Extract from Debt and reserves management report 2011-12 Annex B

Quantitative analysis of debt service cost and risk

B.1 This technical section sets out the results of a quantitative model that is used to assess the impact of different debt issuance strategies on the cost and risk of debt issuance.

B.2 The Portfolio Simulation Tool (PST) model – which is described in detail in Chapter 6 of the *DMO Annual Review 2008-09*[1] - is used to illustrate the impact of alternative debt issuance strategies on debt service cost and risk over a five year horizon. Debt service cost is the cost of the coupon payments and redemptions associated with Government debt, measured in terms of the relevant yield.

B.3 Debt service cost at risk is calculated by deriving a lognormal distribution of nominal yields from 1,000 Monte Carlo simulations and picking the 95th percentile - representing a 5 per cent probability of extreme increases in yields[2]. The yields are translated into an absolute measure of risk in terms of debt service costs by running the PST assuming the same issuance strategies used to calculate debt service costs based on the current yield curve. Debt service cost at risk is only simulated as an absolute measure, that is, the tail risk. It is not currently possible within the modelling framework to calculate the standard deviation of debt service cost, which is a symmetric risk measure.

B.4 Table B.1 illustrates four issuance strategies. Strategies 1 and 4 represent two extreme issuance programmes with 100 per cent allocation to short-term and long-term gilt issuance respectively. These strategies provide a floor and a ceiling in terms of debt service cost and vice-versa in terms of debt service cost at risk (given the prevailing shape of the yield curve). Strategy 2 has a fairly even skew across maturity baskets and is based on the outturn allocation in 2010-11. Strategy 3 represents a slight variation in the maturity breakdown with respect to Strategy 2, with an increase in short-term conventional issuance and a reduction in medium and long-term conventional issuance. All strategies comprise 80 per cent of issuance in conventional gilts and 20 per cent in index-linked gilts, except Strategy 3, which slightly increases the proportion of index-linked gilts in the debt portfolio.

Table B.1: Issuance strategy composition (per cent)

	1-year CV	5-year CV	10-year CV	30-year CV	50-year CV	10-year IL	30-year IL	50-year IL
Strategy 1	39.8	39.8	0	0	0	20.5	0	0
Strategy 2 Actual 2010-11	2.9	29.1	23.0	20.5	4.1	3.2	10.3	7.0
Strategy 3	3.1	30.3	21.6	19.0	3.8	3.5	11.2	7.6

[1] See http://www.dmo.gov.uk/documentview.aspx?docname=research/PST_gar0809.pdf

[2] The debt service cost at risk is the upper 95th percentile of the distribution of debt service cost, i.e. a measure of tail risk, the extreme debt service cost that may occur with a 5 per cent probability. In this exercise, the distribution of yields is used to calculate the associated debt service cost at risk. In a lognormal distribution the underlying variable that is sampled is the natural logarithm of the variable itself. For example, if "yield" is the variable, the sampling applies to log (yield). Use of this approach ensures that by construction the yield can never be negative. For real yields, a normal distribution (not in logs) is used in order to permit negative values in the simulation. Using a commercial risk management system, Monte Carlo methods are a class of computational algorithms that rely on repeated random sampling to compute their results. In this case, the random sampling is drawn from a distribution of historical data from January 2000 to January 2011. The underlying model used for generating the Monte Carlo scenarios is a Geometric Brownian Motion with mean reverting yields and the mean reversion parameters are estimated through Ordinary Least Squares (OLS) regressions using historical data between 2000 and 2008.

Strategy 4	0	0	0	0	79.5	0	0	20.5

CV stands for conventional; IL for index-linked gilt.
Source: Debt Management Office

B.5 The debt service cost and risk trade-off of each of the four issuance strategies has been calculated using the nominal and real yield curves calculated by the PST[3], as well as the 95th percentile of the simulated yield distribution, as explained earlier. The yield curve model used in the PST is the Variable Roughness Penalty (VRP) model developed by the Bank of England and employed by the DMO since 2007[4]. Table B.2 shows the profile of the yield curves used.

