0][period_count+1])/CustomMethods.Exp(Americas_CPI_log[0][period_count])-1;
BS_LoanToBanks[0][period_count+1]=(Loan_TrendWeight[0][0]*CustomMethods.GrowAve(BS_LoanToBanks[0], period_count, 8)+(1-Loan_TrendWeight[0][0])*(Loan_UK_Weight[0][0]*Loan_UK_SensitivityToGDP[0][0]*(UK_GDP_current/UK_GDP_previous-1)+Loan_Europe_Weight[0][0]*Loan_Europe_SensitivityToGDP[0][0]*(Europe_GDP_current/Europe_GDP_previous-1)+Loan_Americas_Weight[0][0]*Loan_Americas_SensitivityToGDP[0][0]*(Americas_GDP_current/Americas_GDP_previous-1)+Loan_AfricaAndME_Weight[0][0]*Loan_AfricaAndME_SensitivityToGDP[0][0]*(AfricaAndMiddleEast_GDP_current/AfricaAndMiddleEast_GDP_previous-1)+Loan_Asia_Weight[0][0]*Loan_Asia_SensitivityToGDP[0][0]*(Asia_GDP_current/Asia_GDP_previous-1))+1)*BS_LoanToBanks[0][period_count]*(1+Loan_SensitivityToCPI[0][0]*(Europe_CPI_growth+Americas_CPI_growth)/2);
Credit_Pool_Provision[0][hist_len-4]=Credit_Pool_Provision[0][hist_len-1];
Credit_Pool_Provision[0][hist_len-3]=Credit_Pool_Provision[0][hist_len-1];
```

```
Credit_Pool_Provision[0][hist_len-2]=Credit_Pool_Provision[0][hist_len-1];
Ave_CreditPoolProvision_current=(Credit_Pool_Provision[0][period_count+1]+Credit_Pool_Provision[0][period_count]+Credit_Pool_Provision[0][period_count-1]+Credit_Pool_Provision[0][period_count-2])/4.0;
Ave_CreditPoolProvision_previous=(Credit_Pool_Provision[0][period_count]+Credit_Pool_Provision[0][period_count-1]+Credit_Pool_Provision[0][period_count-2]+Credit_Pool_Provision[0][period_count-3])/4.0;
BS_LAToBanks_Scaling=BS_LoanToBanks[0][period_count+1]/BS_LoanToBanks[0][hist_len-1];
BS_Allowance_Banks[0][period_count+1]=BS_Allowance_Banks[0][period_count]+Ave_CreditPoolProvision_current*BS_LAToBanks_Scaling/4.0*Credit_Provision_FractionOfBank[0][period_count+1]-Loan_WriteOff_banks[0][period_count+1]*(Ave_CreditPoolProvision_current/Ave_CreditPoolProvision_previous);
BS_NetLoanToBanks[0][period_count+1]=BS_LoanToBanks[0][period_count+1]-BS_Allowance_Banks[0][period_count+1];
BS_LoanToCustomers[0][period_count+1]=(Loan_TrendWeight[0][0]*CustomMethods.GrowAve(BS_LoanToCustomers[0], period_count, 8)+(1-Loan_TrendWeight[0][0])*(Loan_UK_Weight[0][0]*Loan_UK_SensitivityToGDP[0][0]*(UK_GDP_current/UK_GDP_previous-1)+Loan_Europe_Weight[0][0]*Loan_Europe_SensitivityToGDP[0][0]*(Europe_GDP_current/Europe_GDP_previous-1)+Loan_Americas_Weight[0][0]*Loan_Americas_SensitivityToGDP[0][0]*(Americas_GDP_current/Americas_GDP_previous-1)+Loan_AfricaAndME_Weight[0][0]*Loan_AfricaAndME_SensitivityToGDP[0][0]*(AfricaAndMiddleEast_GDP_current/AfricaAndMiddleEast_GDP_previous-1)+Loan_Asia_Weight[0][0]*Loan_Asia_SensitivityToGDP[0][0]*(Asia_GDP_current/Asia_GDP_previous-1))+1)*BS_LoanToCustomers[0][period_count]*(1+Loan_SensitivityToCPI[0][0]*(Europe_CPI_growth+Americas_CPI_growth)/2);
BS_LAToCustomers_Scaling=BS_LoanToCustomers[0][period_count+1]/BS_LoanToCustomers[0][hist_len-1];
BS_Allowance_Customers[0][period_count+1]=BS_Allowance_Customers[0][period_count]+BS_LAToCustomers_Scaling*Ave_CreditPoolProvision_current/4.0*(1-Credit_Provision_FractionOfBank[0][period_count+1])-Loan_WriteOff_customers[0][period_count+1]*(Ave_CreditPoolProvision_current/Ave_CreditPoolProvision_previous);
