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The Economics of Exploration in the UK Continental Shelf:
the 2015 Perspective

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and
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NORTH SEA ECONOMICS

Research in North Sea Economics has been conducted in the Economics Department since 1973. The present and likely future effects of oil and gas developments on the Scottish economy formed the subject of a long term study undertaken for the Scottish Office. The final report of this study, <u>The Economic Impact of North Sea Oil on Scotland</u>, was published by HMSO in 1978. In more recent years further work has been done on the impact of oil on local economies and on the barriers to entry and characteristics of the supply companies in the offshore oil industry.

The second and longer lasting theme of research has been an analysis of licensing and fiscal regimes applied to petroleum exploitation. Work in this field was initially financed by a major firm of accountants, by British Petroleum, and subsequently by the Shell Grants Committee. Much of this work has involved analysis of fiscal systems in other oil producing countries including Australia, Canada, the United States, Indonesia, Egypt, Nigeria and Malaysia. Because of the continuing interest in the UK fiscal system many papers have been produced on the effects of this regime.

From 1985 to 1987 the Economic and Social Science Research Council financed research on the relationship between oil companies and Governments in the UK, Norway, Denmark and The Netherlands. A main part of this work involved the construction of Monte Carlo simulation models which have been employed to measure the extents to which fiscal systems share in exploration and development risks.

Over the last few years the research has examined the many evolving economic issues generally relating to petroleum investment and related fiscal and regulatory matters. Subjects researched include the economics of incremental investments in mature oil fields, economic aspects of the CRINE initiative, economics of gas developments and contracts in the new market situation, economic and tax aspects of tariffing, economics of infrastructure cost sharing, the effects of comparative petroleum fiscal systems on incentives to develop fields and undertake new exploration, the oil price responsiveness of the UK petroleum tax system, and the economics of decommissioning, mothballing and re-use of facilities. This work has been financed by a group of oil companies and Scottish Enterprise, Energy. The work on CO2 Capture, EOR and storage was financed by a grant from the Natural Environmental Research Council (NERC) in the period 2005 – 2008.

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The Economics of Exploration in the UK Continental Shelf: the 2015 Perspective

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1. Introduction and Context

Exploration activity in the UK Continental Shelf (UKCS) has been falling for some years, even when the oil price has been very high. This century the average annual number of exploration wells drilled has been 25.8 with the maximum being 44 in 2008 and the lowest 14 in both 2011 and 2014. The average number of appraisal wells drilled this century has been 36.5, with the highest being 77 in 2007 and the lowest 18 in 2014. The very low figures for 2014 are arguably not primarily the consequence of the collapse in the oil price in the later part of the year. Other factors including the very high cost of drilling wells and relatively low views of prospectivity are also likely to have influenced investment decisions. The tax increases introduced in 2011 by reducing full cycle returns to investors could also have played a role in curtailing exploration and appraisal.

The numbers of discoveries are determined by the volume of exploration wells drilled and the associated success rates. Using DECC definitions the numbers of significant discoveries have declined in recent years from 13 in 2007 to 11 in 2008, 10 in 2009, 6 in 2010, 9 in 2011, 3 in 2012, 4 in 2013, and only 1 in 2014. The reserves discovered per well have also decreased in recent years. The cost inflation for E and A activities has also been remarkably high in recent years. The average costs per E and A well (including sidetracks) increased from just under £12 million in 2009

to over £32 million in 2012, £36.4 million in 2013 and £34.3 million in 2014.

The purpose of this paper is to assess the prospective pre-tax and post-tax returns to new exploration taking into account the recent behaviour of the key factors which determine these returns. These include prospectivity, oil and gas prices, the costs of exploration and development, and the tax arrangements. The position of the investor is examined in two tax situations, namely (1) when he is currently in a full tax-paying position, and (2) when he is not paying tax at the time of his investment.

2. Methodology and Assumptions

A Monte Carlo financial simulation model has been constructed to estimate the distribution of expected monetary values (EMVs) from a specified exploration effort. In the modelling the investor undertakes exploration with a success rate determined by recent experience. When a discovery is made it is appraised. There is again a success rate determined by recent experience. Appraisal success means that there is a potential commercial development. The consequences of developing the discovery are assessed with the use of the Monte Carlo technique. Key stochastic variables are the size of the discovery, the development costs, and oil and gas prices. Schematically the modelling procedure is shown in Figure 1.

Figure 1

Schematic Representation of Investment Sequence Facing Explorationist
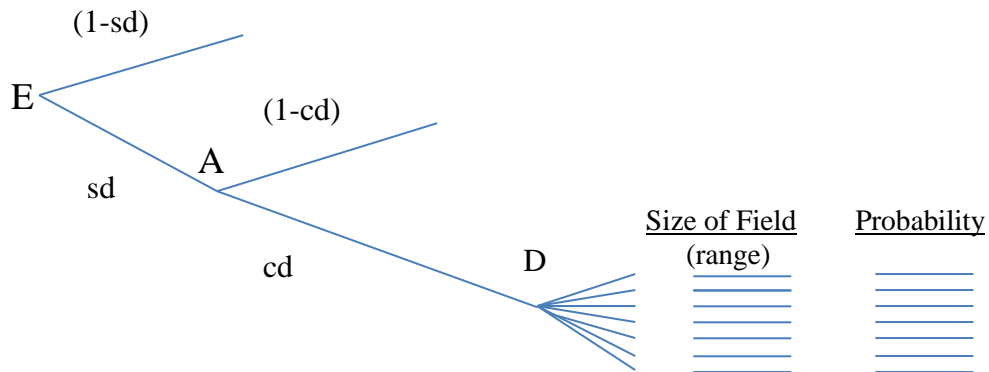
$$EMV = Pcd = \left(\sum_{i=1}^{i=n} prob.\, NPVfi\right) - E - psdA$$

Where P = probability
sd = chance of significant discovery
cd = chance of potentially commercial development
E = exploration costs
A = appraisal costs

The time taken from initial exploration to first production has a significant effect on the full cycle returns when expressed in present value terms. The returns also depend on the extent of the exploration and appraisal effects required. In this study two scenarios were modelled reflecting the experience and performance of the industry over the past few years. For ready convenience these are termed the "fast" and "slow" cases. The phasing under the two cases is shown in Table 1.

Table 1

Phasing of Exploration, Appraisal and Development to First Production

	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Fast	E_1	-	A_1	D_1	D_2	P_1		
Slow	E_1	-	A_1	A_2	-	D_1	D_2	P_1

The prospective returns obviously depend on the costs at the various stages of the cycle. Two scenarios were modelled. In the first one the costs were based on the averages of those incurred over the past few

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years. For exploration and appraisal costs for the whole of the UKCS an average of £35.26 million per well (including sidetracks) was estimated from the experience of recent years to the end of 2014. The study examines the Southern North Sea (SNS), Central North Sea (CNS), West of Shetlands and Scotland (W of S) separately. The Irish Sea is not modelled because of the very low E and A activity there in recent years. For the SNS E and A costs per well were estimated at 50% of the average for the UKCS. For the W of S region the costs were estimated at 1.25 times the average for the UKCS.

Development costs vary markedly across the four regions studied. Separate estimates were made for each region from the average over the past several years to end 2014. For modelling purposes development costs per barrel (or barrel of oil equivalent (boe)) were calculated. Accordingly, the average size of significant discovery in the period 2005-2014 was calculated. These are 16.4 million boe for the SNS, 39.1 million boe for the CNS, 16.5 million boe for the NNS, and 112.6 million for the W of S. The average development costs per boe were then found to be $14.2 for the SNS, $29.6 for the CNS, $21.4 for the NNS, and $19.8 for W of S. Average development costs were spread over 2 to 5 years depending on the size of discovery. Annual operating costs were modelled as a percentage of accumulated development costs with the percentage increasing as the size of field decreased, reflecting economies of scale. The absolute costs for W of S are higher than elsewhere but the larger volumes pull down the relative unit costs.

The above figures are all average costs and average field sizes. This study employs the Monte Carlo technique to reflect the uncertainties facing the explorationist and field developer. The average values noted

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above were made part of distributions of the stochastic variables which determine the range of returns facing the explorationist. The details of the input distributions obviously vary across each of the four regions but have some common features. Thus the distribution of field sizes is taken to be lognormal with a standard deviation expressed as 50% of the mean. The distribution of development costs per boe is taken to be normal with a common standard deviation of 20% as a percentage of the mean value. The mean oil price is set at $70 per barrel in real terms with the assumption that it follows a mean-reverting behaviour through time. The standard deviation was set at 20% of the mean (Minimum and maximum values from the modelling were $28 per barrel and $112 per barrel respectively in real terms. 95% of the price distribution was found to be in the range $43 - $97). The mean gas price was 45 pence per therm in real terms with a standard deviation of 10% of the mean. Mean-reverting behaviour is assumed (The minimum value from the modelling was 32 pence and the maximum 59 pence, both in real terms. 95% of the price distribution was found to be in the range 36 pence – 54 pence).

Other modelling assumptions relate to exploration and appraisal success rates. Significant discoveries are defined as all those published by DECC plus others known to the authors covering the period 2008-2014 inclusive. Appraisal success covers all fields for which development has been started, firmly planned, or contemplated. This definition excludes discoveries for which no field development plan is currently contemplated.

Details of the modelling assumptions for the four regions are summarised below in Table 2.

Table 2

Assumptions for Monte Carlo modelling by region

Before Cost Reductions

		Central North Sea	Southern North Sea	Northern North Sea	West of Shetlands
Exploration success		34.2%	35.3%	40%	50%
Chance of oil		82%	0%	88%	75%
Chance of gas		18%	100%	12%	25%
Appraisal success		47.4%	30%	50%	55.6%
Reserves	Average	39.1 mmboe	16.4 mmboe	16.5 mmboe	112.6 mmboe
	Minimum significant size	8.5 mmboe	3.55 mmboe	3.6 mmboe	24.4 mmboe
	Maximum significant size	110 mmboe	50 mmboe	50 mmboe	320 mmboe
Well costs for E & A		£35.26m.	£17.6m.	£35.26m.	£44.1m.
Average devex per boe		$29.6	$14.24	$21.44	$19.8
Minimum devex per boe		$11.8	$5.7	$8.6	$8
Maximum devex per boe		$47.3	$22.8	$34.3	$31.6

The above modelling assumptions relating to costs reflect the situation prior to the substantial cost savings currently being implemented across the industry. In recognition of this a second scenario was also modelled where exploration and appraisal costs were reduced by 30% in the CNS, NNS and W of S and by 20% in the SNS. Development and operating costs are reduced by 20% in all four regions. Given the current emphasis on cost reductions the results of this reduced cost scenarios are given equal emphasis to those based on recent historic costs.

The taxation system incorporated in the modelling reflects the changes instigated in 2015 including the investment allowance of 62.5% for Supplementary Charge (SC), and the reduction in the rate of SC to 20%.

Two scenarios regarding the tax position of the investor are modelled. The first assumes that the investor is in an ongoing tax-paying position and is able to obtain tax relief on his exploration, appraisal and development expenditures against income from other fields. The second scenario assumes that the investor has no other income against which he can relieve his costs and so utilises the Ring Fence Expenditure Supplement (RFES) to obtain later relief against income from a future discovery.

3. Results

A. Before Cost Reductions

(a) Investor in Tax-Paying Position, Fast Cycle Time

i. CNS

When the risks are taken into account the distribution of the EMV provides an illuminating understanding of the overall investment outlook. In Charts 1 and 2 the respective pre-tax and post-tax EMVs at 10% real discount rate are shown. It is seen that the mean values both before and after tax are unacceptable to investors. The tax system is seen clearly to share the losses between investor and government. Thus the width of the distribution of returns is considerably less after tax than before tax. There is more than a 67% chance that the pre-tax EMV is negative, and only a 10% chance that it will exceed +£23 million. 68% of the pre-tax EMV distribution lies in the range -£38m. to +£14m. and 95% of the distribution lies in the range -£68m. to +£59m. The risk and loss sharing features of the tax system result in the chance of a negative post-tax EMV being 50%. There is only a 10% chance that the EMV will exceed +£19 million after tax. 68% of the post-tax

EMV distribution lies in the range -£14m. to +£14m. and 95% of
the distribution lies in the range -£28m. to +£38m.

Chart 1

CNS - Ongoing (Fast) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-11.07
Median	-11.26
Standard Deviation	30.12
Variance	907.26
Skewness	0.44
Kurtosis	1.39
Coefficient of Variability	-2.72
Minimum	-124.90
Maximum	110.82
Range	235.72
Mean Standard Error	0.95
Trimmed Mean (98%)	-11.38

Pre-Tax EMV @ 10% - CNS
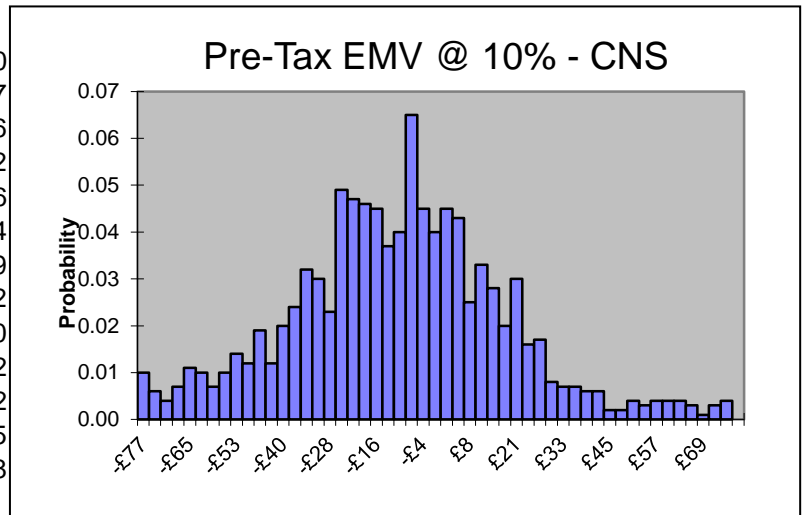
Chart 2

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	0.65
Median	-0.16
Standard Deviation	15.94
Variance	254.05
Skewness	0.75
Kurtosis	2.28
Coefficient of Variability	24.52
Minimum	-53.04
Maximum	87.92
Range	140.96
Mean Standard Error	0.50
Trimmed Mean (98%)	0.41

Post-Tax EMV @ 10% - CNS
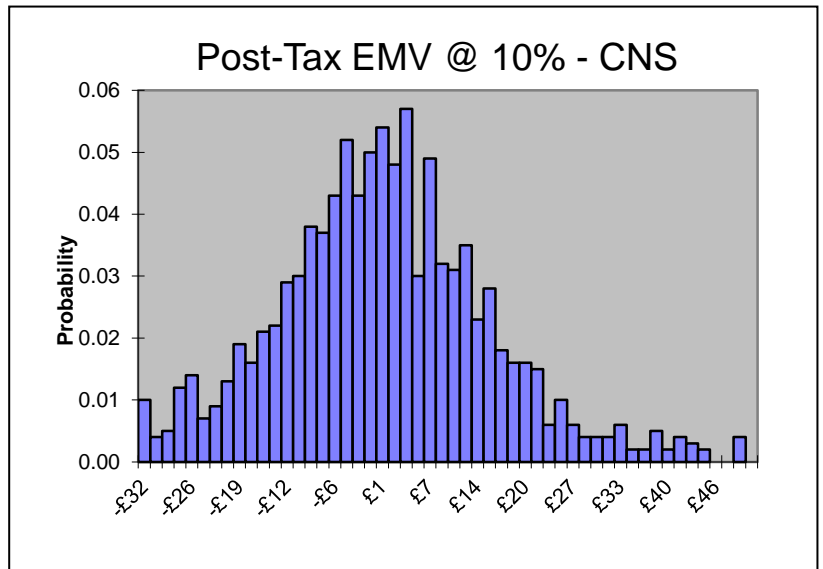
ii.   NNS

When the key risks are included the distribution of EMVs at 10% are shown in Chart 3 (pre-tax) and Chart 4 (post-tax). The mean values are negative in both cases. The range is from a significant negative value to a modest positive one. There is an 82% chance that the EMV will be negative before tax, and a 66% chance that it is negative after tax. There is only a 10% chance that the pre-tax EMV will exceed +£5.5 million. 68% of the pre-tax EMV distribution lies in the range -£27m. to +£1m. and 95% of the distribution lies in the range -£46m. to +£24m. 68% of the post-tax EMV distribution lies in the range -£10m. to +£5m. and 95% of the distribution lies in the range -£18m. to +£17m.