Table B.2: Actual nominal and real interest rates (per cent)

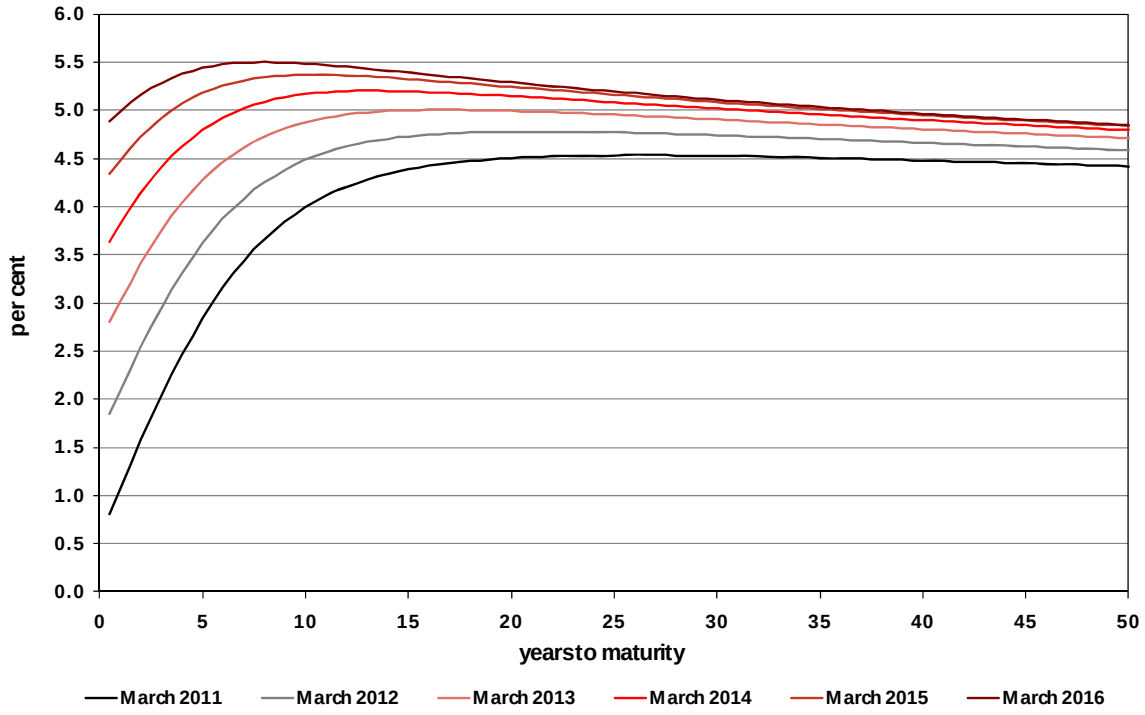
	PST Nominal	PST Real	Upper 95th percentile of simulated yield distribution	
			Nominal	Real[1]
1-year	0.9	-2.5	3.0	0.2
5-year	2.8	-0.1	4.9	2.1
10-year	4.1	0.8	5.3	2.2
30-year	4.7	0.8	4.9	1.7
50-year	4.4	0.6	4.9	1.7

[1] The one-year real benchmark yield has been estimated assuming an equal wedge to that between nominal and real yield curves at the five-year point. The fifty-year nominal and real benchmark points have been assumed to be the same as the respective thirty-year points.
Source: Debt Management Office

B.6 It is worth noting that the PST uses the implied nominal and real forward par yield curves for setting the coupons of new bonds issued over the five-year simulation horizon. Chart B.1 shows the change in the implied nominal forward curve over the five years of the simulation horizon. In practice, of course, it is unlikely that future rates will coincide with the rates implied from the yield curve used in these simulations.