BS_NetLoanToCustomers[0][period_count+1]=BS_LoanToCustomers[0][period_count+1]-BS_Allowance_Customers[0][period_count+1];
BS_OtherAssets[0][period_count+1]=CustomMethods.MovAve(BS_OtherAssets[0],period_count,8);
BS_TotalAssets[0][period_count+1]=BS_Cash[0][period_count+1]+BS_NetLoanToBanks[0][period_count+1]+BS_NetLoanToCustomers[0][period_count+1]+BS_OtherAssets[0][period_count+1];
BS_DueToBanks[0][period_count+1]=CustomMethods.MovAve(BS_DueToBanks[0],period_count,8)*(1+Deposit_SensitivityToCPI[0][0]*(Europe_CPI_growth+Americas_CPI_growth)/2);
BS_Deposits[0][period_count+1]=(Deposit_TrendWeight[0][0]*CustomMethods.GrowAve(BS_Deposits[0], period_count, 8)+(1-Deposit_TrendWeight[0][0])*(Loan_UK_Weight[0][0]*Deposit_UK_SensitivityToGDP[0][0]*(UK_GDP_current/UK_GDP_previous-1)+Loan_Europe_Weight[0][0]*Deposit_Europe_SensitivityToGDP[0][0]*(Europe_GDP_current/Europe_GDP_previous-1)+Loan_Americas_Weight[0][0]*Deposit_Americas_SensitivityToGDP[0][0]*(Americas_GDP_current/Americas_GDP_previous-1)+Loan_AfricaAndME_Weight[0][0]*Deposit_AfricaAndME_SensitivityToGDP[0][0]*(AfricaAndMiddleEast_GDP_current/AfricaAndMiddleEast_GDP_previous-1)+Loan_Asia_Weight[0][0]*Deposit_Asia_SensitivityToGDP[0][0]*(Asia_GDP_current/Asia_GDP_previous-1))+1)*BS_Deposits[0][period_count]*(1+Deposit_SensitivityToCPI[0][0]*(Europe_CPI_growth+Americas_CPI_growth)/2);
BS_OtherLiabilities[0][period_count+1]=CustomMethods.MovAve(BS_OtherLiabilities[0],period_count,8);
```

```
BS_TotalLiabilities[0][period_count+1]=BS_DueToBanks[0][period_count+1]+BS_Deposits[0][period_count
+1]+BS_OtherLiabilities[0][period_count+1];
UK_Int_Change=((UK_3MRate_log[0][period_count+1]-
UK_3MRate_log[0][period_count])+(UK_10YRate_log[0][period_count+1]-
UK_10YRate_log[0][period_count]))/2;
Europe_Int_Change=((Europe_3MRate_log[0][period_count+1]-
Europe_3MRate_log[0][period_count])+(Europe_10YRate_log[0][period_count+1]-
Europe_10YRate_log[0][period_count]))/2;
Americas_Int_Change=((Americas_3MRate_log[0][period_count+1]-
Americas_3MRate_log[0][period_count])+(Americas_10YRate_log[0][period_count+1]-
Americas_10YRate_log[0][period_count]))/2;
AfricaAndMiddleEast_Int_Change=((AfricaAndMiddleEast_3MRate_log[0][period_count+1]-
AfricaAndMiddleEast_3MRate_log[0][period_count])+(AfricaAndMiddleEast_10YRate_log[0][period_count
+1]-AfricaAndMiddleEast_10YRate_log[0][period_count]))/2;
Asia_Int_Change=((Asia_3MRate_log[0][period_count+1]-
Asia_3MRate_log[0][period_count])+(Asia_10YRate_log[0][period_count+1]-
Asia_10YRate_log[0][period_count]))/2;
Average_Int_Change=Loan_UK_Weight[0][0]*UK_Int_Change+Loan_Europe_Weight[0][0]*Europe_Int_C
hange+Loan_Americas_Weight[0][0]*Americas_Int_Change+Loan_AfricaAndME_Weight[0][0]*AfricaAnd
MiddleEast_Int_Change+Loan_Asia_Weight[0][0]*Asia_Int_Change;
LoanAsset_growth=(BS_LoanToBanks[0][period_count+1]+BS_LoanToCustomers[0][period_count+1])/(BS
_LoanToBanks[0][period_count]+BS_LoanToCustomers[0][period_count]);