Chart 3

NNS - Ongoing (Fast) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-13.09
Median	-13.21
Standard Deviation	16.44
Variance	270.41
Skewness	0.31
Kurtosis	1.24
Coefficient of Variability	-1.26
Minimum	-74.57
Maximum	48.67
Range	123.23
Mean Standard Error	0.52
Trimmed Mean (98%)	-13.21

Pre-Tax EMV @ 10% - NNS
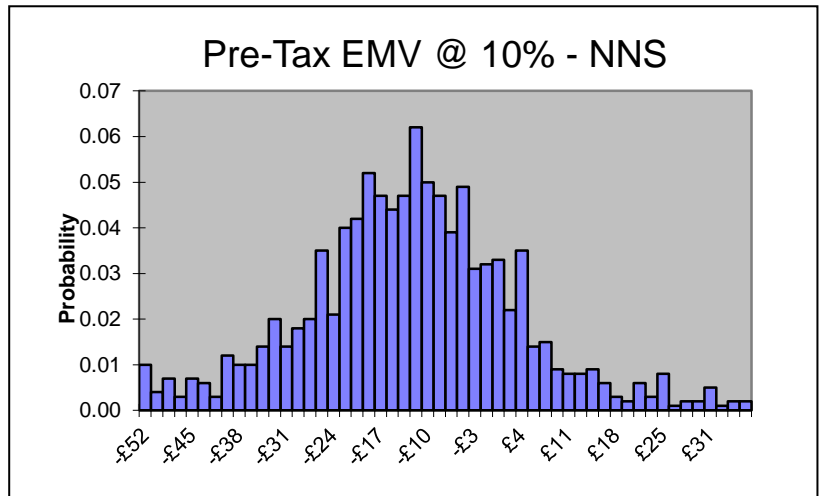
Chart 4

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-2.49
Median	-3.14
Standard Deviation	8.41
Variance	70.76
Skewness	0.68
Kurtosis	2.10
Coefficient of Variability	-3.38
Minimum	-31.99
Maximum	42.73
Range	74.72
Mean Standard Error	0.27
Trimmed Mean (98%)	-2.59

Post-Tax EMV @ 10% - NNS
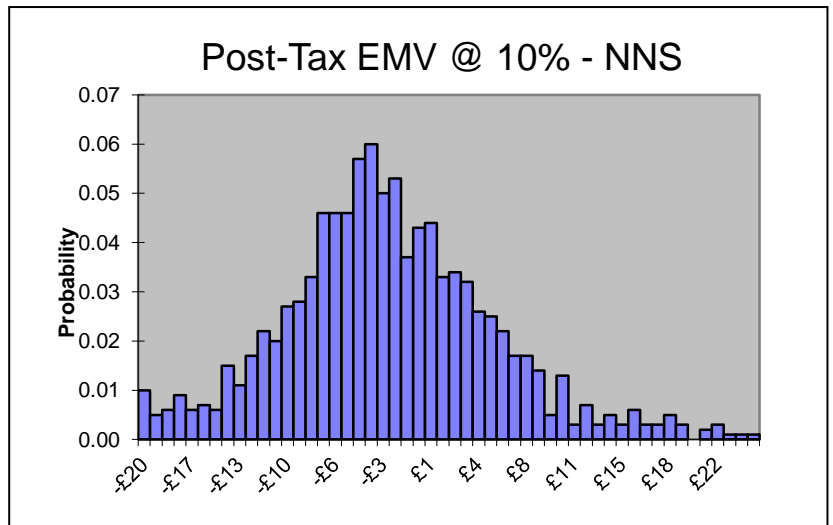
iii.   SNS

When the key risks are considered the pre-tax and post-tax distributions of EMVs are shown in Charts 5 and 6 respectively. The mean values are negative in both cases. The spread is from a substantial negative value to a very small positive one. The chance of a negative EMV exceeds 90% both before and after tax.   68%

of the pre-tax EMV distribution lies in the range -£18m. to -£5m. and 95% of the distribution lies in the range -£28m. to -£0.05m. 68% of the post-tax EMV distribution lies in the range -£7m. to -£1m. and 95% of the distribution lies in the range -£12m. to +£2m.

Chart 5

SNS - Ongoing (Fast) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-10.96
Median	-9.61
Standard Deviation	7.26
Variance	52.76
Skewness	-1.20
Kurtosis	2.98
Coefficient of Variability	-0.66
Minimum	-52.76
Maximum	9.96
Range	62.72
Mean Standard Error	0.23
Trimmed Mean (98%)	-10.81

Chart 6

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-3.72
Median	-3.13
Standard Deviation	3.34
Variance	11.15
Skewness	-1.19
Kurtosis	3.52
Coefficient of Variability	-0.90
Minimum	-24.34
Maximum	6.84
Range	31.19
Mean Standard Error	0.11
Trimmed Mean (98%)	-3.66
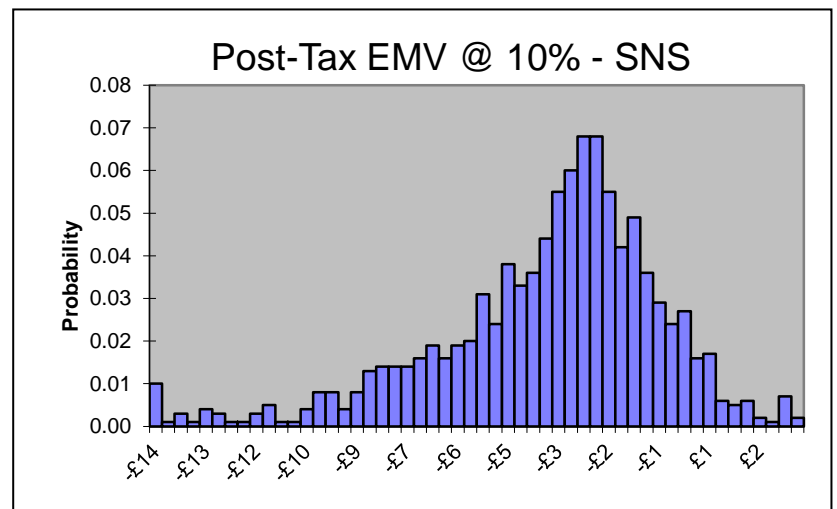
iv.   W of S

When the key risks are taken into account the pre-tax and post-tax distributions of EMVs at 10% are as shown in Charts 7 and 8 respectively. The pre-tax mean values are significantly negative while the post-tax ones are just positive. The chance of a negative EMV is 60% before tax and 47% after tax. There is a 30% chance that the pre-tax EMV will be –£100 million or worse and a 10% chance that it will be –£234 million or worse. On the upside there is a 10% chance that the EMV will exceed +£150 million. 68% of the pre-tax EMV distribution lies in the range -£173 to +£106 and 95% of the distribution lies in the range -£362 to +£300. After tax the chance of a negative EMV is 47%. There is a 10% chance that the EMV could exceed +£107 million.   68% of the post-tax EMV distribution lies in the range -£66m. to +£81m. and 95% of the distribution lies in the range -£152m. to +£187m.

Chart 7

WoS - Ongoing (Fast) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-35.68
Median	-33.72
Standard Deviation	159.89
Variance	25563.34
Skewness	-0.03
Kurtosis	1.43
Coefficient of Variability	-4.48
Minimum	-781.64
Maximum	555.99
Range	1337.63
Mean Standard Error	5.06
Trimmed Mean (98%)	-35.75

Pre-Tax EMV @ 10% - WoS
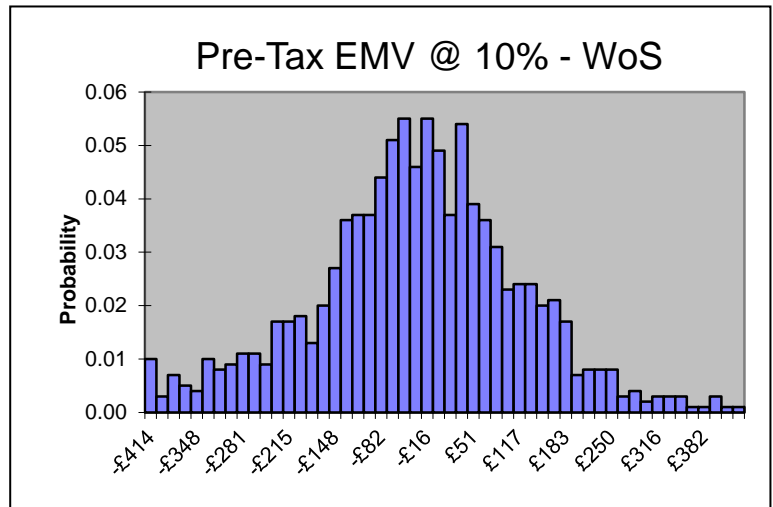
Chart 8

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	7.73
Median	5.24
Standard Deviation	83.11
Variance	6907.36
Skewness	0.23
Kurtosis	1.23
Coefficient of Variability	10.75
Minimum	-332.24
Maximum	314.65
Range	646.89
Mean Standard Error	2.63
Trimmed Mean (98%)	7.32

Post-Tax EMV @ 10% - WoS
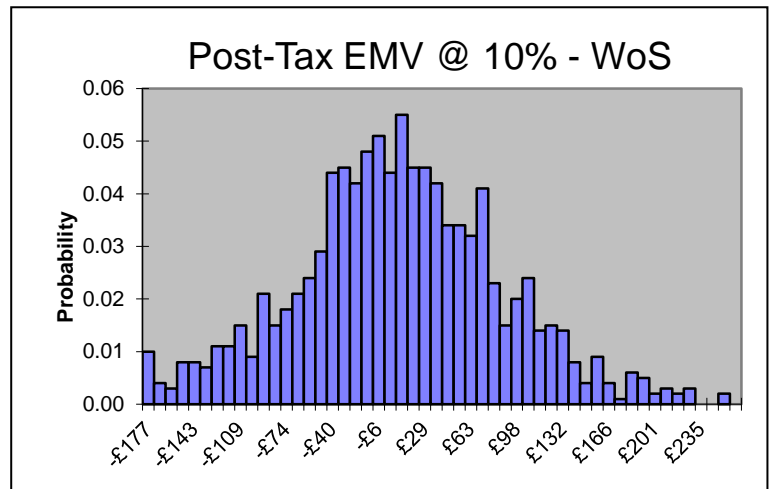
(b) Project Basis, Fast Cycle Time

i.   CNS

The distribution of EMVs at 10% to an investor who has no tax capacity at the time of the investment are shown in Chart 9 (pre-tax) and Chart 10 (post-tax). The mean values are clearly negative in both cases. The spread is quite wide on a pre-tax basis from –£124 million to +£123 million. After tax the spread is from –£122 million to +£77 million. There is a 68% chance that the EMV will be negative before tax, and only a 10% chance that it exceeds +£22 million. 68% of the pre-tax EMV distribution lies in the range -£38m. to +£13m. and 95% of the distribution lies in the range -£67m. to +£57m. After tax there is a 68% chance that the EMV will be negative, with a 30% chance that the value will be –£24 million or worse. There is only a 10% chance that the EMV will exceed +£14 million. 68% of the post-tax EMV distribution lies in the range -£36m. to +£9m. and 95% of the distribution lies in the range -£64m. to +£35m.

Chart 9

CNS - Project (Fast) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-11.13
Median	-11.12
Standard Deviation	29.05
Variance	843.68
Skewness	0.40
Kurtosis	1.47
Coefficient of Variability	-2.61
Minimum	-124.90
Maximum	123.31
Range	248.21
Mean Standard Error	0.92
Trimmed Mean (98%)	-11.37
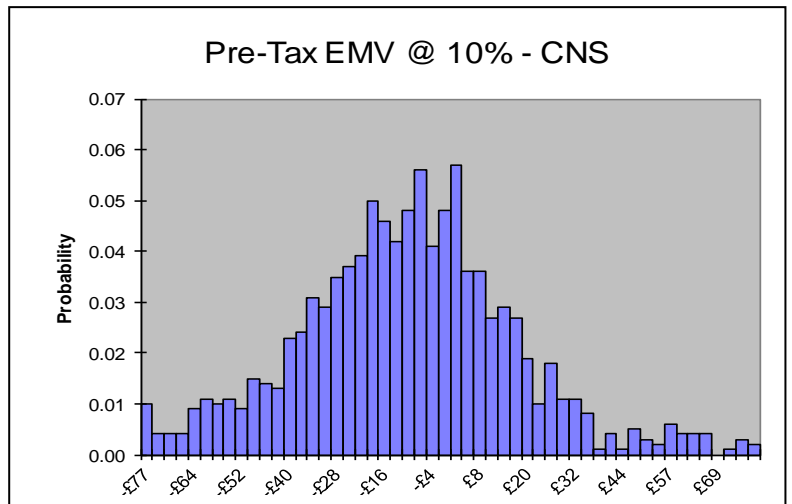
Chart 10

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-12.56
Median	-10.09
Standard Deviation	24.17
Variance	584.22
Skewness	-0.29
Kurtosis	0.69
Coefficient of Variability	-1.92
Minimum	-121.78
Maximum	76.74
Range	198.52
Mean Standard Error	0.76
Trimmed Mean (98%)	-12.50
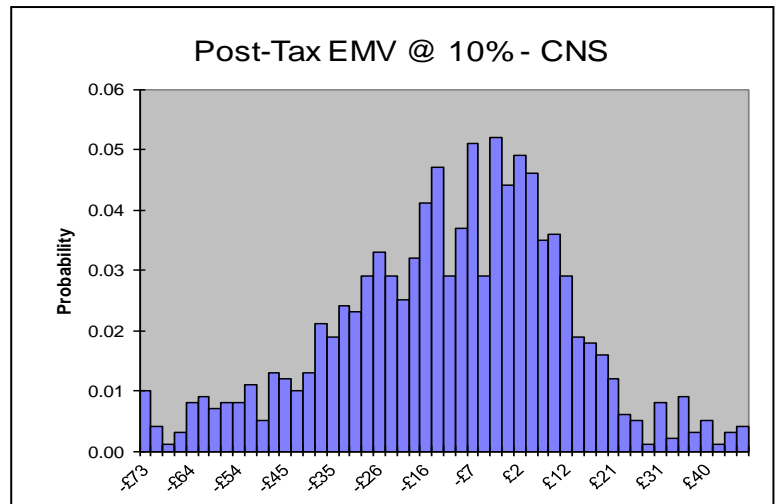
ii.   NNS

The distribution of EMVs at 10% to a project investor in the NNS are shown in Chart 11 (pre-tax) and Chart 12 (post-tax). The mean values are clearly negative in both cases. The chance of a negative pre-tax EMV is -83%. There is a 30% chance that the value will be –£20 million or worse. 68% of the pre-tax EMV distribution lies in the range -£27m. to +£0.12m. and 95% of the distribution lies in the range -£44m. to +£23m. After tax the chance of a negative EMV is nearly 83%, and there is only a 10% chance that the value could be +£3.8 million or better. 68% of the post-tax EMV distribution lies in the range -£26m. to +£0.66m. and 95% of the distribution lies in the range -£43m. to +£16m.

Chart 11

NNS - Project (Fast) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-13.10
Median	-13.08
Standard Deviation	15.74
Variance	247.60
Skewness	0.25
Kurtosis	1.33
Coefficient of Variability	-1.20
Minimum	-74.57
Maximum	49.71
Range	124.27
Mean Standard Error	0.50
Trimmed Mean (98%)	-13.17
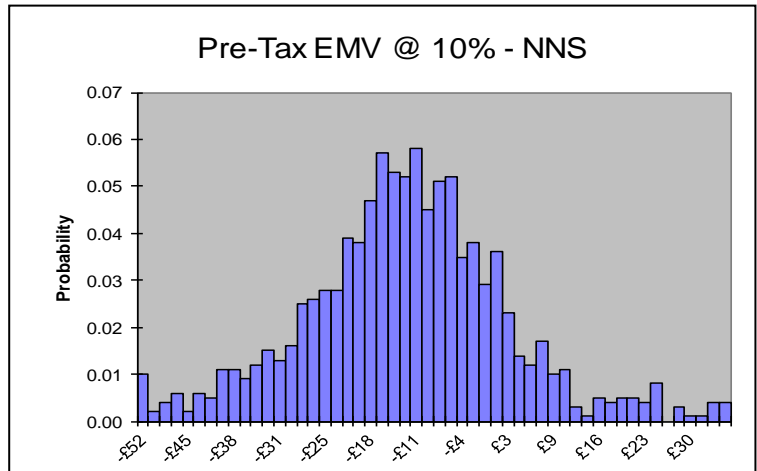
Chart 12

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-12.93
Median	-12.53
Standard Deviation	14.17
Variance	200.89
Skewness	-0.22
Kurtosis	0.60
Coefficient of Variability	-1.10
Minimum	-72.59
Maximum	30.70
Range	103.29
Mean Standard Error	0.45
Trimmed Mean (98%)	-12.87
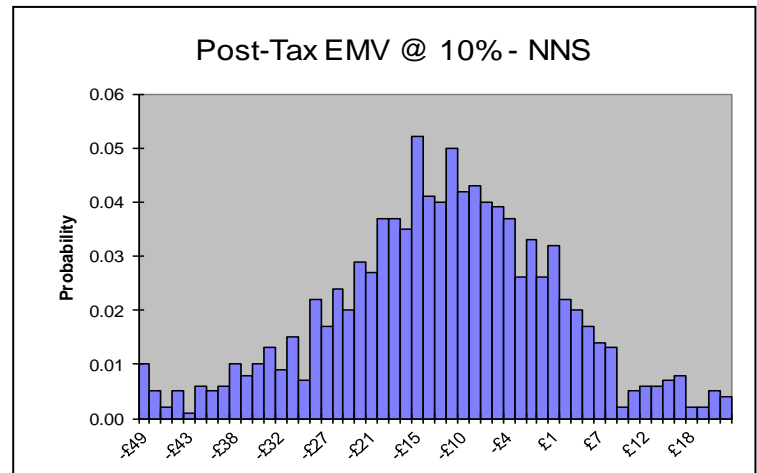
iii.   SNS

The distributions of EMVs to a project investor in the SNS are shown in Chart 13 (pre-tax) and Chart 14 (post-tax). The mean values are clearly negative in both cases. At the minimum values a large negative value is in prospect while the maximum values are only positive to a very modest extent. The chance of a negative EMV exceeds 90% both before and after tax. 68% of the pre-tax

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EMV distribution lies in the range -£18m. to -£5m. and 95% of the distribution lies in the range -£28m. to -£0.05m. 68% of the post-tax EMV distribution lies in the range -£17m. to -£4m. and 95% of the distribution lies in the range -£27m. to +£0.16m. There is only a 2% chance that the post-tax EMV will be positive.