[3] Ten-working day average as at 15 February 2011.
[4] See http://www.bankofengland.co.uk/statistics/yieldcurve/index.htm for more information on the VRP yield curve model.

Chart B.1: Implied nominal forward curves each year of the simulation horizon



Source: Debt Management Office

Simulation results

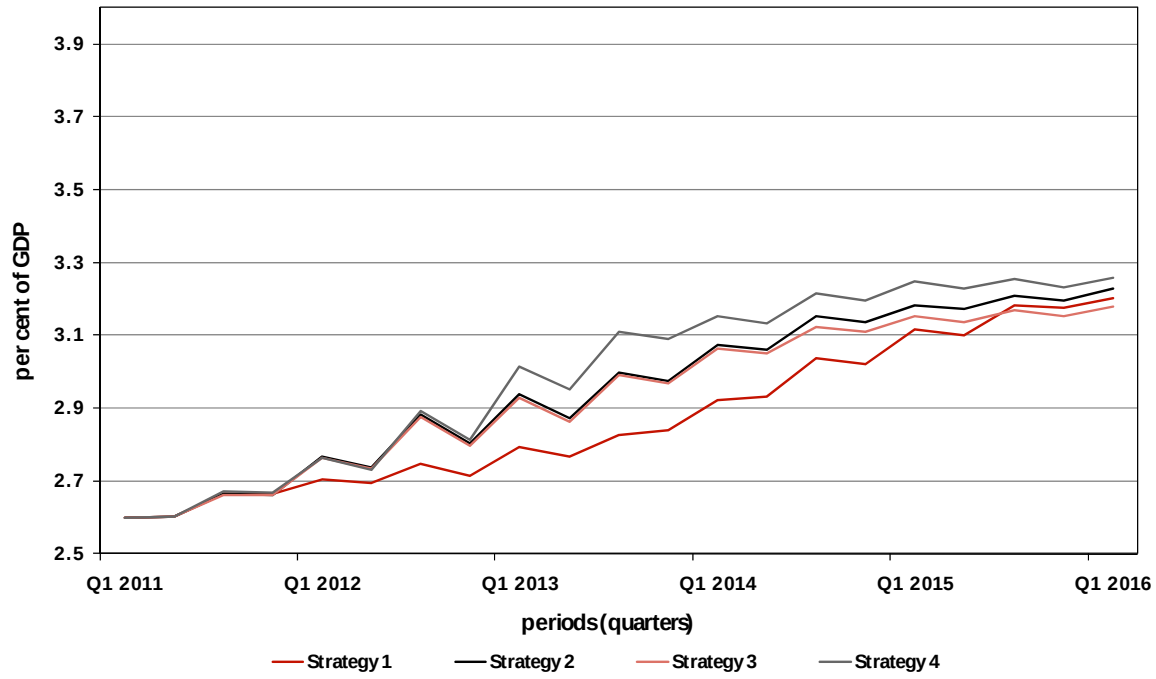
B.7 The results for debt service cost (see Chart B.2) show that cost under Strategy 2 (which is based on the actual strategy followed in 2010-11) and cost under Strategy 3 (a slight variation in the maturity allocation which results in an increase in short-dated issuance) are very similar. The simulation suggests both strategies are cheaper than Strategy 4, for which all issuance is at long maturities, mainly reflecting the upward sloping shape of the yield curve. In line with historically low short-term yields, Strategy 1 is the least costly of the four strategies.

B.8 It is worth noting that the debt service costs of all four strategies seem to converge towards the end of the simulation horizon. This reflects the shape of the implied forward curve[5], see Chart B.1, which flattens considerably during the simulation horizon. The upward trend in the debt service cost of all strategies reflects two factors: the fact that the CGNCR is forecast to be positive in the next five years and redemptions[6] of existing gilts in the debt portfolio that occur each year during the forecast horizon.

