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RISK CONTROL

Memo

Scenario-based RORC Optimisation for a Bank Loan Book

Abstract

Regulatory capital is the primary constraint on banks' strategic decision making in the current regulatory environment. This note shows how banks may use top down analysis of their assets to optimise the Return on Regulatory Capital (RORC). We analyse the loan book of a major international bank using publicly available Pillar 3 data and show that a shift from corporate to retail lending would significantly boost the bank's RORC. The calculations are performed within Risk Control's financial planning software, *Stress Controller™*.

1. Introduction

Efficient management of banks, in the current regulatory environment, requires economical use of regulatory capital. To achieve this, banks should evaluate, for each business activity, the net expected return and the consumption of regulatory capital. This note[1] presents a methodology for making such comparisons and for assessing how strategic changes in lending volumes devoted to different asset classes and markets affect the bank's overall return-to-capital ratios.

Many banks use return on capital (often termed Risk Adjusted Return on Capital or RAROC) as the basis for hurdle rates in pricing loans. Some banks also use RAROC to analyse the performance of business units. Few institutions, however, use the approach in a systematic manner to optimise the bank's exposure to different asset classes. Currently, for many banks, the constraint on lending is regulatory rather than economic capital. It is, therefore, interesting to analyse how different lending book strategies affect the Return on Regulatory Capital or "RORC".

This note shows how such an analysis may be performed in a top-down manner contributing significantly to strategic decision making. We focus on the loan book of a bank although the approach could be extended to cover other business activities and risks. We show how to forecast net returns and regulatory capital for loan exposures broken down by asset class both in a base case projection and subject to shocks to the macroeconomic environment.

We apply our approach to the case of a particular bank, Barclays Group plc. The calculations presented are based entirely on publicly disclosed data. We chose Barclays as the example because of its importance as a major UK bank with a strong international presence. To construct the data for this case study, we use data on the bank's loan book from its Pillar III disclosure and information from its annual report.

The projections are made for a base case and for an adverse scenario involving a recession in the UK. The framework we employ is capable of providing dynamic views of a bank's loan book risk (provision and

[1] This note was written by William Perraudin, Susan Wu and Fang Yao.

regulatory capital) based on user-defined criteria at different aggregation levels. In other words, the RORC calculation can distinguish the risk character of a bank's loan book in a completely bespoke manner. For simplicity's sake, here we limit ourselves to reporting results at an asset class level.

The calculations reported here are performed using Risk Control's application for conditional analysis of risk, *Stress Controller™*. This application consists of web-based software in which much of the logic of a financial modelling exercise may be included through readily editable equations. The software supports the conditional forecasting of default rates in loan pools at different levels of aggregation and permits the user to generate macroeconomic scenarios and to link these through to shocks to loan ratings and probabilities of default.

The memo is organised as follows. Section 2 describes the bank loan book that we analyse. Section 3 discusses the RORC measures on which we focus. Section 4 displays the management adjustments applied to the loan book. Section 5 concludes. Appendices provide information on the loan book calibrations and the generation of macroeconomic scenarios.

2. Description of the bank's loan book

Here, we describe the bank's loan book. The bank provides information on the breakdown of its loan book by region, sector, credit quality, and asset class in its Pillar 3 disclosures. Table 1 shows how the book is broken down by sector and region.[2]

Table 1: Breakdown of the bank's loan book

Industrial sectors	credit class	UK	Europe	Americas	Africa and Middle East	Asia	Total
Banks	Wholesale to bank	6,442	12,756	11,426	2,612	7,029	**40,265**
Other financial institutionsa	Wholesale to customer	26,800	11,036	53,143	8,023	4,386	**103,388**
Manufacturing	Wholesale to customer	5,975	2,158	1,461	1,372	682.4018	**11,647**
Construction and property	Wholesale to customer	17,314	2290.781	911.7345	2182.059	143.0546	**22,842**
Government and central bank	Wholesale to customer	1,549	1741.938	686.1573	1327.238	1811.054	**7,115**
Government and central bank	Wholesale to bank	402	451.949	178.0248	344.3545	469.8815	**1,846**
Energy and water	Wholesale to customer	1,964	3476.484	1705.596	841.9163	547.5319	**8,536**
Wholesale and retail distribution and leisure	Wholesale to customer	9,964	1343.854	481.1331	1368.741	181.4618	**13,339**
Business and other services	Wholesale to customer	14,303	2961.82	2475.618	2147.766	483.9721	**22,372**
Home loans	Home loans	126,668	26183.71	727.3205	13068.52	326.4572	**166,974**
Cards, unsecured loans and other personal lending	Cards	31,480	7590.703	14115.22	4293.799	1433.874	**58,914**
Other wholesale	Wholesale to customer	1,107	247.3307	171.1883	924.8132	81.82667	**2,532**
Other retail	Other retail	4,419	987	683	3,692	327	**10,108**
		248,387	**73,226**	**88,165**	**42,197**	**17,903**	**469,878**

Note: The table shows the breakdown of the bank's loan book by region, sector and credit class. Figures shown are in GBP millions. The source isthe Barclays Group plc Annual Report 2014 (page 149 and 515) and 2013 (page 152).