Chart 13

SNS - Project (Fast) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-10.96
Median	-9.61
Standard Deviation	7.26
Variance	52.76
Skewness	-1.20
Kurtosis	2.98
Coefficient of Variability	-0.66
Minimum	-52.76
Maximum	9.96
Range	62.72
Mean Standard Error	0.23
Trimmed Mean (98%)	-10.81

Chart 14

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-10.54
Median	-9.24
Standard Deviation	7.04
Variance	49.53
Skewness	-1.24
Kurtosis	3.01
Coefficient of Variability	-0.67
Minimum	-51.51
Maximum	6.66
Range	58.17
Mean Standard Error	0.22
Trimmed Mean (98%)	-10.39
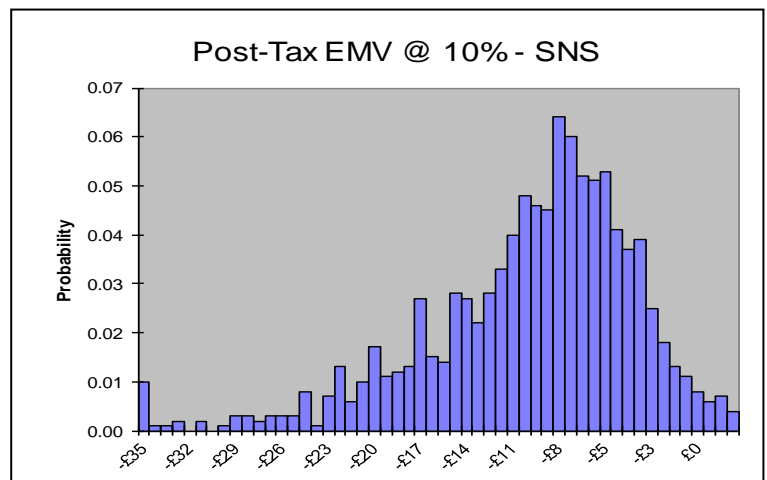
iv.   W of S

The distributions of EMVs for a project investor in the W of S region are shown in Chart 15 (pre-tax) and Chart 16 (post-tax). The mean values are very substantially negative in both cases, attaining nearly –£50 million after tax. There is a nearly 60% chance that the pre-tax EMV will be negative, including a 20% chance that it will be –£145 million or worse. However, there is a 20% chance that there will be a positive EMV of £79 million or better, and a 10% chance that it will exceed +£138 million. 68% of the pre-tax EMV distribution lies in the range -£173m. to +£104m. and 95% of the distribution lies in the range -£362m. to +£290m. After tax there is a 60% chance that the EMV will be negative, and a 20% chance that the value could be –£138 million or worse. There is a 20% chance that the EMV could be +£48 million or better and a 10% chance that it could be +£85 million or better. 68% of the post-tax EMV distribution lies in the range -£165m. to +£64m. and 95% of the distribution lies in the range -£356m. to +£167m.

Chart 15

WoS - Project (Fast) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV @10% Statistics	
Trials	1000
Mean	-35.73
Median	-31.37
Standard Deviation	155.44
Variance	24160.32
Skewness	-0.16
Kurtosis	1.42
Coefficient of Variability	-4.35
Minimum	-781.64
Maximum	518.27
Range	1299.92
Mean Standard Error	4.92
Trimmed Mean (98%)	-35.40
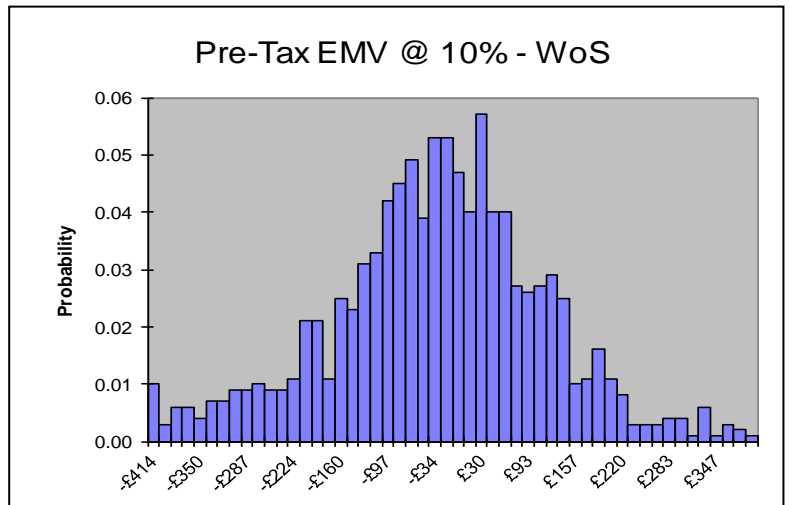
Chart 16

Post-Tax EMV @10% Statistics	
Trials	1000
Mean	-49.36
Median	-26.12
Standard Deviation	129.52
Variance	16775.18
Skewness	-0.93
Kurtosis	2.01
Coefficient of Variability	-2.62
Minimum	-770.27
Maximum	291.65
Range	1061.92
Mean Standard Error	4.10
Trimmed Mean (98%)	-47.52
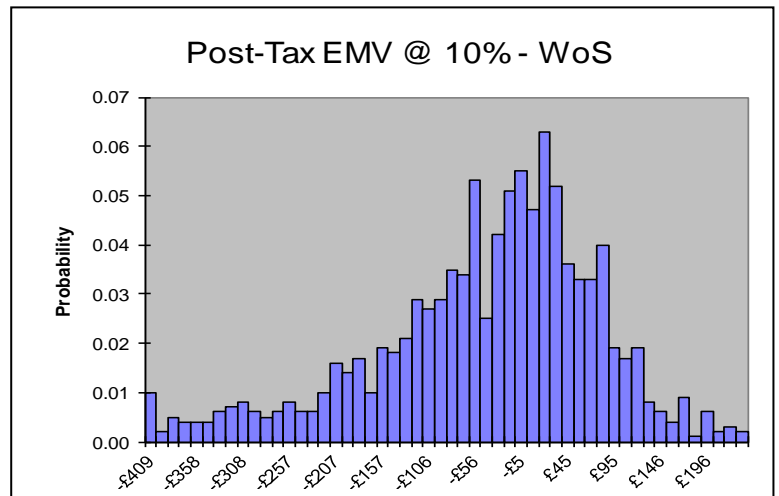
(c) Investor in Tax-Paying Position, Slow Cycle Time

i. CNS

When the cycle time from first exploration to first production becomes longer and extra appraisal costs are incurred the discounted expected returns are reduced. When the key risks are taken into account the mean pre-tax and post-tax values for the EMVs at 10% are clearly negative. See Charts 17 and 18. There is a wide range of possible outcomes, in the pre-tax case from –£109 million to +£100 million. The chance of a negative pre-tax value is nearly 78% and there is only a 10% chance that the upside value can exceed +£13.9 million. 68% of the pre-tax EMV distribution lies in the range -£37m. to +£6m. and 95% of the distribution lies in the range -£64m. to +£44m. There is a 62% chance that the post-tax EMV will be negative, and only a 10% chance that the upside value will exceed +£13.4 million. 68% of the post-tax EMV distribution lies in the range -£14m. to +£8m. and 95% of the distribution lies in the range -£27m. to +£28m.

Chart 17

CNS - Ongoing (Slow) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-15.27
Median	-15.81
Standard Deviation	25.24
Variance	637.25
Skewness	0.44
Kurtosis	1.73
Coefficient of Variability	-1.65
Minimum	-109.16
Maximum	99.80
Range	208.96
Mean Standard Error	0.80
Trimmed Mean (98%)	-15.51
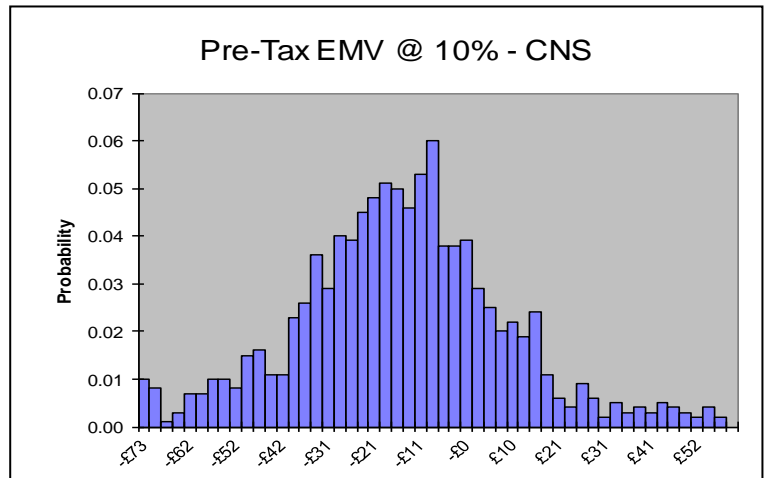
Chart 18

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-2.40
Median	-3.10
Standard Deviation	13.41
Variance	179.75
Skewness	0.76
Kurtosis	2.61
Coefficient of Variability	-5.58
Minimum	-47.67
Maximum	76.30
Range	123.96
Mean Standard Error	0.42
Trimmed Mean (98%)	-2.59
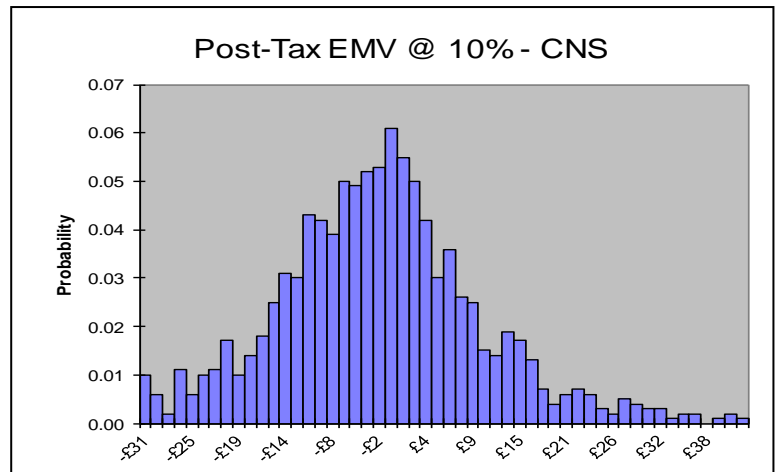
ii. NNS

When the key risks are considered the distribution of EMVs at 10% are shown in Chart 19 (pre-tax) and Chart 20 (post-tax). The mean values are clearly negative, and there is a wide range of outcomes before tax from –£71 million to +£31 million. The chance of a negative EMV is 92% before tax, and there is a 30% chance that the EMV could be –£24 million or worse. 68% of the pre-tax EMV distribution lies in the range -£30m. to -£7m. and 95% of the distribution lies in the range -£47m. to +£13m. After tax the chance of a negative EMV exceeds 83%. 68% of the post-tax EMV distribution lies in the range -£12m. to +£0.3m. and 95% of the distribution lies in the range -£19m. to +£11m.

Chart 19

NNS - Ongoing (Slow) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-18.35
Median	-18.55
Standard Deviation	13.79
Variance	190.10
Skewness	0.25
Kurtosis	1.43
Coefficient of Variability	-0.75
Minimum	-71.45
Maximum	30.84
Range	102.29
Mean Standard Error	0.44
Trimmed Mean (98%)	-18.42

Pre-Tax EMV @ 10% - NNS
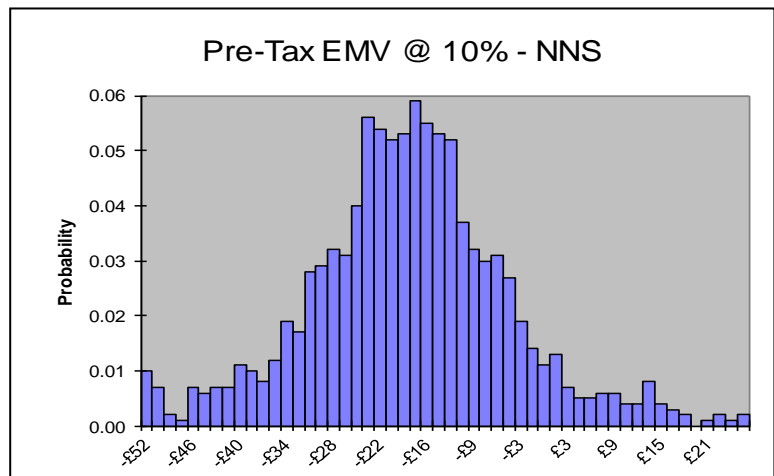
Chart 20

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-5.65
Median	-6.12
Standard Deviation	7.14
Variance	50.99
Skewness	0.57
Kurtosis	1.91
Coefficient of Variability	-1.26
Minimum	-32.15
Maximum	28.44
Range	60.60
Mean Standard Error	0.23
Trimmed Mean (98%)	-5.71

Post-Tax EMV @ 10% - NNS
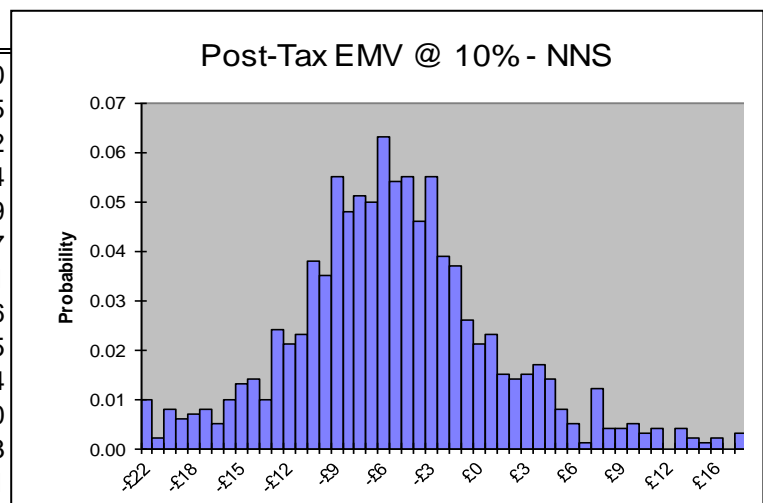
iii.   SNS

When the key risks are introduced the mean values are clearly negative with very significant downside risks. See Charts 21 and 22. The chance of a negative EMV is almost 100% before tax, with a 20% chance that the value could be –£15 million or worse. 68% of the pre-tax EMV distribution lies in the range -£16m. to -

£6m. and 95% of the distribution lies in the range -£26m. to -£2m. After tax the chance of a negative EMV is 96%. 68% of the post-tax EMV distribution lies in the range -£6m. to -£2m. and 95% of the distribution lies in the range -£11m. to +£0.45m.

<div align="center">

Chart 21

SNS - Ongoing (Slow) - Initial Price $70 p/b and 45p/therm (£m.)

</div>

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-11.05
Median	-10.00
Standard Deviation	5.98
Variance	35.77
Skewness	-1.19
Kurtosis	2.85
Coefficient of Variability	-0.54
Minimum	-44.63
Maximum	7.30
Range	51.92
Mean Standard Error	0.19
Trimmed Mean (98%)	-10.94

Pre-Tax EMV @ 10% - SNS

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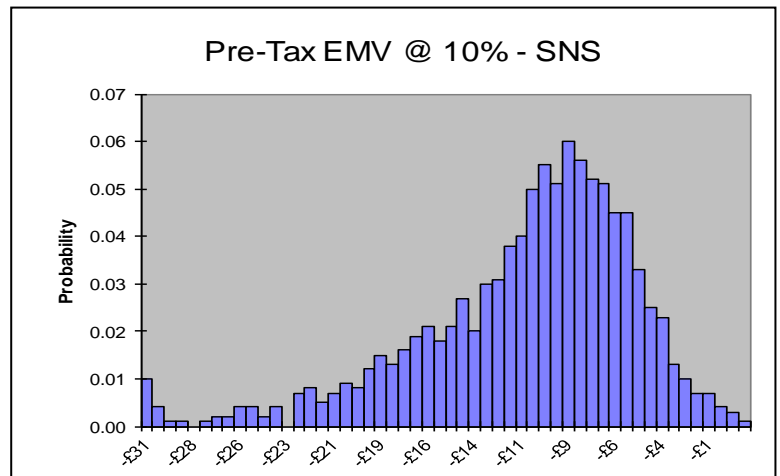
Chart 22

</div>

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-4.04
Median	-3.53
Standard Deviation	2.77
Variance	7.65
Skewness	-1.16
Kurtosis	3.27
Coefficient of Variability	-0.68
Minimum	-20.43
Maximum	5.28
Range	25.71
Mean Standard Error	0.09
Trimmed Mean (98%)	-4.00

Post-Tax EMV @ 10% - SNS
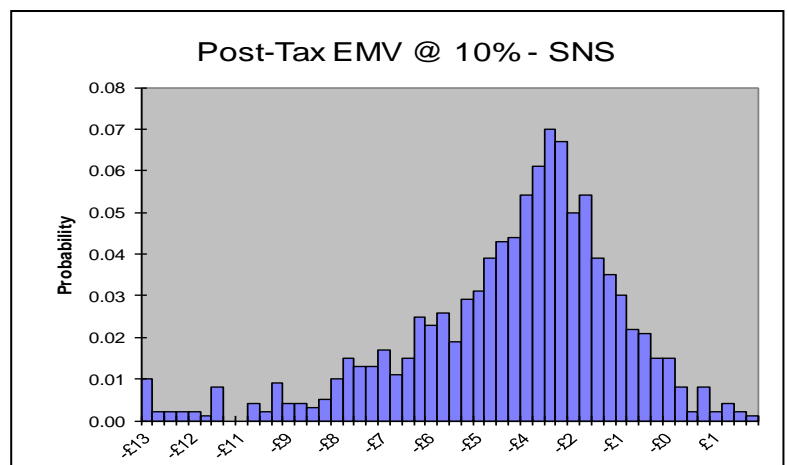
iv.   W of S

When the key risks are considered the distributions of EMVs at 10% are shown in Chart 23 (pre-tax) and Chart 24 (post-tax). The mean values are substantially negative before tax and unacceptable after tax. There is an enormous range of possible outcomes. Before tax the worst is nearly –£650 million and the maximum upside +£438 million. The tax system reduces the range, but it is still very large at –£275 million to +£262million. Before tax there is a 64% chance that the EMV will be negative and a 30% chance that it will be –£97 million or worse. On the upside potential there is a 20% chance that the pre-tax EMV all exceed +£53 million and a 10% chance that it will exceed +£115 million. 68% of the pre-tax EMV distribution lies in the range -£161m. to +£73m. and 95% of the distribution lies in the range -£313m. to +£235m. After tax there is more than a 50% chance that the EMV will be negative, with a 20% chance that it will be –£50 million or worse. There is a 20% chance that the EMV will exceed +£48 million and a 10% chance that it exceeds +£80 million. 68% of the post-tax EMV distribution lies in the range -£59m. to +£60m. and 95% of the distribution lies in the range -£131m. to +£152m.