[5] Implied forward rates are future one period interest rates that when compounded are consistent with the spot yield curve. They embody a forecast of the future short-term rate but also incorporate risk premia and other factors. Rates shown are six-monthly compounded forward rates. Implied forward nominal rates are calculated from the prices of conventional gilts, whereas implied forward real rates are calculated from prices of index-linked gilts.

[6] In the PST, annual redemptions are added to the CGNCR to calculate the overall financing figure.

Chart B.2: Debt service cost (4-quarter moving averages[1])



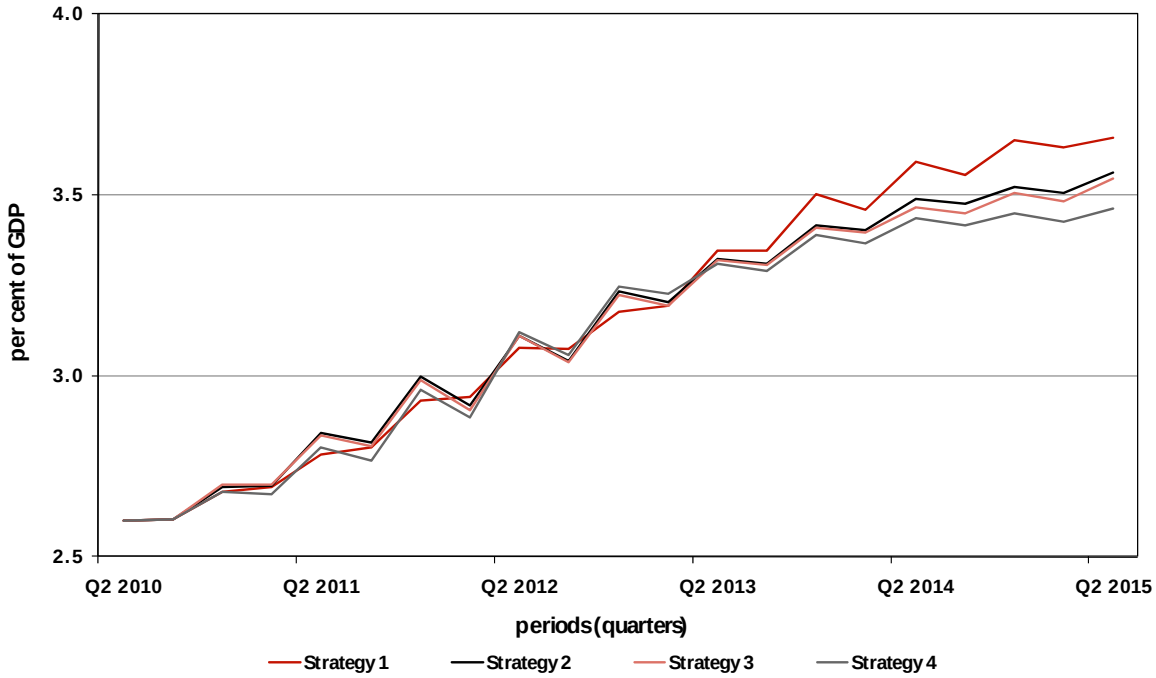
[1] This is an average of 4 quarters which gradually shifts forward by one quarter each quarter, including a new quarter of the dataset and dropping the data for the oldest quarter. A moving average is commonly used to smooth out short-term fluctuations, in this case, the occurrence of quarterly coupon payments.

Source: Debt Management Office

B.9 Debt service cost at risk is shown in Chart B.3. These higher yields do not take the form of a parallel upward shift in the yield curve as can be seen from Table B.2. Instead, the largest increase in yields from current levels takes place in the short to medium term maturity areas, with the long end remaining at broadly similar levels[7]. This translates into a debt service cost at risk which is at its highest at the end of the simulation horizon for Strategy 1 (all short issuance) and lowest for Strategy 4 (all long issuance).

[7] This results from the fact that a mean reverting model is used to generate the Monte Carlo simulations. The volatility around the mean reverting levels resembles what has been observed, in practice, since 2000, namely, much larger volatility in short-term yields than in long-term yields.