More than half the bank's loan exposures are in the UK. Of these, about half are home loans. Cards exceed 10% of the book both in the UK and elsewhere. Exposures to governments and central banks are minor. Those to banks and other financial institutions are substantial, approaching a third of the total book.

To analyse the bank's loan book and how its risk and returns change in different scenarios, we need information about the returns and expected losses of the different asset classes broken down by credit quality. This information must be inferred from partial data provided in the bank's Pillar 3 disclosures and from calibration assumptions derived from other sources.

[2]These figures are derived from the bank's annual reports for 2014 and 2013. We have made the following assumptions and adjustments when deriving Table 1. In the annual report of 2013 the full matrix of loan breakdown by sector and region is given directly, while in 2014 only the aggregation number (the far right side column and the bottom row of Table 1) are provided. We assume that within each sector the distribution across regions remains the same as that in 2013. We then set the sector 'Other financial institutions' as the balancing sector to ensure the sum of each region to be consistent with the region total figures given in the 2014 annual report. For cell UK-Home loans, the value (126,668 million) is specifically given in the 2014 annual report therefore we take this value and assign the difference between this value and the estimated number to another region, Europe.

In Table 2 we present the distribution by credit quality for each asset class. The full set of distributions displayed is not given directly in the annual report. Instead, we infer it from information on performing and non-performing loans included in different sections of the bank's 2014 annual report and make some assumptions to derive the figures in Table 2. [3]

Based on our calibration, 95% of wholesale exposures are either performing strongly or satisfactorily. Around 4% are past due but not impaired. Of home loans, 96% are performing strongly or satisfactorily, while 5% are collectively impaired. For cards, 89% are performing strongly or satisfactorily but a much larger fraction of these are in the latter category. Impaired card exposures amount to 8%.

Table 2: Credit quality distribution of Loans and Advances (L&A)

Asset classes	Performing strong	Performing satisfactory	Performing higher risk	Past due not impaired	Impaired collectively	Impaired individually	Total
Wholesale to bank	0.7499	0.1874	0.0097	0.0394	0.0022	0.0114	1
Wholesale to customer	0.7499	0.1874	0.0097	0.0394	0.0022	0.0114	1
Home loans	0.8578	0.0830	0.0036	0.0026	0.0503	0.0027	1
Cards	0.2124	0.6806	0.0209	0.0061	0.0690	0.0111	1
Other retail	0.7499	0.1874	0.0097	0.0394	0.0022	0.0114	1

Note: The table shows the breakdown of the bank's loan book by asset class and credit quality category. Figures shown are shares of each asset class par value measured in natural units. The source is the 'Credit quality of L&A' data on pages from 147 to 148 and from 171 to 173 of Barclays Group plc Annual Report 2014.

Appendix 1 provides information on the calibration of returns and default probabilities for the loan book broken down by asset class. These calibrations are based mainly on Barclays-specific data taken from the bank's Pillar 3 disclosures but also draw on analysis of aggregate returns reported by other UK banks.

To model the dynamic behaviour of the Barclays loan book, we employ a dynamic version of the Vasicek loan loss distribution proposed by Lamb and Perraudin (2008). In their approach, the transformed loss rate for a granular pool of loans follows an autoregressive linear Gaussian process. A conditional version of the model may be formulated in which shocks to macro variables feed into the aggregate shock driving losses on the granular loan pool. In this case, a key parameter is the sensitivity of this aggregate shock to the macroeconomic shock.

In the current application, we identify the macroeconomic shock with deviations from forecast GDP. It is assumed that loans in individual geographical regions are affected by GDP shocks specific to those regions. We employ sensitivity parameters that we have estimated in a series of past stress testing analyses for different clients.

3. Calculation of RORC

Risk Adjusted Return on Capital (RAROC) may be defined as

$$\boldsymbol{RAROC} = \frac{Expected\ profit}{Economic\ capital} \tag{1}$$

RAROC is a natural measure of performance for financial firms like banks and insurers that are constrained in their access to equity capital. When applied systematically, RAROC provides a consistent view of profitability across the business.