Chart 23

WoS - Ongoing (Slow) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-42.47
Median	-40.47
Standard Deviation	132.97
Variance	17680.33
Skewness	-0.03
Kurtosis	1.40
Coefficient of Variability	-3.13
Minimum	-649.63
Maximum	438.20
Range	1087.83
Mean Standard Error	4.20
Trimmed Mean (98%)	-42.43

Pre-Tax EMV @ 10% - WoS
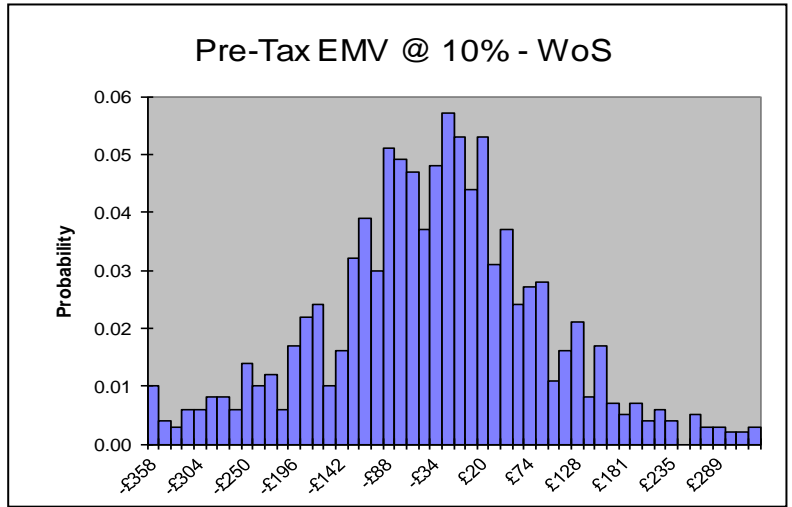
Chart 24

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	0.16
Median	-1.79
Standard Deviation	69.21
Variance	4790.48
Skewness	0.25
Kurtosis	1.17
Coefficient of Variability	440.38
Minimum	-274.86
Maximum	261.50
Range	536.36
Mean Standard Error	2.19
Trimmed Mean (98%)	-0.14

Post-Tax EMV @ 10% - WoS

27
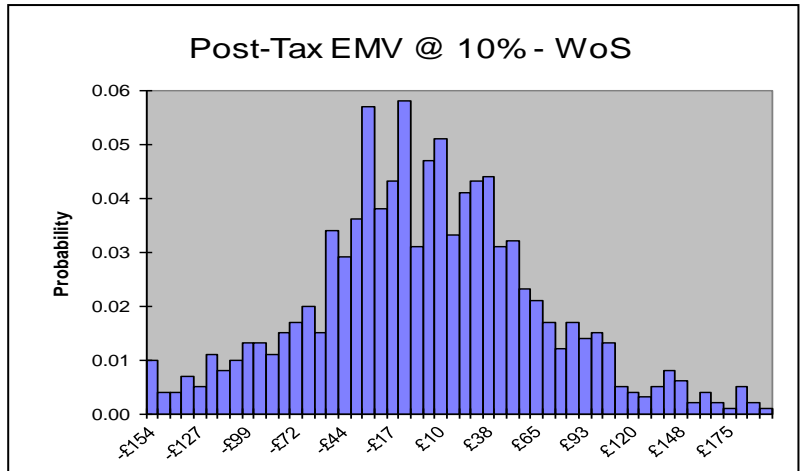
(d) Project Investor, Slow Cycle Time

i.   CNS

The distributions of EMVs at 10% to the project investor in the CNS under the slow cycle time assumptions are shown in Chart 25 (pre-tax) and Chart 26 (post-tax). It is seen that the mean values are clearly negative in both situations. There is a large range of possible outcomes with the pre-tax values being from –£140 million to +£168 million. But there is a more than 78% chance that the pre-tax EMV will be negative, and a 30% chance that it will be –£25.8 million or worse. There is only a 20% chance that the value will be +£1.5 million or better. 68% of the pre-tax EMV distribution lies in the range -£36m. to +£6m. and 95% of the distribution lies in the range -£64m. to +£32m. After tax there is still a greater than 78% chance that the EMV will be negative. 68% of the post-tax EMV distribution lies in the range -£34m. to +£5m. and 95% of the distribution lies in the range -£61m. to +£22m.

Chart 25

CNS - Project (Slow) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-15.60
Median	-15.25
Standard Deviation	24.99
Variance	624.33
Skewness	0.17
Kurtosis	4.72
Coefficient of Variability	-1.60
Minimum	-140.11
Maximum	168.41
Range	308.52
Mean Standard Error	0.79
Trimmed Mean (98%)	-15.60

Pre-Tax EMV @ 10% - CNS
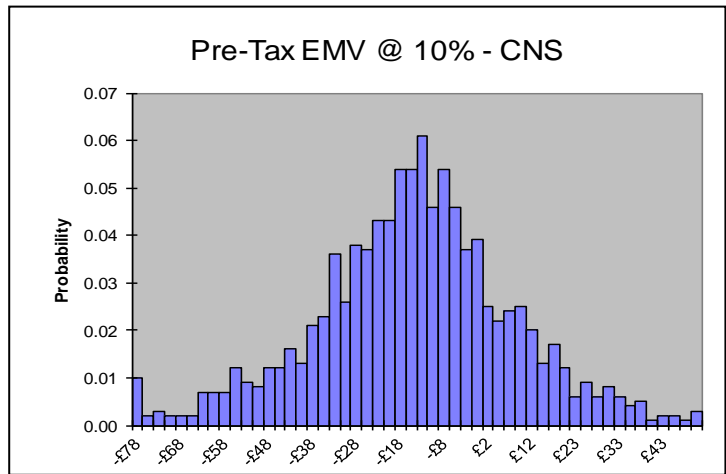
Chart 26

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-15.82
Median	-14.21
Standard Deviation	22.10
Variance	488.32
Skewness	-0.58
Kurtosis	2.87
Coefficient of Variability	-1.40
Minimum	-136.79
Maximum	101.87
Range	238.67
Mean Standard Error	0.70
Trimmed Mean (98%)	-15.58
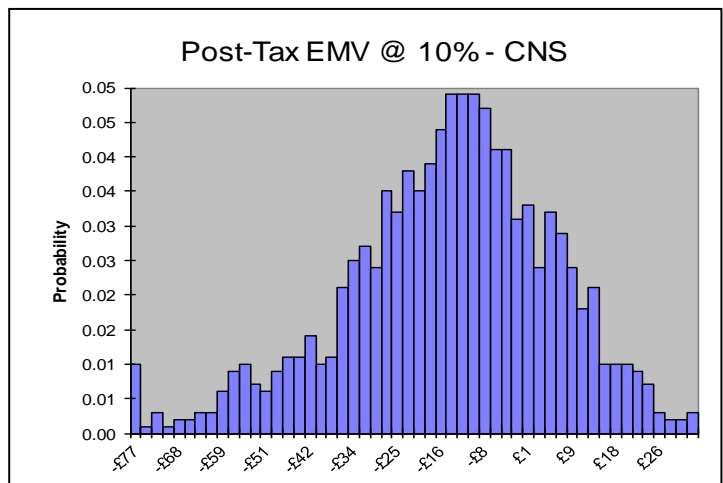
Post-Tax EMV @ 10% - CNS

ii.   NNS

The distributions of EMVs at 10% for the project investor in the NNS are shown in Chart 27 (pre-tax) and Chart 28 (post-tax). The mean values are seen to be clearly negative. The range of outcomes is wide, namely from –£76 million to +£64 million before tax. The chance that the EMV will be negative is well over 90% both before and after tax.   68% of the pre-tax EMV

distribution lies in the range -£29m. to -£7m. and 95% of the distribution lies in the range -£46m. to +£7m. 68% of the post-tax EMV distribution lies in the range -£29m. to -£6m. and 95% of the distribution lies in the range -£45m. to +£6m.

Chart 27

NNS - Project (Slow) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV @ 10% Statistics	
Trials	1000
Mean	-18.31
Median	-18.27
Standard Deviation	13.25
Variance	175.52
Skewness	0.08
Kurtosis	3.00
Coefficient of Variability	-0.72
Minimum	-76.15
Maximum	64.38
Range	140.53
Mean Standard Error	0.42
Trimmed Mean (98%)	-18.33
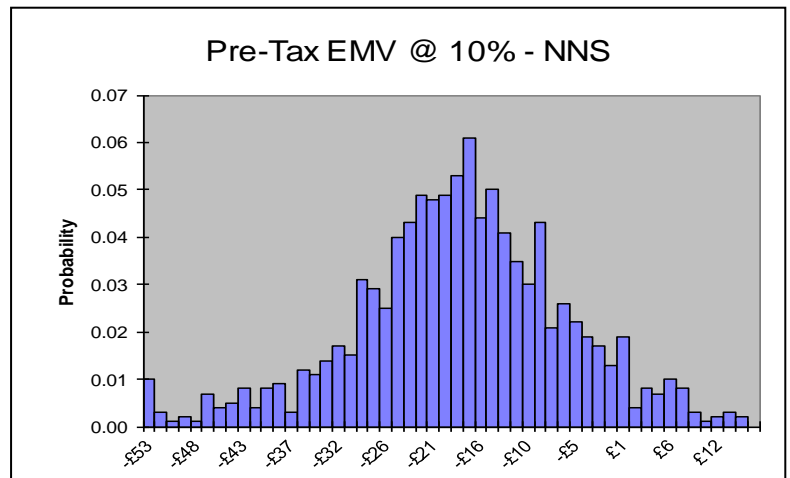
Chart 28

Post-Tax EMV @ 10% Statistics	
Trials	1000
Mean	-17.78
Median	-17.65
Standard Deviation	12.65
Variance	159.92
Skewness	-0.22
Kurtosis	1.70
Coefficient of Variability	-0.71
Minimum	-74.26
Maximum	42.13
Range	116.39
Mean Standard Error	0.40
Trimmed Mean (98%)	-17.72
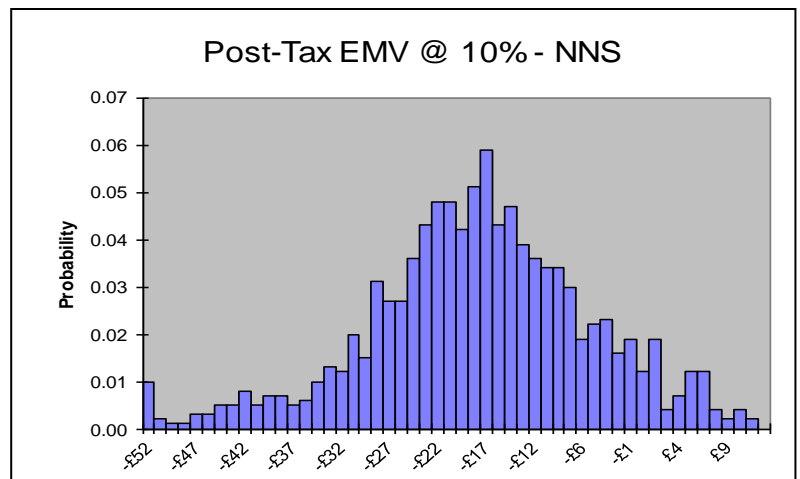
iii. SNS

The distributions of EMVs for the project investor in the SNS are shown in Chart 29 (pre-tax) and Chart 30 (post-tax). The mean values are clearly negative. The pre-tax range is from –£50 million to +£15 million. But there is more than a 90% chance that the value will be negative before and after tax. There is only a 2% chance that the post-tax EMV will be positive. 68% of the pre-tax distribution lies in the range -£16.18m. to -£6.09m. and 95% lies in the range -£25.15m. to -£1.83m. 68% of the post-tax distribution lies in the range -£15.67m. to -£5.85m. and 95% lies in the range -£24m. to -£1.52m.

Chart 29

SNS - Project (Slow) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-11.04
Median	-9.90
Standard Deviation	6.00
Variance	36.00
Skewness	-1.19
Kurtosis	3.72
Coefficient of Variability	-0.54
Minimum	-50.15
Maximum	14.73
Range	64.88
Mean Standard Error	0.19
Trimmed Mean (98%)	-10.93
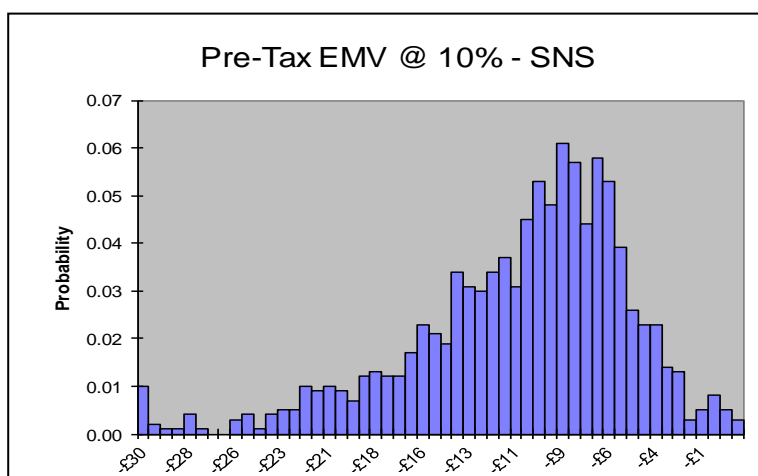
Chart 30

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-10.68
Median	-9.60
Standard Deviation	5.83
Variance	33.96
Skewness	-1.22
Kurtosis	3.57
Coefficient of Variability	-0.55
Minimum	-48.79
Maximum	9.35
Range	58.14
Mean Standard Error	0.18
Trimmed Mean (98%)	-10.57
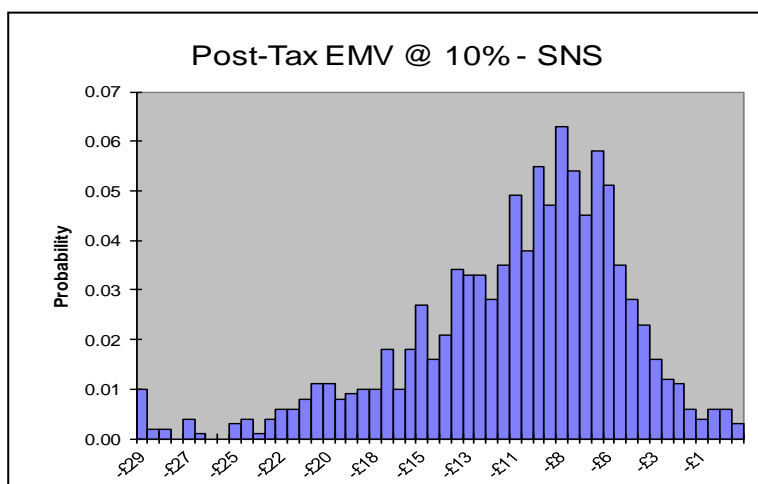
iv.   W of S

The distributions of EMVs for the project investor in the W of S region are shown in Chart 31 (pre-tax) and Chart 32 (post-tax). The mean values are very substantially negative in both cases. The range of outcomes is extremely wide, namely from –£777 million to +£570 million. There is a 66% chance that the pre-tax value will be negative, and a 20% chance that the value will be –£129 million or worse. 68% of the pre-tax EMV distribution lies in the range -

£159m. to +£66m. and 95% of the distribution lies in the range -£308m. to +£206m.   After tax the chance of the EMV being negative is around 66%, with a 20% chance that it will be –£125 million or worse.   There is a 20% chance that the value will be +£30 million or better.   68% of the post-tax EMV distribution lies in the range -£154m. to +£44m. and 95% of the distribution lies in the range -£303m. to +£123m.