```

4. AUM model

```
UK_equity_growth=UK_Equity_current/UK_Equity_previous-1;
Europe_equity_growth=Europe_Equity_current/Europe_Equity_previous-1;
Asia_equity_growth=Asia_Equity_current/Asia_Equity_previous-1;
Americas_equity_growth=Americas_Equity_current/Americas_Equity_previous-1;
UK_GDP_growth=UK_GDP_current/UK_GDP_previous-1;
Europe_GDP_growth=Europe_GDP_current/Europe_GDP_previous-1;
Asia_GDP_growth=Asia_GDP_current/Asia_GDP_previous-1;
Americas_GDP_growth=Americas_GDP_current/Americas_GDP_previous-1;
double [] Vector_equity_growth = new double [] {UK_equity_growth, Europe_equity_growth,
Asia_equity_growth, Americas_equity_growth};
double [] Vector_GDP_growth = new double [] {UK_GDP_growth, Europe_GDP_growth, Asia_GDP_growth,
Americas_GDP_growth};
double [] Vector_Int_change = new double [] {UK_Int_Change, Europe_Int_Change, Asia_Int_Change,
Americas_Int_Change};
print(82); print(MTX_AUM_Performance[1][1]);
if (AUM_equity_OR[0][period_count+1]==-999) {
AUM_Equity_growth=AUM_perf_growthaddon_equity[0][period_count+1]+CustomMethods.SumCol(Custo
mMethods.VecCal(Vector_equity_growth,CustomMethods.VecCal(CustomMethods.MtxVec(MTX_AUM_Regi
onWeight,0,1),CustomMethods.MtxVec(MTX_AUM_RegionSensitivity,0,1),3),3));
} else {
AUM_Equity_growth=AUM_equity_OR[0][period_count+1];
}
if (AUM_fixedincome_OR[0][period_count+1]==-999) {
AUM_FixedIncome_growth=AUM_perf_growthaddon_fixedincome[0][period_count+1]+CustomMethods.Su
mCol(CustomMethods.VecCal(Vector_Int_change,CustomMethods.VecCal(CustomMethods.MtxVec(MTX_AU
M_RegionWeight,1,1),CustomMethods.MtxVec(MTX_AUM_RegionSensitivity,1,1),3),3));
} else {
AUM_FixedIncome_growth=AUM_fixedincome_OR[0][period_count+1];
}
```

```
if (AUM_multiassets_OR[0][period_count+1]==-999) {
AUM_MultiAssets_growth=AUM_perf_growthaddon_multiassets[0][period_count+1]+CustomMethods.Sum
Col(CustomMethods.VecCal(Vector_GDP_growth,CustomMethods.VecCal(CustomMethods.MtxVec(MTX_AU
M_RegionWeight,2,1),CustomMethods.MtxVec(MTX_AUM_RegionSensitivity,2,1),3),3));
} else {
AUM_MultiAssets_growth=AUM_multiassets_OR[0][period_count+1];
}
AUM_equity[0][period_count+1]=AUM_equity[0][period_count]*(1+AUM_Equity_growth);
AUM_fixed_income[0][period_count+1]=AUM_fixed_income[0][period_count]*(1+AUM_FixedIncome_gro
wth);
AUM_multi_assets[0][period_count+1]=AUM_multi_assets[0][period_count]*(1+AUM_MultiAssets_growth
);
Total_AUM[0][period_count+1]=AUM_equity[0][period_count+1]+AUM_fixed_income[0][period_count+1]
+AUM_multi_assets[0][period_count+1];
AUM_growth=Total_AUM[0][period_count+1]/Total_AUM[0][period_count];
```

5. IS model

```
IS_Revenue[0][period_count+1]=IS_Revenue[0][period_count]*AUM_growth;
IS_Revenue[0][period_count+1]=IS_Revenue[0][period_count]*(AUM_growth+AUM_rate_growth_Addon[
0][period_count+1]);
IS_Revenue[0][period_count+1]=(AUM_equity[0][period_count+1]*AUM_equity_rate_bps[0][period_count
+1]/10000+AUM_fixed_income[0][period_count+1]*AUM_fixedincome_rate_bps[0][period_count+1]/1000
0+AUM_multi_assets[0][period_count+1]*AUM_multiassets_rate_bps[0][period_count+1]/10000)/4.0;