In the context of a bank's loan book, the numerator, expected profit, may be represented using either net margin or net operating profit. These are calculated as:

$$\boldsymbol{Netmargin} = Interestincome - Interestcost - Expectedloss \tag{2}$$

$$\boldsymbol{Netoperatingprofit} = Netmargin - Shareofoperatingexpenses \tag{3}$$

[3]Due to the lack of information on 'Other retail' and the breakdown of Wholesale into 'to bank' and 'to customer', we assume credit quality distribution of Wholesale to bank, Wholesale to customer and Other retail are the same as the overall 'Wholesale'.

In this study, we employ regulatory rather than economic capital as the denominator in equation (1). This is appropriate for most banks for which regulatory capital is the binding constraint on lending activities. The resulting performance measures may be termed Return on Regulatory Capital or "RORC" ratios:

$$\boldsymbol{RORC\ Marginratio} = \frac{Netmargin}{Regulatorycapital} \tag{4}$$

$$\boldsymbol{RORC\ Return\ ratio} = \frac{Net\ operating\ profit}{Regulatory\ capital} \tag{5}$$

We assume a static portfolio of loan volumes as shown in Table 3. Our approach may easily be extended to allow for variations over time in loan amounts by asset class but results are easier to interpret if one supposes a static portfolio.

Table 3: Amount of loan book by asset class

Loan by asset class (£mn)	Current
Wholesale to bank	42,111
Wholesale to customer	191,771
Home loan	166,974
Cards	58,914
Other retail	10,108
Total amount	**469,878**

Note: The table shows the par value of the bank's loans by asset class measured in GBP millions.

As mentioned in the Introduction, the calculations here described are performed using Risk Control's framework application for stress testing, *Stress Controller™*. This application calculates the expected loss and regulatory capital for each individual loan exposure or diversified loan pool and aggregates the results by asset class. The expected loss and regulatory capital forecasts are calculated conditional on user-defined scenarios (explained in Appendix 2).

Table 4: Expected loss of loan book by asset class (quarterly non-cumulative)

Loan by asset class (£mn)	Current	P1		P2		P3…
		Base case	Stressed case	Base case	Stressed case	
Wholesale to bank	-1	-1	-1	-1	-1	…
Wholesale to customer	-150	-136	-165	-125	-169	…
Home loan	-195	-185	-233	-179	-259	…
Cards	-795	-756	-892	-723	-923	…
Other retail	-34	-34	-41	-33	-45	…
Total EL	**-1,176**	**-1,112**	**-1,332**	**-1,061**	**-1,397**	**…**

Note: The table shows the results of expected loss of the bank's loan by asset class measured in GBP million, under the base case and the stressed case. The stressed scenario is defined by assuming that UK GDP experience shock of 4% in the first 4 quarters.

Here, we present results for a base case (statistical trend projections based on long-term historical data) and a stressed case (statistical trend projections conditional on user-defined shocks upon selected variables). The stress scenario is defined by assuming that UK GDP experience shocks of -2% and -1% (relative to its statistical trend) in the first two quarters, followed by shocks of -0.5% in both the 3rd and 4th quarters. *Stress Controller™*, allows for spill overs between regions by calculating mean shocks to variables other than UK GDP conditional on the assumed shocks to the latter.[4]

[4]The conditional means are calculated using the covariance matrix for shocks for all the variables in the model.

Table 5: Pillar I capital of loan book by asset class

Loan by asset class (£mn)	Current	P1		P2		P3...
		Base case	Stressed case	Base case	Stressed case	
Wholesale to bank	507	456	522	413	546	...
Wholesale to customer	3,090	3,046	3,558	3,040	3,881	...
Home loan	5,977	6,520	7,964	7,064	9,446	...
Cards	9,329	9,322	10,190	9,291	10,557	...
Other retail	648	698	797	741	898	...
Total Pillar I capital	**19,551**	**20,041**	**23,031**	**20,549**	**25,328**	**...**

Note: The table shows the results of Pillar I capital of the bank's loan by asset class measured in GBP million, under the base case and the stressed case. The stressed scenario is defined by assuming that UK GDP experience shock of 4% in the first 4 quarters.

Table 4 shows the time paths of expected losses for each asset class in the base and stressed scenario cases. The UK recession has a clear impact on the credit quality of the bank's loan book. In the first period (P1), the bank's total loan book expected loss increases from £1,112 million in base case to £1,332 million in stressed case. Regulatory capital is also higher in the stress case (£23,031 million in period 1) than in the base case (£23,031 million) as one may observe from Table 5.