Chart 31

WoS - Project (Slow) - Initial Price $70 p/b and 45p/therm (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-44.31
Median	-38.91
Standard Deviation	131.49
Variance	17289.08
Skewness	-0.39
Kurtosis	2.70
Coefficient of Variability	-2.97
Minimum	-777.08
Maximum	569.61
Range	1346.70
Mean Standard Error	4.16
Trimmed Mean (98%)	-43.56
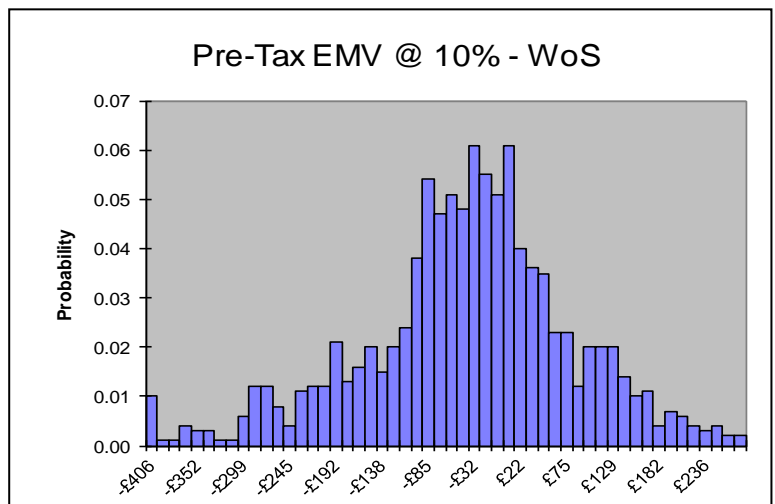
Chart 32

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-52.04
Median	-33.63
Standard Deviation	113.63
Variance	12911.26
Skewness	-1.15
Kurtosis	3.44
Coefficient of Variability	-2.18
Minimum	-766.02
Maximum	342.02
Range	1108.04
Mean Standard Error	3.59
Trimmed Mean (98%)	-50.02
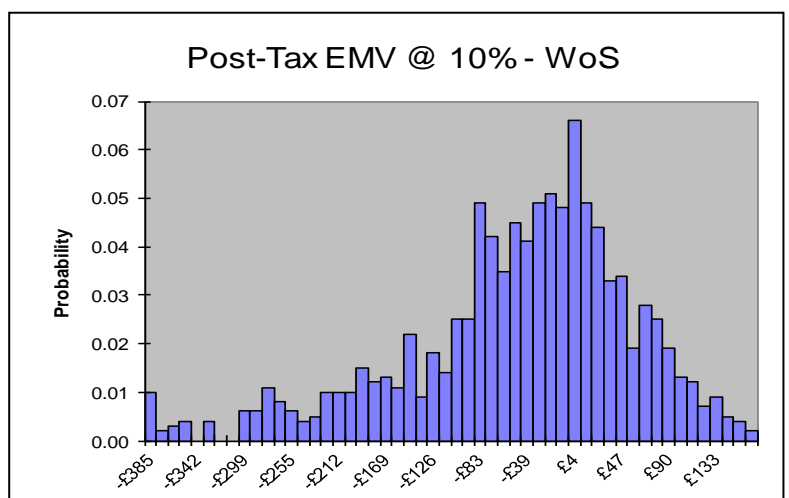
B. After Cost Reductions

(a) Investor in Tax-Paying Position, Fast Cycle Time

i. CNS

The distributions of EMVs at 10% after the cost reductions for an investor in a tax-paying position and with the fast cycle time assumptions in the CNS are shown in Chart 33 (pre-tax) and Chart 34 (post-tax). The mean values are clearly positive. There is a very wide range of outcomes, namely from –£59 million to +£261.5 million before tax, and –£19 million to +£160 million after tax. There is more than a 74% chance that the pre-tax EMV will be positive, and a 20% chance that it will exceed +£40 million. 68% of the pre-tax EMV distribution lies in the range -£9m. to +£47m. and 95% of the distribution lies in the range -£27m. to +£97m.. After tax there is only a 14% chance that the EMV will be negative, and there is a 30% chance that it will exceed +£20 million and a 10% chance that it will exceed +£37 million. 68% of the post-tax EMV distribution lies in the range +£0.37m. to +£30m. and 95% of the distribution lies in the range -£7m. to +£57m.

Chart 33

CNS - Ongoing (Fast) - Initial Price $70 p/b and 45p/therm Cost Reduction(£m.)

Pre-Tax EMV @10% Statistics	
Trials	1000
Mean	20.07
Median	15.77
Standard Deviation	31.99
Variance	1023.59
Skewness	1.50
Kurtosis	5.44
Coefficient of Variability	1.59
Minimum	-59.14
Maximum	261.50
Range	320.64
Mean Standard Error	1.01
Trimmed Mean (98%)	19.29

Pre-Tax EMV @ 10% - CNS
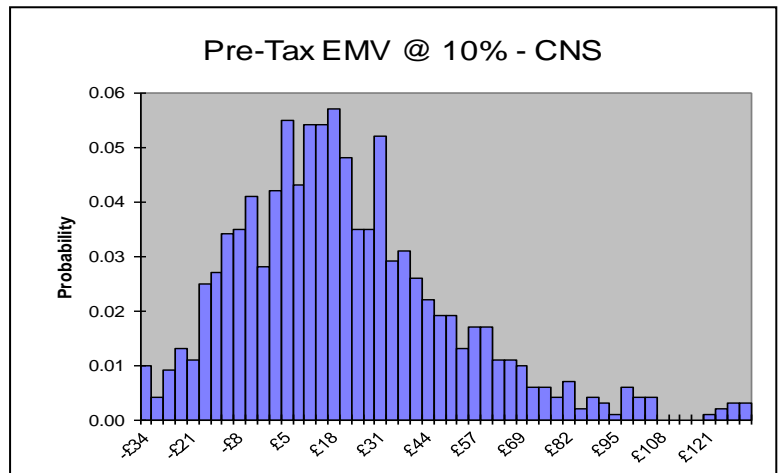
Chart 34

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	15.88
Median	12.92
Standard Deviation	17.32
Variance	299.94
Skewness	1.78
Kurtosis	7.38
Coefficient of Variability	1.09
Minimum	-19.16
Maximum	160.25
Range	179.41
Mean Standard Error	0.55
Trimmed Mean (98%)	15.39

Post-Tax EMV @ 10% - CNS

35
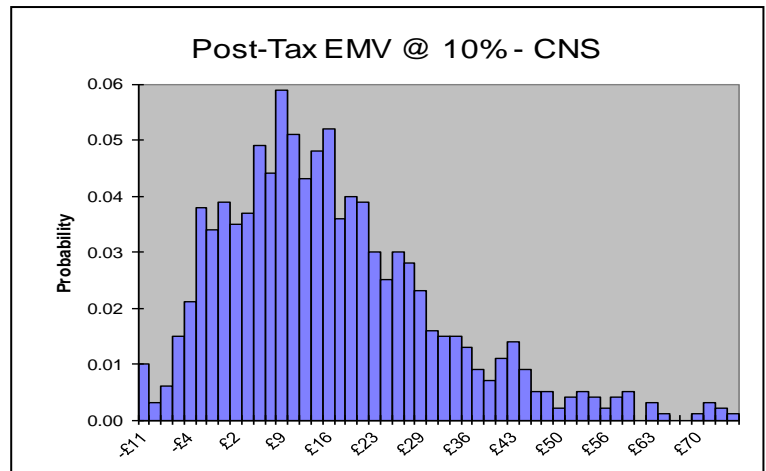
ii. NNS

In Charts 35 and 36 the prospective EMVs for the investor in the NNS after the cost reductions are shown before and after tax respectively. The mean values are just positive in both situations. There is a wide range of possible outcomes from a minimum of −£38 million to +£132 million before tax. There is a 61% chance that the EMV will be positive before tax, and a 20% chance that it will exceed +£17.5 million. 68% of the pre-tax EMV distribution lies in the range -£8m. to +£21m. and 95% of the distribution lies in the range -£20m. to +£47m. After tax there is a nearly 77% chance that the EMV will be positive, and a 20% chance that it will exceed +£12.6 million. 68% of the post-tax EMV distribution lies in the range -£1m. to +£15m. and 95% of the distribution lies in the range -£6m. to +£28m.

Chart 35

NNS - Ongoing (Fast) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	6.48
Median	4.26
Standard Deviation	16.87
Variance	284.62
Skewness	1.36
Kurtosis	4.81
Coefficient of Variability	2.60
Minimum	-37.68
Maximum	131.97
Range	169.64
Mean Standard Error	0.53
Trimmed Mean (98%)	6.12
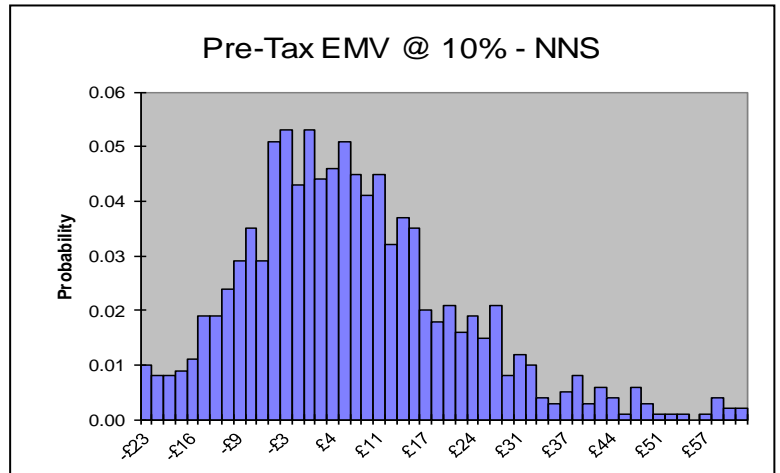
Chart 36

Post-Tax EMV@10% Statistics

Trials	1000
Mean	6.79
Median	5.46
Standard Deviation	9.07
Variance	82.25
Skewness	1.66
Kurtosis	6.92
Coefficient of Variability	1.34
Minimum	-12.42
Maximum	82.72
Range	95.14
Mean Standard Error	0.29
Trimmed Mean (98%)	6.56
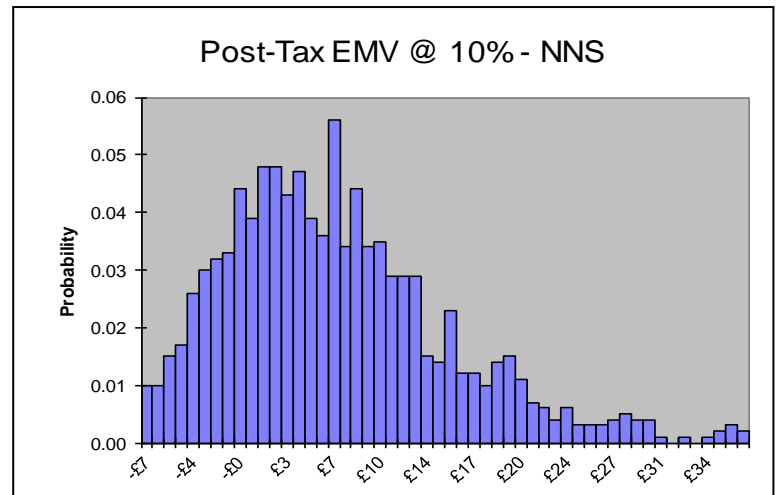
iii.   SNS

The distributions of EMVs for the investor in the SNS after cost reductions are shown in Chart 37 (pre-tax) and Chart 38 (post-tax). The mean values are slightly negative in both cases. There is an 82% chance that the pre-tax EMV will be negative, and a 20% chance that it will be worse than –£7.2 million. 68% of the pre-tax EMV distribution lies in the range -£8m. to +£0.3m. and 95% of the distribution lies in the range -£15m. to +£6m. After tax there is a 59% chance that the EMV will be negative. There is only a 10% chance that the value will exceed +£2.48 million.   68% of the post-tax EMV distribution lies in the range -£2m. to +£2m. and 95% of the distribution lies in the range -£5m. to +£5m.

Chart 37

SNS - Ongoing (Fast) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics	
Trials	1000
Mean	-3.79
Median	-3.56
Standard Deviation	4.94
Variance	24.37
Skewness	-0.38
Kurtosis	2.31
Coefficient of Variability	-1.30
Minimum	-31.26
Maximum	16.02
Range	47.28
Mean Standard Error	0.16
Trimmed Mean (98%)	-3.76

Chart 38

Post-Tax EMV@10% Statistics	
Trials	1000
Mean	-0.27
Median	-0.46
Standard Deviation	2.28
Variance	5.20
Skewness	0.22
Kurtosis	2.58
Coefficient of Variability	-8.56
Minimum	-12.89
Maximum	9.55
Range	22.44
Mean Standard Error	0.07
Trimmed Mean (98%)	-0.27
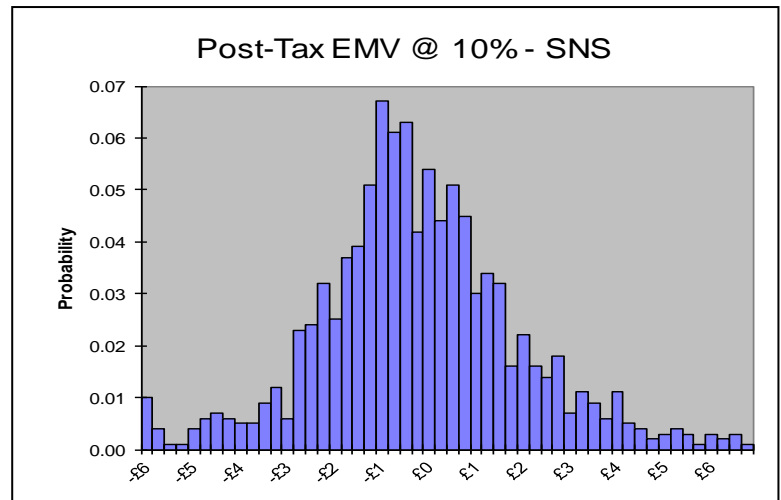
iv.   W of S

The distributions of EMVs for the investor in the W of S region after cost reductions are shown in Chart 39 (pre-tax) and Chart 40 (post-tax). It is seen that the mean values are substantially positive both before and after tax for the investor already in a tax-paying position. The spread of outcomes is extremely wide with a pre-tax minimum value of –£414 million and a maximum of +£736 million. There is a nearly 28% chance that the EMV will be negative and a 20% chance that it will exceed +£216 million before tax. 68% of the pre-tax EMV distribution lies in the range -£46m. to +£245m. and 95% of the distribution lies in the range -£189m. to +£464m. After tax the chance that the EMV will be negative is less than 19%, and there is a 20% chance that it will exceed +£140 million. 68% of the post-tax EMV distribution lies in the range -£7m. to +£153m. and 95% of the distribution lies in the range -£66m. to +£274m.

Chart 39

WoS - Ongoing (Fast) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	96.73
Median	79.12
Standard Deviation	164.57
Variance	27084.13
Skewness	0.64
Kurtosis	1.19
Coefficient of Variability	1.70
Minimum	-414.89
Maximum	735.68
Range	1150.57
Mean Standard Error	5.20
Trimmed Mean (98%)	94.79

Pre-Tax EMV @ 10% - WoS
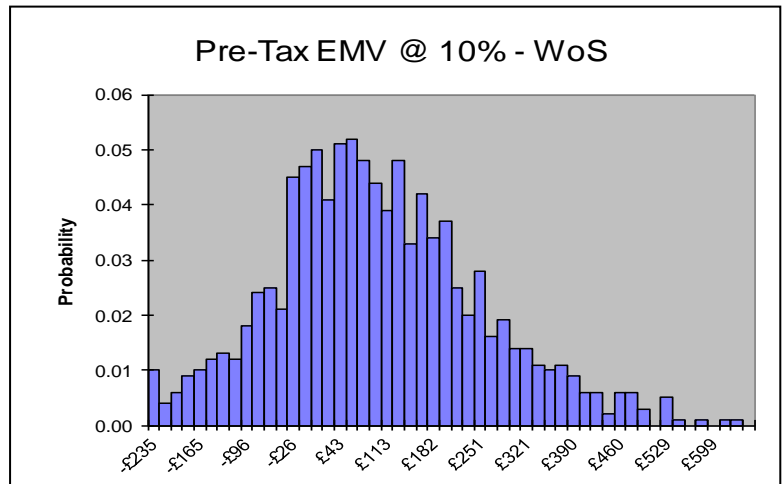
Chart 40

Post-Tax EMV@10% Statistics

Trials	1000
Mean	73.16
Median	60.85
Standard Deviation	87.30
Variance	7620.76
Skewness	0.82
Kurtosis	1.23
Coefficient of Variability	1.19
Minimum	-159.66
Maximum	420.04
Range	579.70
Mean Standard Error	2.76
Trimmed Mean (98%)	71.84

Post-Tax EMV @ 10% - WoS
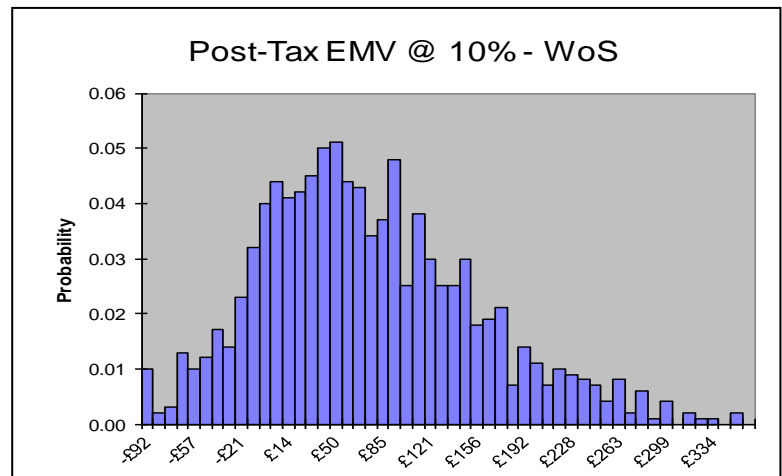
(b) Project Investor, Fast Cycle Time

i. CNS

The distributions of EMVs for the project investor after cost reductions are shown in Chart 41 (pre-tax) and Chart 42 (post-tax). The mean values are positive at £20 million before tax and £11.3 million after tax. There is a large range of possible outcomes with a pre-tax minimum of –£59 million and a maximum of +£274 million. There is a 24% chance that, before tax, the EMV will be negative, and there is a 30% chance that it will be +£30 million or better. 68% of the pre-tax EMV distribution lies in the range -£7m. to +£47m. and 95% of the distribution lies in the range -£27m. to +£94m. After tax the chance of a negative EMV remains at 24%, and there is a 30% chance that it will be greater than +£18.6 million. 68% of the post-tax EMV distribution lies in the range -£6m. to +£28m. and 95% of the distribution lies in the range -£26m. to +£55m.