IS_NetIntIncome[0][period_count+1]=IS_NetIntIncome[0][period_count]*(IntIncome_Weight_On_Loan[0]
[0]*LoanAsset_growth)*(1+IntIncome_Sensitivity_IntRate[0][0]*Average_Int_Change);
IS_TotalIncome[0][period_count+1]=IS_Revenue[0][period_count+1]+IS_NetIntIncome[0][period_count+1
];
BS_LATotal_Scaling=(BS_LoanToCustomers[0][period_count+1]+BS_LoanToBanks[0][period_count+1])/(B
S_LoanToCustomers[0][hist_len-1]+BS_LoanToBanks[0][hist_len-1]);
Provision_Charge_Ratio=-IS_CreditCharges[0][hist_len-1]*4.0/Credit_Pool_Provision[0][hist_len-1];
print(115); print(Credit_Pool_Provision[0][hist_len-1]);
IS_CreditCharges[0][period_count+1]=-
1*BS_LATotal_Scaling*Provision_Charge_Ratio*Ave_CreditPoolProvision_current/4.0;
print(2801); print(BS_LATotal_Scaling); print(2802); print(Ave_CreditPoolProvision_current);
IS_ExtroImpairment[0][period_count+1]=Extrodinary_Impairment[0][period_count+1];
IS_OPExpenses[0][period_count+1]=IS_OPExpenses[0][period_count]*(1+OperationExpense_growth[0][per
iod_count+1]);
IS_OtherExpenses[0][period_count+1]=CustomMethods.MovAve(IS_OtherExpenses[0],period_count,8);
IS_PBT[0][period_count+1]=IS_TotalIncome[0][period_count+1]+IS_CreditCharges[0][period_count+1]+IS
_ExtroImpairment[0][period_count+1]+IS_OPExpenses[0][period_count+1]+IS_OtherExpenses[0][period_c
ount+1];
IS_Tax[0][period_count+1]=-
1*CustomMethods.Max(0,1*Tax_AverageRate[0][0]*IS_PBT[0][period_count+1]);
IS_PAT_ConOperation[0][period_count+1]=IS_PBT[0][period_count+1]+IS_Tax[0][period_count+1];
IS_DisconOperation[0][period_count+1]=Discontinued_GainLoss[0][period_count+1];
IS_PAT[0][period_count+1]=IS_PAT_ConOperation[0][period_count+1]-
IS_DisconOperation[0][period_count+1];
```

6. BS model round 2

```
test1=CustomMethods.MovAve(IS_PAT[0], period_count,8);
print(Dividend_Payout_Ratio[0][period_count+1]);
Dividend=CustomMethods.Max(0, CustomMethods.MovAve(IS_PAT[0],
period_count,8)*Dividend_Payout_Ratio[0][period_count+1]);
```

```
BS_Equity_Control[0][period_count+1]=BS_Equity_Control[0][period_count]+Capital_Injection[0][period_
count+1]+(IS_PAT[0][period_count+1]-Dividend);
BS_Equity_NoControl[0][period_count+1]=BS_Equity_NoControl[0][period_count];
BS_TotalEquity[0][period_count+1]=BS_Equity_Control[0][period_count+1]+BS_Equity_NoControl[0][peri
od_count+1];
BS_TotalLiaAndEquity[0][period_count+1]=BS_TotalLiabilities[0][period_count+1]+BS_TotalEquity[0][peri
od_count+1];
BS_Cash[0][period_count+1]=CustomMethods.Max(0, BS_Cash[0][period_count+1]-
CustomMethods.Max(IS_PAT[0][period_count+1],0)*Dividend_Payout_Ratio[0][period_count+1]);
BS_TotalAssets[0][period_count+1]=BS_Cash[0][period_count+1]+BS_NetLoanToBanks[0][period_count+1
]+BS_NetLoanToCustomers[0][period_count+1]+BS_OtherAssets[0][period_count+1];
```

7. BS re-balancing

```
BS_Cash[0][period_count+1]=BS_Cash[0][period_count+1]+CustomMethods.Max(0,BS_TotalLiaAndEquity[
0][period_count+1]-BS_TotalAssets[0][period_count+1])*GapAbsorb_Asset_Cash[0][0];
BS_TradingAssets[0][period_count+1]=BS_TradingAssets[0][period_count+1]+CustomMethods.Max(0,BS_T
otalLiaAndEquity[0][period_count+1]-