To forecast net returns, we first calibrate initial net interest income and cost of the loan book in the initial ('Current') period based on the bank's annual report. (The calibration is described in Appendix 1.) In our initial analysis, we suppose that the effective interest income rates and cost rates are constant. The dynamics of the interest income and cost forecasts of any asset class are only affected, therefore, by changes in volume of loans in that asset class (which we will vary as shown below).

Note that the modelling of effective interest rates is a key part of the financial planning process in most banks and substantial resources are often deployed to develop and maintain such models. The models vary substantially across institutions reflecting the nature of the bank's business and its products. We do not attempt here to model effective interest rates but the *Stress Controller™* platform we employ can easily accommodate detailed, bespoke modelling of the kind seen in many banks.

Operating expenses are introduced in this modelling exercise by allowing for user-defined growth rates. We do not attempt to make such expenses endogenous to the model but regard them as dynamic parameters to be set by management.

Table 6 presents annualised risk-adjusted return ratios calculated based on the forecasted net margin, net profit and regulatory capital of the base and the stressed cases. In the stress scenario, higher forecast expected losses and regulatory capital lead to a return to capital ratio that is significantly lower than in the base case, being 16.4% rather than 23.3%.

Table 6: Annualised risk-adjusted margin ratio and return ratio

Loan by asset class (£mn)	Current		P1				P2			
			Base case		Stressed case		Base case		Stressed case	
	Margin ratio	Return ratio	Margin ratio	Return ratio	Margin ratio	Return ratio	Margin ratio	Return ratio	Margin ratio	Return ratio
Wholesale to bank	30.9%	10.2%	34.5%	11.6%	30.0%	10.0%	38.2%	12.9%	28.8%	9.6%
Wholesale to customer	16.0%	10.7%	18.0%	12.7%	12.1%	7.6%	19.5%	14.2%	10.8%	6.6%
Home loan	49.3%	20.4%	45.8%	19.4%	35.1%	13.4%	42.6%	18.2%	28.5%	10.2%
Cards	48.9%	28.4%	50.6%	30.1%	40.9%	22.2%	52.2%	31.6%	38.3%	20.3%
Other retail	29.2%	23.9%	27.4%	22.5%	20.5%	16.2%	26.0%	21.4%	16.2%	12.4%
Overall loan book	**42.7%**	**22.6%**	**42.9%**	**23.3%**	**33.5%**	**16.4%**	**42.8%**	**23.7%**	**29.5%**	**13.9%**

Note: The table shows the results of annualised RAROC ratios (margin ratio and return ratio) of bank's loan book by each asset class, for 'Current', 'Period 1' and 'Period 2', under both the base and the stressed cases.

4. Management adjustments of loan book

In this section, we present 'what if' style calculations, adjusting parameters describing the policies available to the bank's senior managers. This is accomplished within the *Stress Controller™* software by editing time series parameters.

We consider policy changes in the fractions of regulatory capital that the bank devotes to each asset class. In particular, we suppose that the bank's managers re-adjust the regulatory capital at the beginning of each quarter (Period), and choose to re-jig the fractions of the lending book between asset classes in three different manners (MA1, MA2, MA3), as shown in Table 7.[5]

Table 7: Changes of regulatory capital devoted to asset classes

Weights of the regulatory capital (%)	P1				P2				P3				P4			
	Pre-adjustment	Post-Adjustment MA 1	MA 2	MA 3	Pre-adjustment	Post-Adjustment MA 1	MA 2	MA 3	Pre-adjustment	Post-Adjustment MA 1	MA 2	MA 3	Pre-adjustment	Post-Adjustment MA 1	MA 2	MA 3
Wholesale to bank	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Wholesale to customer	15%	14%	14%	14%	15%	12%	12%	12%	15%	11%	11%	11%	15%	10%	10%	10%
Home loan	33%	33%	33%	31%	34%	36%	34%	32%	36%	38%	36%	32%	37%	40%	37%	32%
Cards	47%	47%	48%	49%	45%	46%	48%	50%	44%	46%	48%	51%	42%	45%	47%	52%
Other retail	3%	3%	3%	3%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Note: The table shows the fractional breakdown of regulatory capital that the bank devotes to different asset classes in Period 1 to Period 4. In effect, the given total par value is split between asset classes in such a way that the shares of regulatory capital equal those shown in the table.

Table 8 shows the results from pre-adjustment and the post-adjustment results for a base case. Table 9 compares the results for the stressed scenario.[6] Both tables show results for Periods 1 to 4. Here, we can see that the overall net operating profit RORC ratio for the loan book as a whole increases in both the base and the stressed cases, which is mainly caused by the shift from corporate lending to bank lending, the latter category of exposures offering a higher return to capital during both the base and the stressed period.