Chart 41

CNS - Project (Fast) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	20.09
Median	16.10
Standard Deviation	31.15
Variance	970.10
Skewness	1.55
Kurtosis	6.59
Coefficient of Variability	1.55
Minimum	-59.14
Maximum	274.41
Range	333.54
Mean Standard Error	0.98
Trimmed Mean (98%)	19.33

Pre-Tax EMV @ 10% - CNS

Probability (y-axis: 0.00 – 0.07)

x-axis: -£34, -£21, -£9, £4, £16, £29, £41, £54, £66, £79, £91, £104, £116
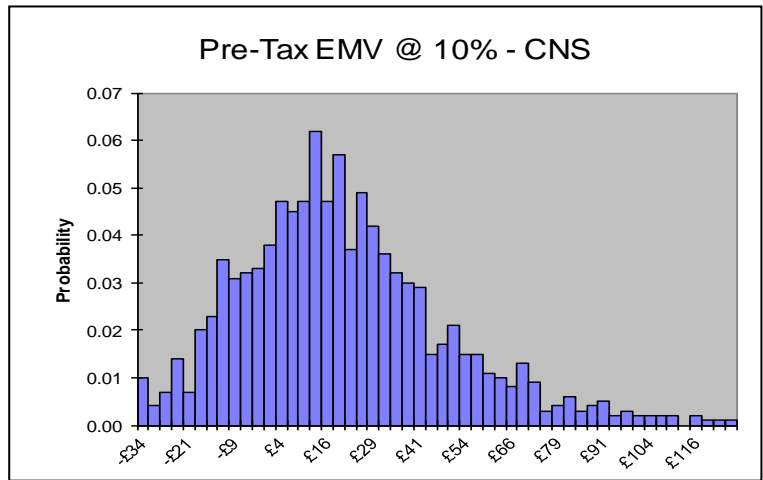
Chart 42

Post-Tax EMV@10% Statistics

Trials	1000
Mean	11.25
Median	10.56
Standard Deviation	19.87
Variance	394.62
Skewness	0.83
Kurtosis	4.32
Coefficient of Variability	1.77
Minimum	-57.08
Maximum	157.87
Range	214.95
Mean Standard Error	0.63
Trimmed Mean (98%)	10.98

Post-Tax EMV @ 10% - CNS

Probability (y-axis: 0.00 – 0.06)

x-axis: -£32, -£24, -£16, -£8, -£0, £8, £16, £24, £32, £40, £48, £56, £64

43
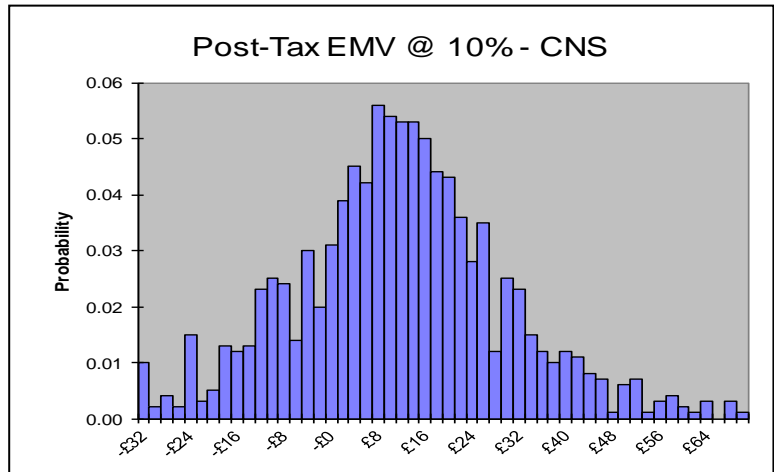
ii. NNS

In the NNS the distributions of EMVs for the project investor are shown in Chart 43 (pre-tax) and Chart 44 (post-tax). The mean values are positive to a modest degree in both cases. The spread of outcomes before tax is from –£38 million to +£135 million. There is a chance of just under 37% that the EMV will be negative before tax, and a 20% chance that it will exceed +£17 million. 68% of the pre-tax EMV distribution lies in the range -£7m. to +£21m. and 95% of the distribution lies in the range -£19m. to +£46m. After tax the chance of the EMV being negative is just over 35%, and there is a 20% chance that it will exceed +£11.6 million.   68% of the post-tax EMV distribution lies in the range -£7m. to +£14m. and 95% of the distribution lies in the range -£18m. to +£27m.

Chart 43

# NNS - Project (Fast) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	6.49
Median	4.42
Standard Deviation	16.27
Variance	264.64
Skewness	1.38
Kurtosis	5.62
Coefficient of Variability	2.51
Minimum	-37.68
Maximum	134.92
Range	172.60
Mean Standard Error	0.51
Trimmed Mean (98%)	6.16
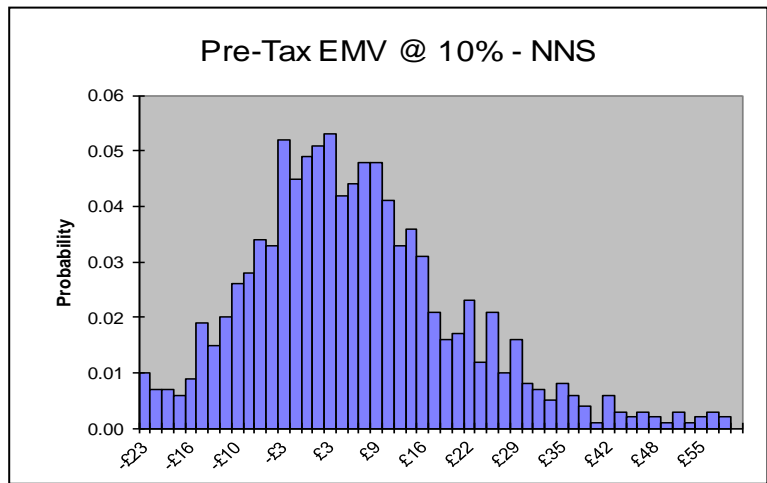
Chart 44

Post-Tax EMV@10% Statistics

Trials	1000
Mean	3.55
Median	3.64
Standard Deviation	11.32
Variance	128.19
Skewness	0.47
Kurtosis	2.83
Coefficient of Variability	3.19
Minimum	-36.09
Maximum	79.52
Range	115.62
Mean Standard Error	0.36
Trimmed Mean (98%)	3.46
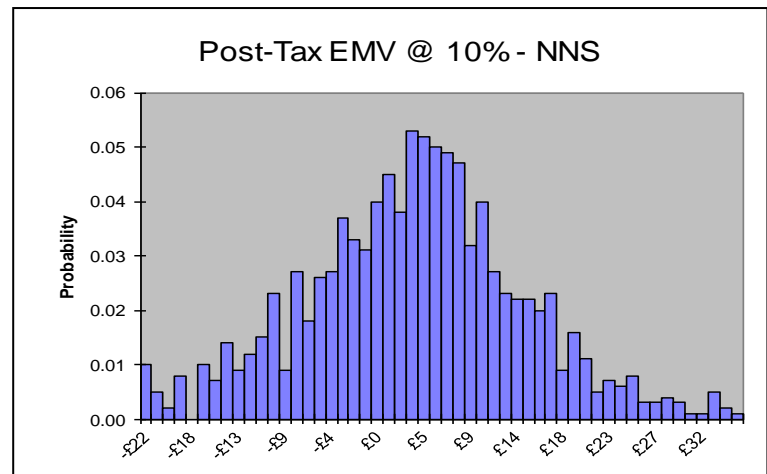
iii.   SNS

The distributions of EMVs at 10% for the project investor in the SNS are shown in Chart 45 (pre-tax) and Chart 46 (post-tax). The mean values are just negative before and after tax. The spread of outcomes before tax is from –£31.3 million to +£16 million. There is, however, an 82% chance that the EMV will be negative before tax, and only a 10% chance that it will exceed +£1.8 million. 68% of the pre-tax EMV distribution lies in the range -£8m. to +£0.3m. and 95% of the distribution lies in the range -£15 to +£6. After tax the chance of a negative EMV is 81%, and there is only a 10% chance of the value exceeding +£1.5 million. 68% of the post-tax EMV distribution lies in the range -£8m. to +£0.4m. and 95% of the distribution lies in the range -£14m. to +£4m.

Chart 45

SNS - Project (Fast) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	-3.79
Median	-3.56
Standard Deviation	4.94
Variance	24.37
Skewness	-0.38
Kurtosis	2.31
Coefficient of Variability	-1.30
Minimum	-31.26
Maximum	16.02
Range	47.28
Mean Standard Error	0.16
Trimmed Mean (98%)	-3.76

Pre-Tax EMV @ 10% - SNS

Chart 46

Post-Tax EMV@10% Statistics

Trials	1000
Mean	-3.65
Median	-3.33
Standard Deviation	4.47
Variance	19.97
Skewness	-0.81
Kurtosis	2.36
Coefficient of Variability	-1.23
Minimum	-30.27
Maximum	9.56
Range	39.82
Mean Standard Error	0.14
Trimmed Mean (98%)	-3.58
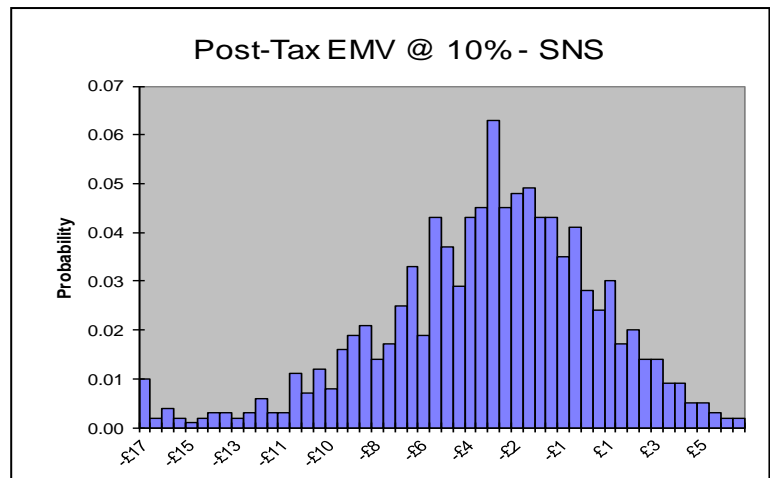
Post-Tax EMV @ 10% - SNS

47

iv.　W of S

The distributions of EMVs for the project investor in the W of S region are shown in Chart 47 (pre-tax) and Chart 48 (post-tax). The mean values are healthily positive at £96.9 million before tax and £48 million after tax. The range of possible outcomes is very wide, however, with the pre-tax minimum value being –£415 million and the maximum +£704 million. The chance of the EMV being negative before tax is just under 28%. The upside potential is large. There is a 40% chance that the pre-tax EMV will exceed +£119 million, and a 20% chance that it will exceed +£216 million. 68% of the pre-tax EMV distribution lies in the range -£42m. to +£240m. and 95% of the distribution lies in the range -£189m. to +£459m. After tax there is a nearly 29% chance that the EMV will be negative, a 30% chance that it will exceed +£98 million, and a 10% chance that it will exceed +£173 million. 68% of the post-tax EMV distribution lies in the range -£39m. to +£140m. and 95% of the distribution lies in the range -£185m. to +£256m.

Chart 47

## <u>WoS - Project (Fast) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)</u>

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	96.91
Median	82.27
Standard Deviation	160.88
Variance	25882.47
Skewness	0.53
Kurtosis	0.95
Coefficient of Variability	1.66
Minimum	-414.89
Maximum	703.58
Range	1118.47
Mean Standard Error	5.09
Trimmed Mean (98%)	95.40
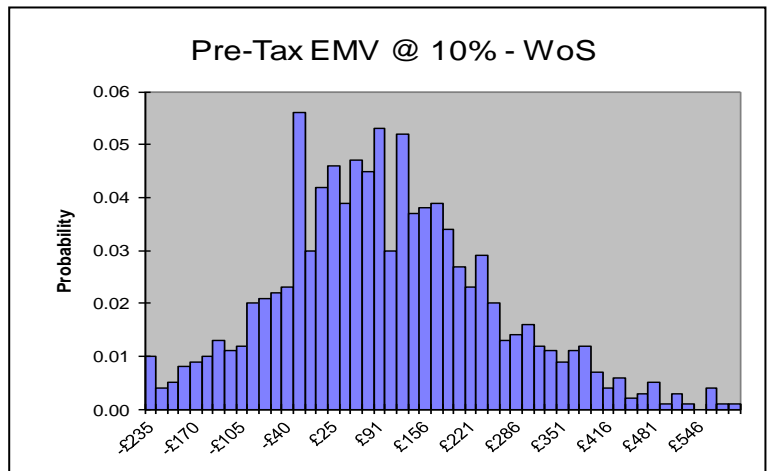
Chart 48

Post-Tax EMV@10% Statistics

Trials	1000
Mean	48.04
Median	50.64
Standard Deviation	107.10
Variance	11469.34
Skewness	-0.24
Kurtosis	1.16
Coefficient of Variability	2.23
Minimum	-405.79
Maximum	400.99
Range	806.79
Mean Standard Error	3.39
Trimmed Mean (98%)	48.38
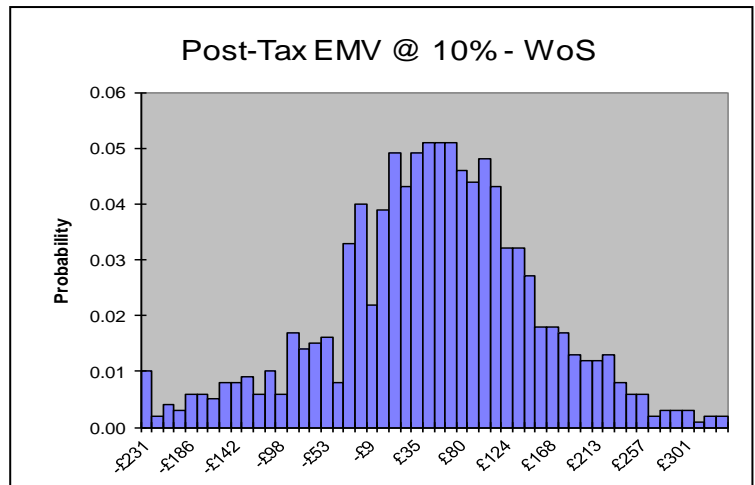
(c) Investor in Tax-Paying Position, Slow Cycle Time

i.   CNS

The distributions of EMVs for an investor under slow cycle conditions from first exploration to first production are shown in Chart 49 (pre-tax) and Chart 50 (post-tax). It is seen that the mean values are positive pre-tax (£12.3 million) and post-tax (£11.1 million).   The pre-tax range is very wide, namely from –£53 million to +£226 million. There is a 33% chance that the pre-tax EMV will be negative, and a 30% chance that it will exceed +£19.9 million. There is a 20% chance that it will exceed +£29 million. 68% of the pre-tax EMV distribution lies in the range -£11m. to +£34m. and 95% of the distribution lies in the range -£26m. to +£77m.   There is a 20% chance that the post-tax EMV will be negative.   68% of the post-tax EMV distribution lies in the range -£1m. to +£23m. and 95% of the distribution lies in the range -£8m. to +£45m.

Chart 49

CNS - Ongoing (Slow) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	12.29
Median	7.84
Standard Deviation	26.68
Variance	712.02
Skewness	1.59
Kurtosis	6.15
Coefficient of Variability	2.17
Minimum	-53.24
Maximum	226.03
Range	279.26
Mean Standard Error	0.84
Trimmed Mean (98%)	11.62

Pre-Tax EMV @ 10% - CNS
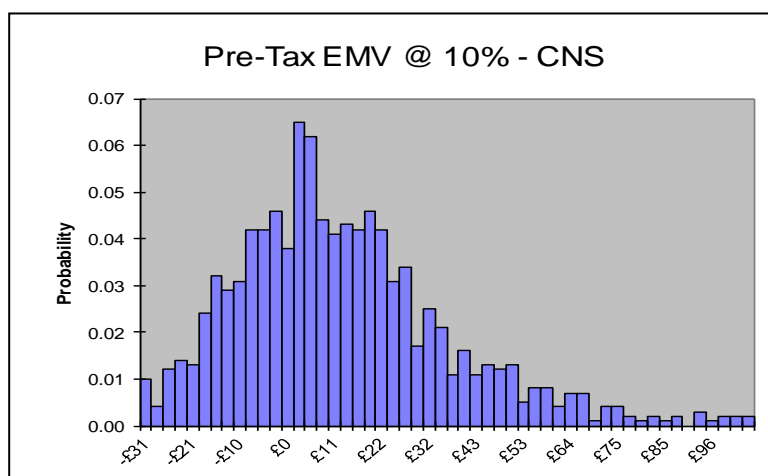
Chart 50

Post-Tax EMV@10% Statistics

Trials	1000
Mean	11.10
Median	8.27
Standard Deviation	14.42
Variance	208.00
Skewness	1.86
Kurtosis	7.99
Coefficient of Variability	1.30
Minimum	-17.40
Maximum	136.12
Range	153.51
Mean Standard Error	0.46
Trimmed Mean (98%)	10.68

Post-Tax EMV @ 10% - CNS
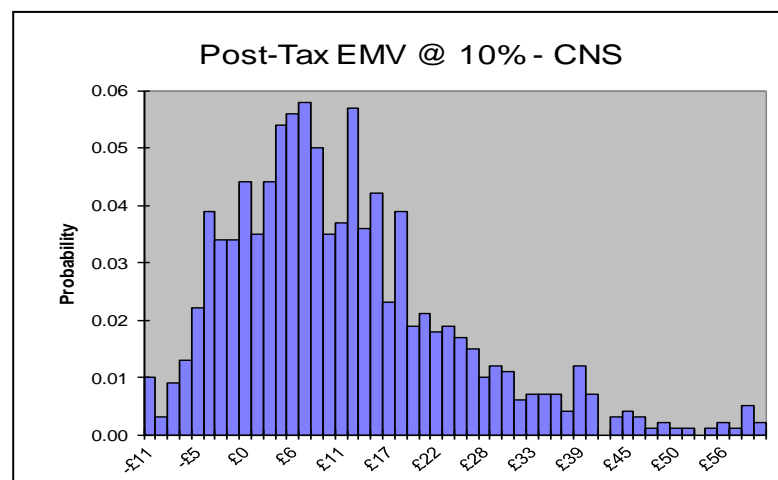
ii.   NNS

The distributions of EMVs for the investor in the NNS are shown in Chart 51(pre-tax) and Chart 52 (post-tax). The mean values are just positive. There is a 55% chance that the EMV will be negative before tax. There is a 20% chance that it will exceed +£8.6 million. 68% of the pre-tax EMV distribution lies in the range -£12m. to +£12m. and 95% of the distribution lies in the range -

£22m. to +£35m. After tax there is a 38% chance that the EMV will be negative, and a 20% chance that it will exceed +£7.9 million.   68% of the pre-tax EMV distribution lies in the range -£3m. to +£10m. and 95% of the distribution lies in the range -£7m. to +£22m.