BS_TotalAssets[0][period_count+1])*GapAbsorb_Asset_TradingPortfolio[0][0];
BS_OtherAssets[0][period_count+1]=BS_OtherAssets[0][period_count+1]+CustomMethods.Max(0,BS_Total
LiaAndEquity[0][period_count+1]-BS_TotalAssets[0][period_count+1])*GapAbsorb_Asset_Other[0][0];
BS_DueToBanks[0][period_count+1]=BS_DueToBanks[0][period_count+1]+CustomMethods.Max(0,BS_Tot
alAssets[0][period_count+1]-
BS_TotalLiaAndEquity[0][period_count+1])*GapAbsorb_Liability_DueToBanks[0][0];
BS_Deposits[0][period_count+1]=BS_Deposits[0][period_count+1]+CustomMethods.Max(0,BS_TotalAssets[
0][period_count+1]-
BS_TotalLiaAndEquity[0][period_count+1])*GapAbsorb_Liability_CustomerAccount[0][0];
BS_DebtIssue[0][period_count+1]=BS_DebtIssue[0][period_count+1]+CustomMethods.Max(0,BS_TotalAsse
ts[0][period_count+1]-BS_TotalLiaAndEquity[0][period_count+1])*GapAbsorb_Liability_DebtIssue[0][0];
BS_OtherLiabilities[0][period_count+1]=BS_OtherLiabilities[0][period_count+1]+CustomMethods.Max(0,BS
_TotalAssets[0][period_count+1]-
BS_TotalLiaAndEquity[0][period_count+1])*GapAbsorb_Liability_Other[0][0];
BS_TotalAssets[0][period_count+1]=BS_Cash[0][period_count+1]+BS_NetLoanToBanks[0][period_count+1
]+BS_NetLoanToCustomers[0][period_count+1]+BS_OtherAssets[0][period_count+1];
BS_TotalLiabilities[0][period_count+1]=BS_DueToBanks[0][period_count+1]+BS_Deposits[0][period_count
+1]+BS_OtherLiabilities[0][period_count+1];
BS_TotalLiaAndEquity[0][period_count+1]=BS_TotalLiabilities[0][period_count+1]+BS_TotalEquity[0][peri
od_count+1];
BS_Gap_Check[0][period_count+1]=BS_TotalAssets[0][period_count+1]-
BS_TotalLiaAndEquity[0][period_count+1];
```

8. Report items

```
Q0_Credit_RWA=RWA_CreditRisk[0][hist_len-1];
Q0_CreditPool_RWAProvision=Credit_Pool_RWAProvision[0][hist_len-1];
Credit_Pool_RWAProvision[0][hist_len-4]=Credit_Pool_RWAProvision[0][hist_len-1];
Credit_Pool_RWAProvision[0][hist_len-3]=Credit_Pool_RWAProvision[0][hist_len-1];
Credit_Pool_RWAProvision[0][hist_len-2]=Credit_Pool_RWAProvision[0][hist_len-1];
Ave_CreditPoolRWAProvision_current=(Credit_Pool_RWAProvision[0][period_count+1]+Credit_Pool_RWA
Provision[0][period_count]+Credit_Pool_RWAProvision[0][period_count-
1]+Credit_Pool_RWAProvision[0][period_count-2])/4.0;
Ave_CreditPoolRWAProvision_previous=(Credit_Pool_RWAProvision[0][period_count]+Credit_Pool_RWA
Provision[0][period_count-1]+Credit_Pool_RWAProvision[0][period_count-
2]+Credit_Pool_RWAProvision[0][period_count-3])/4.0;
print(161); print(Ave_CreditPoolRWAProvision_previous);print(Ave_CreditPoolRWAProvision_current);
```

```
RWA_CreditRisk[0][period_count+1]=Q0_Credit_RWA*Ave_CreditPoolRWAProvision_current/Q0_CreditP
ool_RWAProvision*BS_LATotal_Scaling;
RWA_MarketRisk[0][period_count+1]=(BS_TradingAssets[0][period_count+1]+BS_FVAssets[0][period_cou
nt+1]+BS_DerivativeAssets[0][period_count+1]+BS_ForSaleAssets[0][period_count+1])*MktRWA_MVAsset
s_Ratio[0][period_count+1]*(Ave_CreditPoolRWAProvision_current/Ave_CreditPoolRWAProvision_previou
s);
RWA_MarketRisk[0][period_count+1]=RWA_MarketRisk[0][period_count]*(RWA_CreditRisk[0][period_co