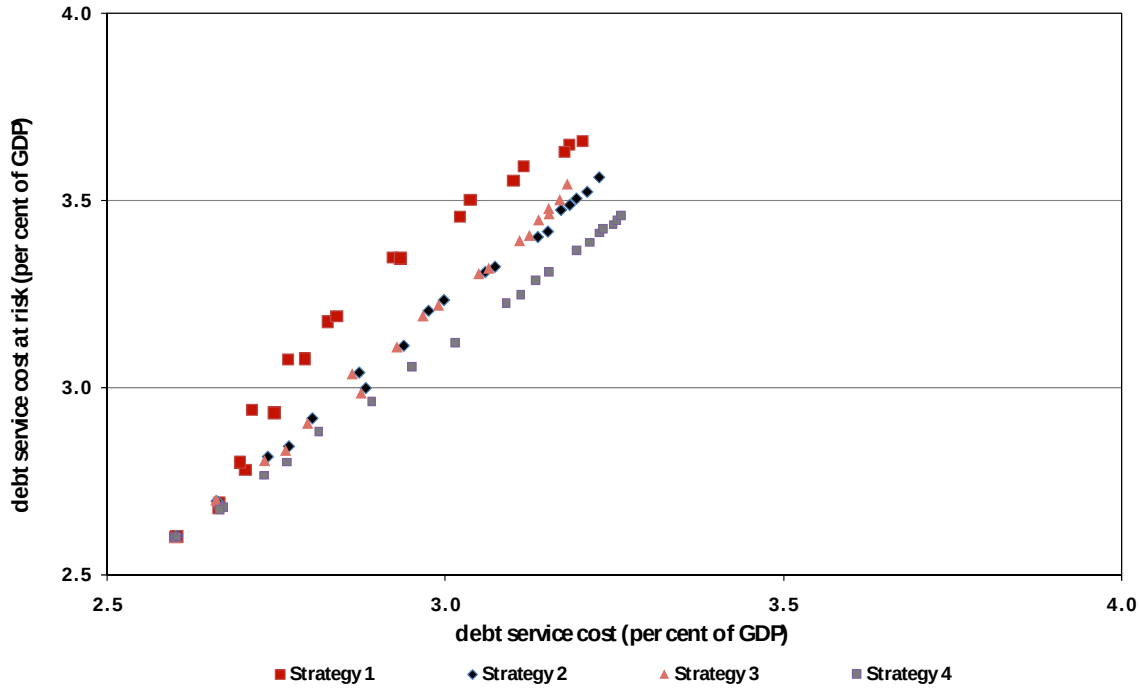
Chart B.3: Debt service cost at risk (4-quarter moving averages)



Source: Debt Management Office

B.10 Chart B.4 shows a form of scatter plot obtained by combining the data from Chart B.2 and Chart B.3 and illustrates the simulated debt service cost and risk trade-off. This indicates how much extra risk would be incurred for every extra unit of cost when following each issuance strategy over the five year horizon. The picture that emerges is broadly as would be expected assuming an upward sloping yield curve.