Table 8: Base case RORC ratios for pre- and post-adjustment

Return Ratio		P0	P1	P2	P3	P4	Margin Ratio		P0	P1	P2	P3	P4
Pre-adjustment		5.6%	5.8%	5.9%	6.0%	6.0%	**Pre-adjustment**		10.7%	10.7%	10.7%	10.6%	10.5%
Post-adjustment	**MA 1**	5.6%	5.8%	6.0%	6.0%	6.0%	**Post-adjustment**	**MA 1**	10.7%	10.8%	10.9%	10.8%	10.8%
	MA 2	5.6%	5.9%	6.0%	6.1%	6.1%		**MA 2**	10.7%	10.9%	10.9%	10.9%	10.9%
	MA 3	5.6%	5.9%	6.1%	6.2%	6.4%		**MA 3**	10.7%	10.9%	11.0%	11.0%	11.1%

Note: The table shows the results of pre- and post-adjustment RORC ratios (return ratio and margin ratio) of bank's loan book under the base scenario, from Period 1 to Period 4.

Table9: Stressed case RORC ratios for pre- and post-adjustment

Return Ratio		P0	P1	P2	P3	P4	Margin Ratio		P0	P1	P2	P3	P4
Pre-adjustment		5.6%	4.1%	3.5%	3.3%	3.1%	**Pre-adjustment**		10.7%	8.4%	7.4%	7.0%	6.6%
Post-adjustment	**MA 1**	5.6%	4.1%	3.6%	3.4%	3.3%	**Post-adjustment**	**MA 1**	10.7%	8.5%	7.5%	7.3%	7.0%
	MA 2	5.6%	4.1%	3.6%	3.5%	3.4%		**MA 2**	10.7%	8.5%	7.6%	7.3%	7.1%
	MA 3	5.6%	4.2%	3.7%	3.6%	3.6%		**MA 3**	10.7%	8.5%	7.6%	7.4%	7.3%

Note: The table shows the results of pre- and post-adjustment RORC ratios (return ratio and margin ratio) of bank's loan book under the stressed scenario, from Period 1 to Period 4.

5. Conclusion

This note describes an approach to analysing strategic shifts in a bank's loan book based on measures of Return on Regulatory Capital or "RORC". We illustrate the approach by analysing possible shifts in the loan book composition of a major bank. Our study suggests that, by implementing a shift away from corporate lending,

[5]The adjustment of regulatory capital is viewed as taking place at the beginning of each period. The corresponding new size of each asset class is then inferred by applying the regulatory capital-amount ratio of the point of time (i.e. the end of the last period). The end of period measure of the regulatory capital will be inferred based on the new size and the regulatory capital amount ratio as per the end of the period.

[6]The stressed scenario is the same as defined earlier: 4% of UK GDP shock in the first 4 quarters.

the bank could improve its return and margin RORCs by about half a per cent. We perform the analysis in a base case and in a recession scenario.

Our calculations, which are based on publicly available Pillar 3 data, should be viewed as illustrative of what can be achieved by a strategic top down analysis of the (capital) costs and (return) benefits of lending to different market segments in the current regulatory environment.

Appendix1: Loan book calibration

To work out net expected returns, we calibrate probabilities of default by asset class and credit quality groups as shown in Table A1.1. The PDs are chosen from the PD ranges provided by the bank which are shown in Table A1.2. The bank only provides information for the overall retail and wholesale, so we make assumptions to further differentiate between different asset classes.[7]

Table A1.1: Calibrated Default Probabilities for different asset class and credit quality groups

Asset classes	Performing strong	Performing satisfactory	Performing higher risk	Past due not impaired	Impaired collectively	Impaired individually
Wholesale to bank	0.01	0.02	0.03	15	20	20
Wholesale to customer	0.01	0.6	11	15	20	20
Home loans	0.3	2	10	15	20	20
Cards	0.6	5	12	15	20	20
Other retail	0.4	2	10	15	20	20

Note: Figures shown are in percent.

Table A1.2: Performing loan credit quality ranges

	Retail lending	Wholesale lending	
Financial statement description	PD	PD	Default grade
strong	0.0-0.6%	0.0-0.05%	1-3
		0.05-0.15%	4-5
		0.15-0.30%	6-8
		0.3-0.60%	9-11
Satisfactory	0.60-10%	0.6-2.15%	12-14
		2.15-11.35%	15-19
Higher risk	10.00%+	11.35%+	20-21

Note: The table presents the probability of default ranges employed by the bank for its performing loan categories. The source is the 'Internal measures of credit quality' table on page 146 of the Barclays Group plc Annual Report 2014.