unt+1]/RWA_CreditRisk[0][period_count]);
RWA_OperationalRisk[0][period_count+1]=BS_TotalAssets[0][period_count+1]*OpRWA_TotalAssets_Ratio
[0][period_count+1]*(Ave_CreditPoolRWAProvision_current/Ave_CreditPoolRWAProvision_previous);
RWA_Total[0][period_count+1]=RWA_CreditRisk[0][period_count+1]+RWA_MarketRisk[0][period_count+
1]+RWA_OperationalRisk[0][period_count+1];
CoreTier1_Cap[0][period_count+1]=BS_TotalEquity[0][period_count+1]*CoreTier1_Equity_Ratio[0][period
_count+1];
Tier1_Cap[0][period_count+1]=BS_TotalEquity[0][period_count+1]*Tier1_Equity_Ratio[0][period_count+1]
;
Tier2_Cap[0][period_count+1]=BS_SubDebt[0][period_count+1]*Tier2_SubLiabilities_Ratio[0][period_cou
nt+1];
Deduction_Cap[0][period_count+1]=(Tier1_Cap[0][period_count+1]+Tier2_Cap[0][period_count+1])*Deduc
tion_Capital_Ratio[0][period_count+1];
Total_Cap[0][period_count+1]=Tier1_Cap[0][period_count+1]+Tier2_Cap[0][period_count+1]+Deduction_
Cap[0][period_count+1];
CoreTier1_CapRatio[0][period_count+1]=CoreTier1_Cap[0][period_count+1]/RWA_Total[0][period_count+
1];
Tier1_CapRatio[0][period_count+1]=Tier1_Cap[0][period_count+1]/RWA_Total[0][period_count+1];
Total_CapRatio[0][period_count+1]=Total_Cap[0][period_count+1]/RWA_Total[0][period_count+1];
Return_On_Equity[0][period_count+1]=4.0*IS_PAT[0][period_count+1]/BS_Equity_Control[0][period_cou
nt+1];
Return_On_RWA[0][period_count+1]=4.0*IS_PAT[0][period_count+1]/RWA_Total[0][period_count+1];
Loan_LossRate[0][period_count+1]=-
4.0*10000*IS_CreditCharges[0][period_count+1]/(BS_LoanToBanks[0][period_count+1]+BS_LoanToCusto
mers[0][period_count+1]);
Credit_RWA=(CapRequired_CreditRisk[0][hist_len-
1]/0.08)*Ave_CreditPoolRWAProvision_current/Q0_CreditPool_RWAProvision*BS_LATotal_Scaling;
Credit_RWA=(CapRequired_CreditRisk[0][hist_len-
1]/0.08)*Ave_CreditPoolRWAProvision_current/Q0_CreditPool_RWAProvision;
Credit_RWA=(CapRequired_CreditRisk[0][hist_len-
1]/0.08)*Ave_CreditPoolProvision_current/Ave_CreditPoolProvision_previous;
CapRequired_CreditRisk[0][period_count+1]=Credit_RWA*0.08;
CapRequired_MarketRisk[0][period_count+1]=CapRequired_MarketRisk[0][period_count]*(BS_TotalAssets
[0][period_count+1]/BS_TotalAssets[0][period_count]);
CapRequired_OperationalRisk[0][period_count+1]=IS_Revenue[0][period_count+1]*4*0.12;
CapRequired_Total[0][period_count+1]=CapRequired_CreditRisk[0][period_count+1]+CapRequired_Market
Risk[0][period_count+1]+CapRequired_OperationalRisk[0][period_count+1];
CapResources_Tier1[0][period_count+1]=CapResources_Tier1[0][period_count]+(BS_TotalEquity[0][period
_count+1]-BS_TotalEquity[0][period_count]);
CapResources_Tier2[0][period_count+1]=CapResources_Tier2[0][period_count];
CapResources_Deduction[0][period_count+1]=CapResources_Deduction[0][period_count];
CapResources_Total[0][period_count+1]=CapResources_Tier1[0][period_count+1]+CapResources_Tier2[0][
period_count+1]+CapResources_Deduction[0][period_count+1];
CapRatio_Adequacy[0][period_count+1]=CustomMethods.ConvertNaNAndInfinite(CapResources_Total[0][p
eriod_count+1]/CapRequired_Total[0][period_count+1],0);
```