Chart B.4: Simulated debt service cost and debt service cost at risk trade-offs

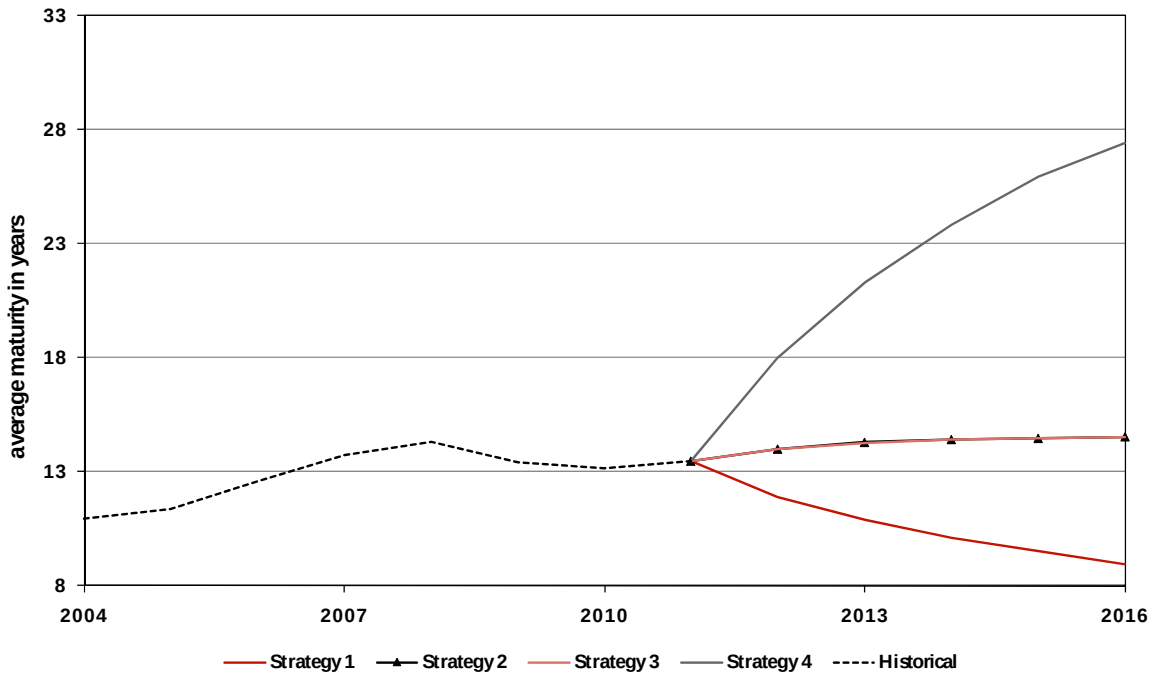


Source: Debt Management Office

B.11 Strategy 1 is the riskiest strategy, and is also the least costly, relying on short-term issuance which thus needs to be refinanced more often. Strategy 4, which is the most costly, is also the least risky, as it wholly comprises long-term issuance which needs to be rolled over less frequently. Strategy 2 (based on the actual issuance strategy followed in 2010-11) and Strategy 3 incorporate gilt issuance across a range of maturities and thus imply a more even trade-off[8].

B.12 It is worth noting that it is several years into the simulation before the cost and risk trade-offs of these strategies start to diverge significantly. This is due to the large size of the existing debt portfolio which induces inertia so that any changes in the structure of the debt portfolio are slow to take effect. This feature can be easily depicted by the average maturity of the debt portfolio, historical and simulated, under the different issuance scenarios, as shown in Chart B.5[9].

Chart B.5: Simulated average maturity of the debt portfolio



Source: Debt Management Office

Conclusions

B.13 The quantitative modelling conducted by the DMO shows that a diversified issuance strategy offers a cost and risk trade-off which lies between that of an all short issuance strategy – in which debt service costs are lower but debt service cost at risk is higher – and an all long issuance strategy – in which debt service cost at risk is lower but debt service costs are higher.

B.14 The results of this model are presented to illustrate the cost and risk implications of pursuing theoretical 'extreme' issuance strategies relative to more balanced strategies. However, 'extreme' strategies would fail to take into account a broad range of factors[10] including: relative cost-effectiveness, demand, operational constraints and practical considerations and, therefore, in reaching its decision the Government has favoured a more balanced strategy that takes into account these factors.

[8] In order to completely depict the cost and risk characteristics of each issuance strategy, a longer horizon that covers all cash flows up to the maturity of the longest bond should be considered. This is, however, beyond the scope of this analysis.
[9] Includes gilts and Treasury bills.
[10] See complete version of Annex B at http://www.dmo.gov.uk/documentview.aspx?docname=remit/drmr1112.pdf&page=Remit/full_details.