In Table A1.3, we confirm that the initially calibrated total loss rates (70 bps) approximately match the target total loss rates (78 bps) derived from the information disclosed by the bank in its annual report. To achieve this we adjust the PDs in Table A1.1 and the recovery rates (displayed in the 2nd column of Table A1.3) to ensure that, for each asset class, the loss rate from our calibration (displayed in the 3rd column of Table A1.3) matches the loss rate disclosed by the bank (displayed in the 6th column of Table A1.3).

As described above, we calibrate the starting levels of the return ratios of each asset class by benchmark them to the observations of representative UK banks' financial data. In Table A1.4 under the heading of 'Observations from UK banks', we show a few main benchmark ratios we have employed in the calibration of this study. The ratio 'provision over gross income' is closely related to the PD calibration. In column 'effective income rate' we show the income interest rates calibration employed this study. To achieve the 'provision over gross income'

[7]Within the same credit quality group, we assume that the calibrated PD of 'Cards' is higher than those of the other retail classes and that the PD for 'Home loans' is no higher than 'Other retail'. Similarly, PDs of 'Wholesale to customer' are calibrated to be significantly higher than that of 'Wholesale to bank'.

ratio displayed in the 3rd column, we need to adjust the starting level of the loss rates of the loan book to the values displayed in the 6th column and so the total loss rate will go up to 96.84 bps.

Table A1.3: Target and calibrated loss rates

Asset classes	recovery ratio	initially calibrated loss rate (bps)	amount weight of each class	initially calibrated total loss rate (bps)	loss rate from report (bps)	target total loss rate (bps)
Wholesale to bank	0.99	0.874	0.090	70.370	0.283	78.227
Wholesale to customer	0.6	43.562	0.408		15.512	
Home loans	0.7	46.773	0.355		53.906	
Cards	0.5	273.642	0.125		405.763	
Other retail	0.55	73.541	0.022		85.538	

Note: The table shows that the initially calibrated total loss rates (70 bps) approximately match the target.

Table A1.4: Adjust credit quality calibration to meet UK bank benchmark

	Observation from UK banks			Calibrated for the bank under study		
Asset classes	net revenue margin (gross margin)	provision over gross income	profit margin	effective income rate	benchmarked loss rate (bps)	benchmarked total loss rate (bps)
Wholesale to bank	40.0%	1.0%	8.0%	0.8%	0.80	96.84
Wholesale to customer	42.0%	26.0%	9.0%	1.2%	31.20	
Home loans	45.0%	8.0%	15.0%	4.7%	37.60	
Cards	73.0%	30.0%	25.0%	18.0%	540.00	
Other retail	43.0%	20.0%	18.0%	6.8%	136.00	

Note: The table presents the main benchmark ratios employed to calibrate the starting levels of the return ratios of each asset class to the representative UK banks' financial data.

We collected the information in Table A1.5 from the bank's annual report.

Table A1.5: Business division interest income and cost

by business division (£mn)	net int income	cost: income ratio	gross int income
Personal and corporate bai	6,290	0.62	16,553
Barclaycard	3,044	0.43	5,340
Africa banking	2,093	0.64	5,814
Investment banking	647	0.82	3,594

Note: The table presents the interest income and cost of bank's loan book by business division, measured in GBP millions. The information is collected from bank's annual report.

We assume that the sum of the first two business divisions, 'Personal and corporate banking' and 'Barclaycard', to be equivalent to the loan book concerned in this study. We then infer the initial level (period 'Current') of all risk adjusted return related items for each loan asset class. The process and its results are summarised in Tables A1.6, A1.7 and A1.8.

To determine the share of operating expenses for each loan asset class, we look into major UK banks' financial data to obtain the proxies of the related profit margins for each loan asset class. We then derive the ratio of operating expense to gross revenue as follows for each asset class:

$$\begin{aligned} &Ratio\ of\ operating\ expense\ to\ gross\ interest\ income \\ &= net\ interest\ income\ margin \\ &\quad - ratio\ of\ provision\ to\ gross\ interest\ income \\ &\quad - profit\ margin \end{aligned} \tag{A1.1}$$

Table A1.6: Inferred initial net interest income of the loan book for period 'Current'

Loan by asset class (£mn)	amount	effective int income rate	gross int income	cost:income ratio	int cost	net int income
Wholesale to bank	42,111	0.8%	337	0.525	177	160
Wholesale to customer	191,771	1.2%	2,301	0.525	1,208	1,093
Home loan	166,974	4.7%	7,848	0.525	4,120	3,728
Cards	58,914	18.0%	10,605	0.27	2,863	7,741
Other retail	10,108	6.8%	687	0.525	361	326
Total	**469,878**		**21,778**		**8,729**	**13,049**

Note: The table shows the calibrated effective interest income rates that ensure the sum of the gross interest income (£21,778 millions) matches the information in Table A1.5 (the sum of 'Personal and corporate banking' and 'Barclaycard' gross interest income is £21,893 millions). The averaged cost-to-income ratio of business divisions 'Personal and corporate banking' and 'Barclaycard' (listed in Table A1.5) is applied to all loan asset classes, except for asset class 'Cards' we set the cost-to-income ratio as 0.27 which is based on our observations of other UK banks.