Chart 51

NNS - Ongoing (Slow) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	0.08
Median	-2.03
Standard Deviation	14.09
Variance	198.49
Skewness	1.34
Kurtosis	4.18
Coefficient of Variability	169.44
Minimum	-34.08
Maximum	99.84
Range	133.92
Mean Standard Error	0.45
Trimmed Mean (98%)	-0.22
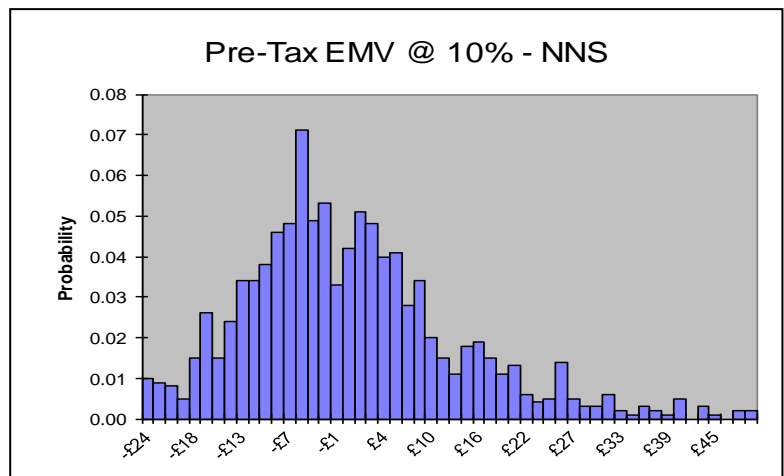
Chart 52

Post-Tax EMV@10% Statistics

Trials	1000
Mean	3.15
Median	1.82
Standard Deviation	7.57
Variance	57.36
Skewness	1.61
Kurtosis	5.87
Coefficient of Variability	2.41
Minimum	-13.21
Maximum	63.25
Range	76.46
Mean Standard Error	0.24
Trimmed Mean (98%)	2.95
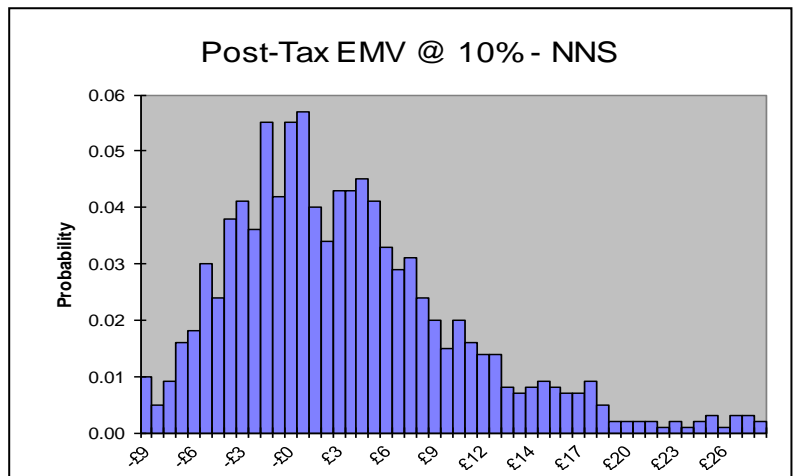
iii.   SNS

The distributions of EMVs for the investor in the SNS are shown in Chart 53 (pre-tax) and Chart 54 (post-tax). The mean values are modestly negative. There is a 90% chance that the EMV will be negative before tax. Because of loss-sharing through the tax system the chance of a post-tax negative EMV is around 75%. 68% of the pre-tax EMV distribution lies in the range -£8m. to -£1m. and 95% of the distribution lies in the range -£14m. to +£4m. 68% of the post-tax EMV distribution lies in the range -£2m. to +£0.5m. and 95% of the distribution lies in the range -£5m. to +£3m.

Chart 53

SNS - Ongoing (Slow) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	-4.73
Median	-4.51
Standard Deviation	4.05
Variance	16.41
Skewness	-0.37
Kurtosis	2.31
Coefficient of Variability	-0.86
Minimum	-26.46
Maximum	12.70
Range	39.17
Mean Standard Error	0.13
Trimmed Mean (98%)	-4.70
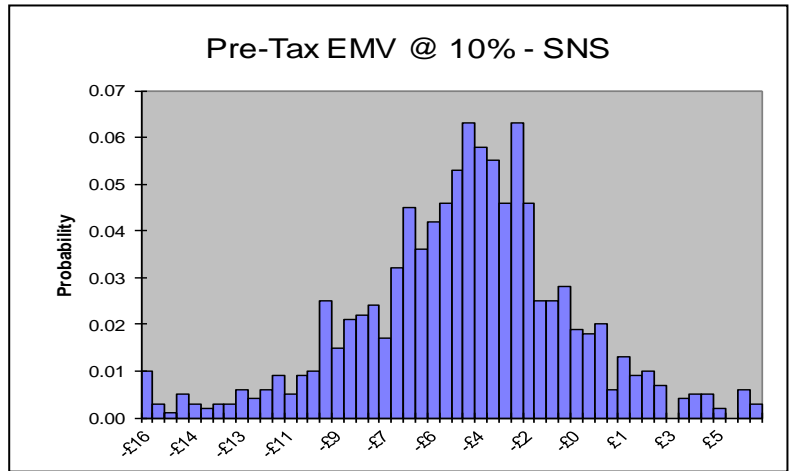
Chart 54

Post-Tax EMV@10% Statistics

Trials	1000
Mean	-0.97
Median	-1.11
Standard Deviation	1.88
Variance	3.52
Skewness	0.22
Kurtosis	2.57
Coefficient of Variability	-1.93
Minimum	-10.76
Maximum	7.70
Range	18.45
Mean Standard Error	0.06
Trimmed Mean (98%)	-0.97
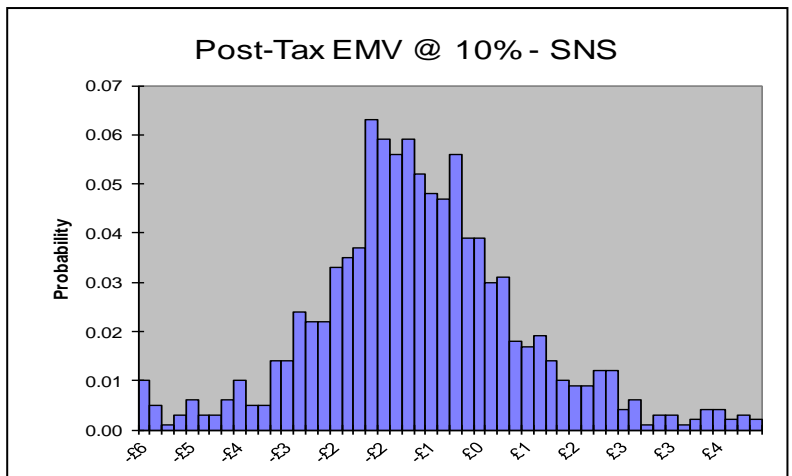
iv.   W of S

The distributions of EMVs in the W of S region are shown in Chart 55 (pre-tax) and Chart 56 (post-tax). The mean values are healthily positive at £71 million before tax and £56 million after tax. There is a chance of just over 31% that the pre-tax EMV will be negative and a 20% chance that it will be –£34.8 million or worse. On the upside there is a 30% chance that the EMV will exceed £124 million and a 20% chance that it will exceed +£169 million. 68% of the pre-tax EMV distribution lies in the range -£48m. to +£194m. and 95% of the distribution lies in the range -£163m. to +£388m. After tax the chance of the EMV being negative is just over 21% and there is a 20% chance that it will exceed +£108 million. 68% of the post-tax EMV distribution lies in the range -£9m. to +£122m. and 95% of the distribution lies in the range -£59m. to +£231m.

Chart 55

WoS - Ongoing (Slow) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	70.82
Median	54.51
Standard Deviation	136.52
Variance	18638.94
Skewness	0.66
Kurtosis	1.16
Coefficient of Variability	1.93
Minimum	-342.60
Maximum	608.99
Range	951.60
Mean Standard Error	4.32
Trimmed Mean (98%)	69.34

Pre-Tax EMV @ 10% - WoS
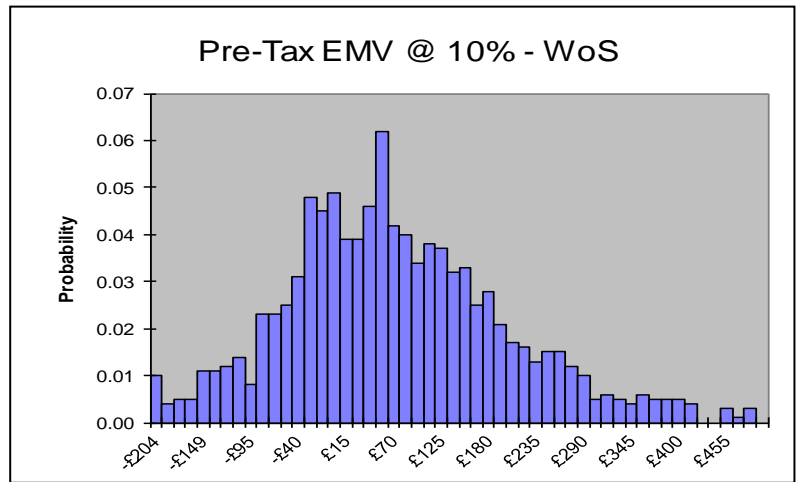
Chart 56

Post-Tax EMV@10% Statistics

Trials	1000
Mean	56.14
Median	45.55
Standard Deviation	72.42
Variance	5245.19
Skewness	0.84
Kurtosis	1.22
Coefficient of Variability	1.29
Minimum	-137.71
Maximum	341.12
Range	478.83
Mean Standard Error	2.29
Trimmed Mean (98%)	55.10
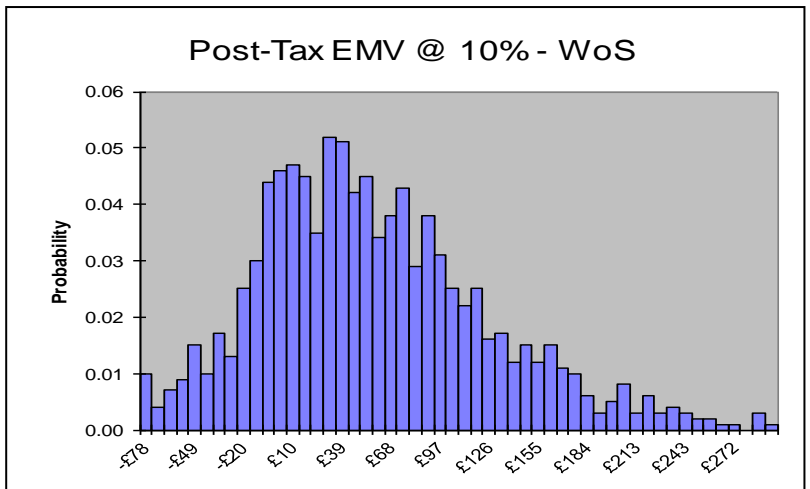


Post-Tax EMV @ 10% - WoS

(d) Project Investor, Slow Cycle Time

i. CNS

The distributions of EMVs for the project investor in the CNS are shown in Chart 57 (pre-tax) and Chart 58 (post-tax). The mean pre-tax value is +£11.8 million and the post-tax value +£6.5 million. There is a 30% chance that the EMV will be negative before tax, and a 10% chance that it will be worse than –£15.8 million. But there is also a 30% chance that the EMV will exceed +£19.5 million and a 20% chance that it will exceed +£28 million. 68% of the pre-tax EMV distribution lies in the range -£10m. to +£32m. and 95% of the distribution lies in the range -£31m. to +£71m. After tax there remains a 30% chance that the EMV will be negative and a 30% chance that it will exceed +£13.3 million. 68% of the post-tax EMV distribution lies in the range -£9m. to +£21m. and 95% of the distribution lies in the range -£30m. to +£41m.

Chart 57

CNS - Project (Slow) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV @10% Statistics

Trials	1000
Mean	11.81
Median	9.58
Standard Deviation	26.08
Variance	679.92
Skewness	1.76
Kurtosis	12.74
Coefficient of Variability	2.21
Minimum	-69.19
Maximum	282.62
Range	351.81
Mean Standard Error	0.82
Trimmed Mean (98%)	11.32
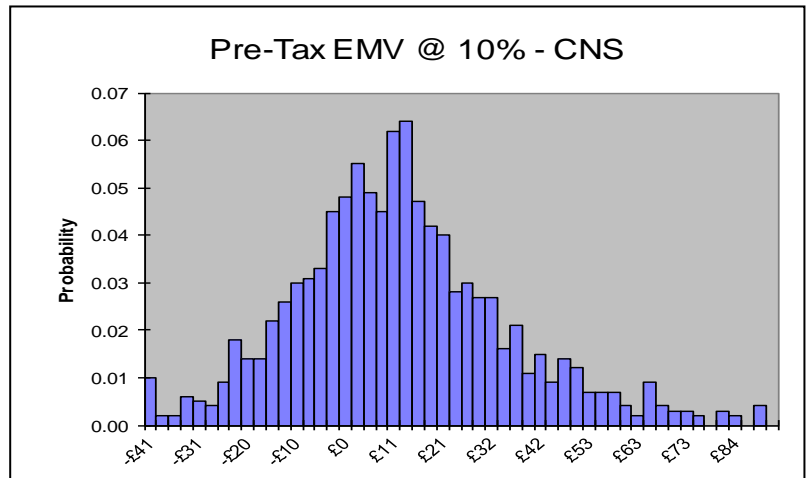
Chart 58

Post-Tax EMV @10% Statistics

Trials	1000
Mean	6.48
Median	6.94
Standard Deviation	17.98
Variance	323.46
Skewness	0.54
Kurtosis	6.20
Coefficient of Variability	2.77
Minimum	-66.99
Maximum	159.32
Range	226.31
Mean Standard Error	0.57
Trimmed Mean (98%)	6.39
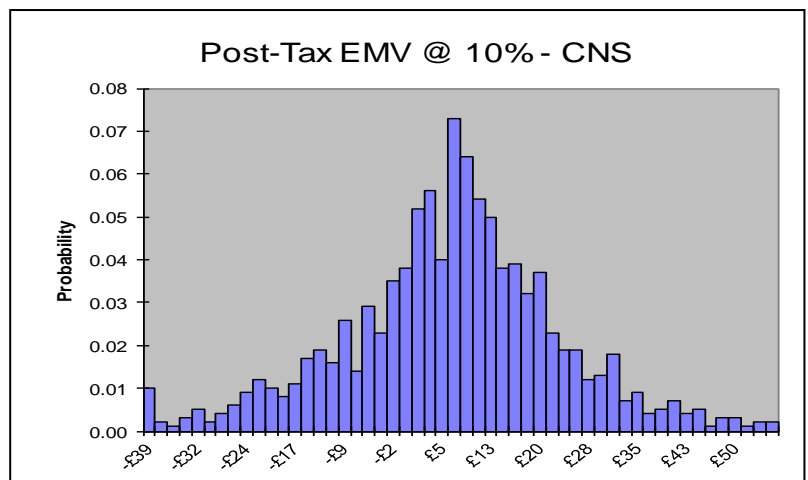
ii.   NNS

The distributions of EMVs for the investor in the NNS are shown in Chart 59 (pre-tax) and Chart 60 (post-tax). The mean values are negative to a modest extent. There is a greater than 56% chance that the EMV will be negative before tax. 68% of the pre-tax EMV distribution lies in the range -£11m. to +£12m. and 95% of the

distribution lies in the range -£23m. to +£31m. After tax the chance of a negative EMV is nearly 56%. 68% of the post-tax EMV distribution lies in the range -£11m. to +£9m. and 95% of the distribution lies in the range -£23m. to +£21m.