Table A1.7: Ratio of operating expenses to gross interest income

Loan by asset class	net revenue margin (gross margin)	provision over gross income	profit margin	operating expenses over gross income
Wholesale to bank	40.0%	1.0%	8.0%	31.0%
Wholesale to customer	42.0%	26.0%	9.0%	7.0%
Home loan	45.0%	8.0%	15.0%	22.0%
Cards	73.0%	30.0%	25.0%	18.0%
Other retail	43.0%	20.0%	18.0%	5.0%

Note: The table presents the fraction of operation expenses over gross income for each loan asset class as well as the date employed to determine it.

Table A1.8: Regulatory capital and inferred initial net return of the loan book for period 'Current'

Loan by asset class (£mn)	amount	pillar I capita	quarterly net int income	quarterly expected loss	quarterly risk adj. net margin	annualized risk adj. net margin reg cap ratio	share of quarterly operating expenses	quarterly risk adj. net profit	annualized risk adj. net op profit reg cap ratio
Wholesale to bank	42,111	507	40	-1	39	30.9%	-26	13	10.2%
Wholesale to customer	191,771	3,090	273	-150	123	16.0%	-40	83	10.7%
Home loan	166,974	5,977	932	-195	737	49.3%	-432	305	20.4%
Cards	58,914	9,329	1,935	-795	1,140	48.9%	-477	663	28.4%
Other retail	10,108	648	82	-34	47	29.2%	-9	39	23.9%
Total	**469,878**	**19,551**	**3,262**	**-1176**	**2,086**	**42.7%**	**-984**	**1,102**	**22.6%**

Note: The table shows the calculation of two risk adjusted return ratios for the initial period. The P/L items are calculated and reported on a quarterly basis and in a non-cumulative measure. The ratios are annualized in this table.

Appendix 2: Macroeconomic scenario calibration

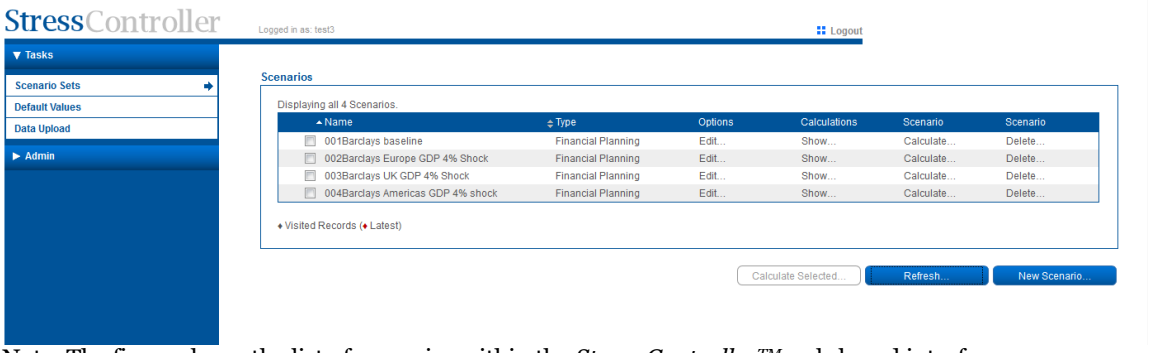
In devising stress tests, one must first accomplish the (often challenging) task of generating consistent time paths for multiple macroeconomic variables. For example, one may wish to consider the impact of a recession in the US affecting say US GDP. However, this raises the issue of what the impact on European or Asian GDP is and also what happens to interest rates, exchange rates, consumer prices and commodity prices.

Risk Control's *Stress Controller™* software contains an embedded macroeconomic model in which one may specify a series of shocks to a particular variable and calculate conditional forecasts of this and other variables 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 academics and practitioners in economic forecasting units in central banks and other bodies to forecast macro time series.

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 and by weighted sums of variables from other regions.

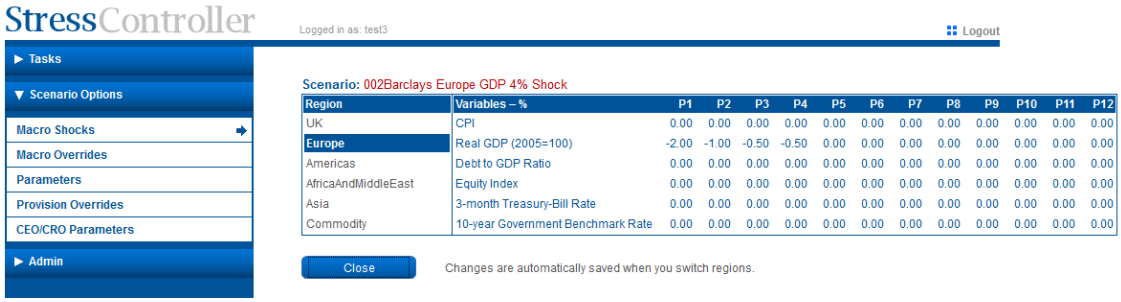
The GVAR model included in *Stress Controller™* is highly flexible in that one may readily change the countries and regions. In the exercise reported in this note, we adopt a set of regions consistent with the bank's approach to categorizing its loan exposures. Specifically, we suppose that the regions 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.

Figure A2.1: The *Stress Controller™* Web Application



Note: The figure shows the list of scenarios within the *Stress Controller™* web-based interface.

Figure A2.2: Editing Scenarios - Shocks to GDP



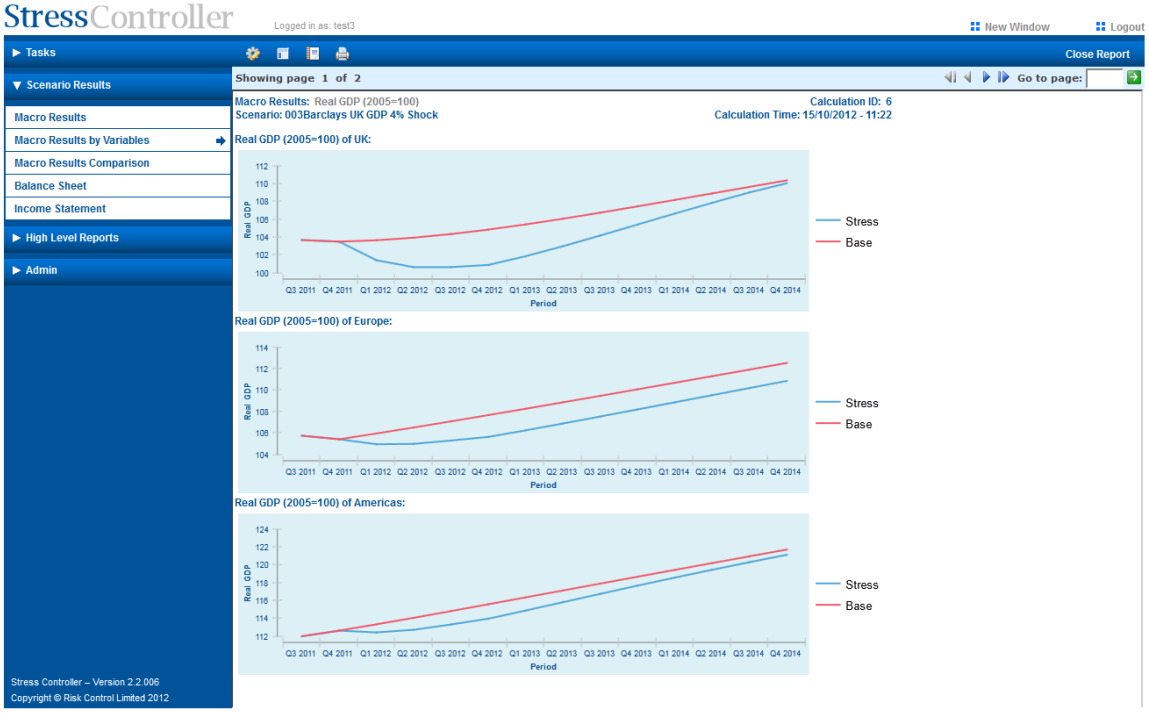
Note: The figure presents a screen shot during the editing of a scenario. Scenarios consist of sequences of period-by-period shocks to macroeconomic variables. Non-interest-rate macro time series are stored in log form. A shock of negative one unit in a given quarter to a scenario variable such as GDP corresponds to a minus 1% innovation.

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 are made to the scenario itself or after the underlying data has been updated. The process and its results are presented in Tables A2.1, A2.2 and A2.3.

Stress Controller™ produces time paths of macroeconomic variables such as those shown in Figure A2.3. 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 A2.3: Results on GDP time paths for different regions



Note: The figure presents the results on GDP time paths under the base case and the stressed case for different regions.