Chart 59

## NNS - Project (Slow) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV @10% Statistics	
Trials	1000
Mean	0.07
Median	-1.66
Standard Deviation	13.73
Variance	188.62
Skewness	1.46
Kurtosis	8.88
Coefficient of Variability	210.82
Minimum	-39.44
Maximum	129.71
Range	169.15
Mean Standard Error	0.43
Trimmed Mean (98%)	-0.18

Pre-Tax EMV @ 10% - NNS
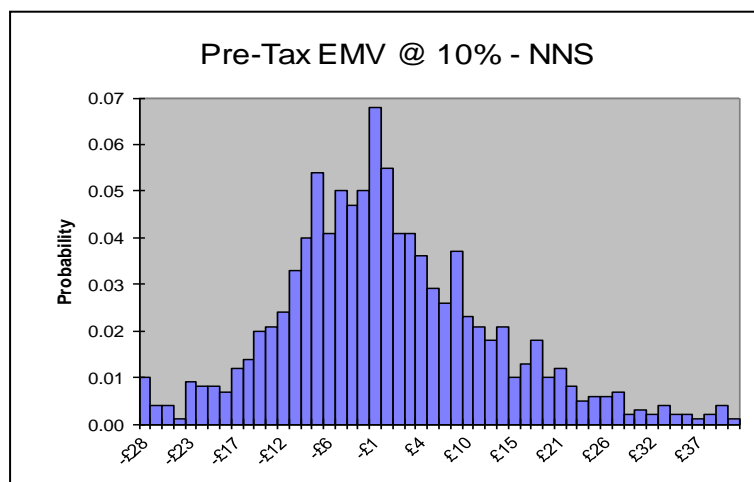
Chart 60

Post-Tax EMV @10% Statistics	
Trials	1000
Mean	-0.93
Median	-1.08
Standard Deviation	10.89
Variance	118.61
Skewness	0.35
Kurtosis	2.73
Coefficient of Variability	-11.66
Minimum	-38.14
Maximum	75.90
Range	114.04
Mean Standard Error	0.34
Trimmed Mean (98%)	-0.99

Post-Tax EMV @ 10% - NNS
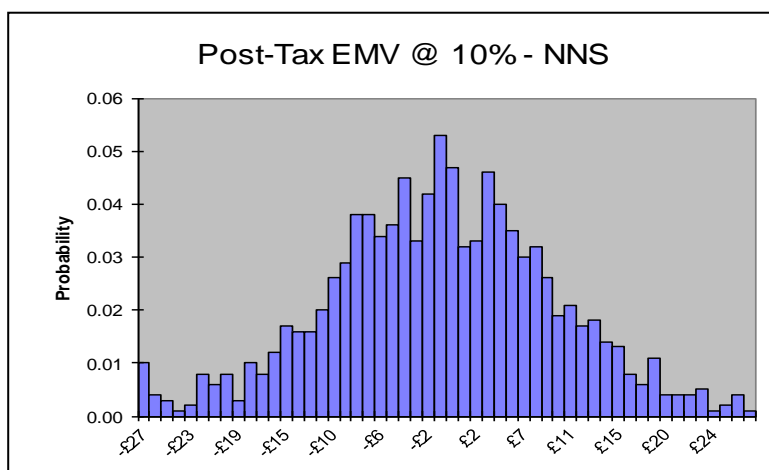
iii.   SNS

The distributions of EMVs for the investor in the SNS region are shown in Chart 61 (pre-tax) and Chart 62 (post-tax). The mean values are negative to a modest extent. The chance of a negative EMV is around 90% before and after tax.   68% of the pre-tax EMV distribution lies in the range -£8m. to -£1m. and 95% of the distribution lies in the range -£13m. to +£3m.   68% of the post-tax EMV distribution lies in the range -£8m. to -£1m. and 95% of the distribution lies in the range -£13m. to +£2m.

Chart 61

SNS - Project (Slow) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	-4.72
Median	-4.43
Standard Deviation	4.05
Variance	16.44
Skewness	-0.28
Kurtosis	3.86
Coefficient of Variability	-0.86
Minimum	-30.42
Maximum	20.84
Range	51.26
Mean Standard Error	0.13
Trimmed Mean (98%)	-4.70

Pre-Tax EMV @ 10% - SNS
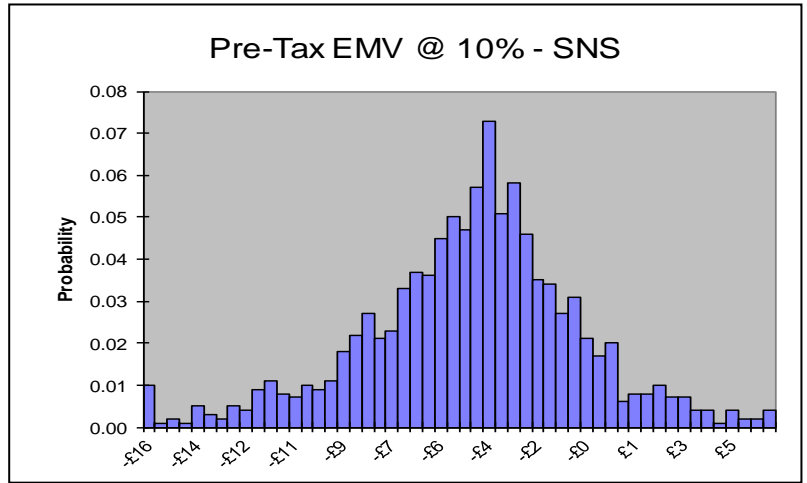
Chart 62

Post-Tax EMV@10% Statistics

Trials	1000
Mean	-4.50
Median	-4.19
Standard Deviation	3.81
Variance	14.51
Skewness	-0.62
Kurtosis	2.81
Coefficient of Variability	-0.85
Minimum	-29.43
Maximum	12.25
Range	41.69
Mean Standard Error	0.12
Trimmed Mean (98%)	-4.45

Post-Tax EMV @ 10% - SNS
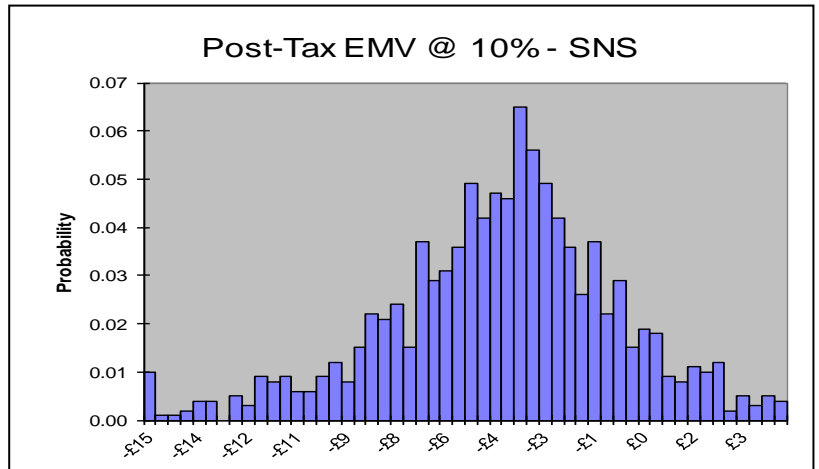
iv.   W of S

The distributions of EMVs for the investor in the W of S region are shown in Chart 63 (pre-tax) and Chart 64 (post-tax). The mean values are healthily positive, exceeding +£68 million before tax and +£33 million after tax. There is a very wide range of outcomes, ranging from –£417 million to +£1.05 billion before tax. There is a less than 29% chance that the pre-tax EMV will be negative, and there is a 50% chance that it will exceed +£58 million. There is also a 30% chance that it will exceed +£117 million, and a 20% chance that it will exceed +£163 million. 68% of the pre-tax EMV distribution lies in the range -£51m. to +£182m. and 95% of the distribution lies in the range -£165m. to +£371m. After tax the chance of a negative EMV is 29%, and there is a 40% chance that the EMV will exceed +£55 million. There is a 20% chance that it will exceed +£98 million. 68% of the post-tax EMV distribution lies in the range -£48m. to +£110m. and 95% of the distribution lies in the range -£162m. to +£215m.

Chart 63

WoS - Project (Slow) - Initial Price $70 p/b and 45p/therm Cost Reduction (£m.)

Pre-Tax EMV@10% Statistics

Trials	1000
Mean	68.60
Median	58.70
Standard Deviation	134.53
Variance	18098.37
Skewness	0.77
Kurtosis	3.62
Coefficient of Variability	1.96
Minimum	-417.22
Maximum	1054.58
Range	1471.80
Mean Standard Error	4.25
Trimmed Mean (98%)	67.21

Pre-Tax EMV @ 10% - WoS
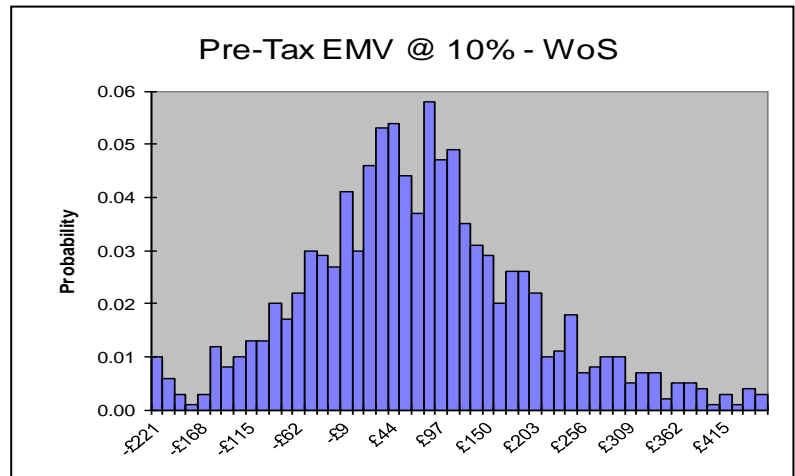
Chart 64

Post-Tax EMV@10% Statistics

Trials	1000
Mean	33.27
Median	37.98
Standard Deviation	92.58
Variance	8570.36
Skewness	-0.21
Kurtosis	2.62
Coefficient of Variability	2.78
Minimum	-408.36
Maximum	590.41
Range	998.77
Mean Standard Error	2.93
Trimmed Mean (98%)	33.59

Post-Tax EMV @ 10% - WoS
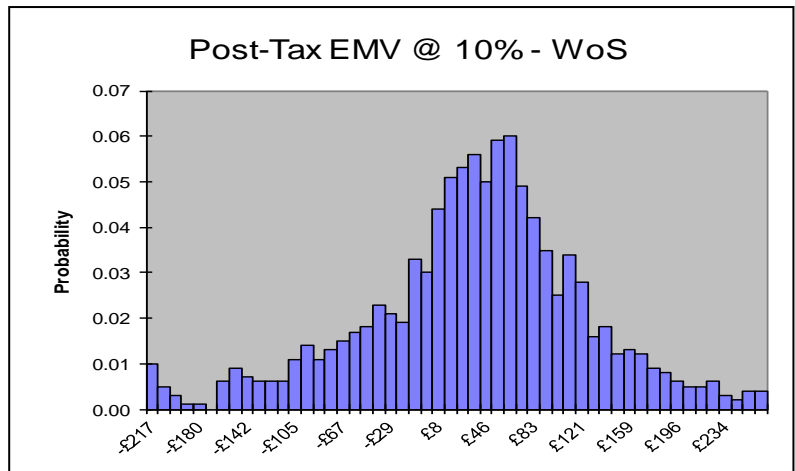
Some key results of the modelling are shown in Table 3 (before cost reduction) and Table 4 (after cost reduction) to permit ready comparisons. Before cost reductions it is seen that the mean EMVs are negative before tax in all the four regions. Further, the chances of a negative EMV are very high before and after tax, varying from over 90% to 47%. With respect to the upside potential it remains low in the CNS, NNS, and SNS. Only in the W of S region is there a significant upside potential. It is also

noteworthy, however that the chance of a very large loss is also high in this region. It is clear from Table 3, that the investor in the W of S region can make a much bigger loss than in the other regions. It is also clear from the results in Table 3 that investors who are in a full tax-paying position at the time of their investments retain a worthwhile advantage over those who do not have tax cover. The latter also face the prospect that they may never obtain relief for unsuccessful exploration. The results show the extent to which the current tax system shares in the losses as well as the gains from exploration investments.

Table 3

Comparative Returns Before Cost Reductions

Tax-Paying Investor, Fast Cycle Time	CNS	NNS	SNS	W of S
Pre-Tax Mean EMV (£m.)	-11.1	-13.1	-11	-35.7
68% EMV range (£m.)	-38 - +14	-27 - +1	-18 - +5	-173 - +106
95% EMV range (£m.)	-68 - +59	-46 - +24	-28 - -0.1	-362 - +300
Chance of negative EMV	67%	82%	97%	60%
30% Chance EMV will Exceed (£m.)	1.25	-6	-7	33
Post-Tax Mean EMV (£m.)	0.7	-2.5	-3.7	7.7
68% EMV range (£m.)	-14 - +14	-10 - +5	-7 - -1	-66 - +81
95% EMV range (£m.)	-28 - +38	-18 - +17	-12 - +2	-152 - +187
Chance of negative EMV Post-Tax	50%	66%	91%	47%
30% Chance EMV will Exceed (£m.)	6.9	0.7	-2	44
Project Investor, Fast Cycle Time				
Post-Tax Mean EMV (£m.)	-12.6	-13	-10.5	-49
68% EMV range (£m.)	-36 - +9	-26 - +0.7	-17 - -4	-165 - +64
95% EMV range (£m.)	-64 - +38	-43 - +16	-27 - +0.2	-356 - +167
Chance of negative EMV Post-Tax	68%	82%	97%	60%
30% Chance EMV will Exceed (£m.)	0.6	-6	-6.5	19
Tax-Paying Investor, Slow Cycle Time				
Pre-Tax Mean EMV (£m.)	-15.3	-18.4	-11.1	-42
68% EMV range (£m.)	-37 - +6	-36 - 17	-16 - -6	-161 - +73
95% EMV range (£m.)	-64 - +44	-47 - +13	-26 - -2	-313 - +152
Chance of negative EMV	77%	92%	99%	64%
30% Chance EMV will Exceed (£m.)	-5.4	-13	-7.7	14
Post-Tax Mean EMV (£m.)	-2.4	-5.7	-4	0.2
68% EMV range (£m.)	-14 - +8	-12 - +0.3	-6 - -2	-59 - +60
95% EMV range (£m.)	-27 - +28	-19 - +11	-11 - +0.5	-131 - +152
Chance of negative EMV Post-Tax	62%	83%	96%	50%
30% Chance EMV will Exceed (£m.)	2.3	-3.2	-2.7	31
Project Investor, Slow Cycle Time				
Post-Tax Mean EMV (£m.)	-15.8	-18	-10.7	-52
68% EMV range (£m.)	-34 - +5	-29 - -6	-16 - -6	-154 - +44
95% EMV range (£m.)	-61 - +22	-45 - +6	-24 - -2	-303 - +123
Chance of negative EMV Post-Tax	78%	92%	98%	66%
30% Chance EMV will Exceed (£m.)	-4.6	-12	-7.5	6

Table 4

Comparative Returns After Cost Reductions

Tax-Paying Investor, Fast Cycle Time	CNS	NNS	SNS	W of S
Pre-Tax Mean EMV (£m.)	20	6.5	-4	97
68% EMV range (£m.)	-9 - +47	-8 - +21	-8 - +0.3	-46 - +245
95% EMV range (£m.)	-27 - +97	-20 - +47	-15 - +6	-189 - +464
Chance of negative EMV	25%	38%	82%	28%
30% Chance EMV will Exceed (£m.)	30	12.1	-1.6	163
Post-Tax Mean EMV (£m.)	16	6.8	-0.3	73
68% EMV range (£m.)	+0.4 - +30	-1 - +15	-2 - +2	-7 - +153
95% EMV range (£m.)	-7 - +57	-6 - +28	-5 - +5	-66 - +274
Chance of negative EMV Post-Tax	14%	22%	59%	18%
30% Chance EMV will Exceed (£m.)	21	10	0.6	107
Project Investor, Fast Cycle Time				
Post-Tax Mean EMV (£m.)	11.25	3.6	-3.6	48
68% EMV range (£m.)	-6 - +28	-7 - +14	-8 - +0.4	-39 - +140
95% EMV range (£m.)	-26 - +55	-18 - +27	-14 - +4	-185 - +256
Chance of negative EMV Post-Tax	24%	35%	81%	28%
30% Chance EMV will Exceed (£m.)	18.6	8.2	-1.4	98.5
Tax-Paying Investor, Slow Cycle Time				
Pre-Tax Mean EMV (£m.)	12.3	0.1	-4.7	71
68% EMV range (£m.)	-11 - +34	-12 - +12	-8 - -1	-48 - +194
95% EMV range (£m.)	-26 - +77	-22 - +35	-14 - +4	-163 - +388
Chance of negative EMV	33%	55%	90%	31%
30% Chance EMV will Exceed (£m.)	20	4.5	-2.9	125
Post-Tax Mean EMV (£m.)	11.1	3	-1	56
68% EMV range (£m.)	-1 - +23	-3 - +10	-2 - +0.5	-9 - +212
95% EMV range (£m.)	-8 - +45	-7 - +22	-5 - +3	-59 - +231
Chance of negative EMV Post-Tax	20%	38%	75%	21%
30% Chance EMV will Exceed (£m.)	15	5.4	-0.3	84
Project Investor, Slow Cycle Time				
Post-Tax Mean EMV (£m.)	6.5	-0.9	-4.5	-33.3
68% EMV range (£m.)	-9 - +21	-11 - +9	-8 - -1	-48 - +110
95% EMV range (£m.)	-30 - +41	-23 - +21	-13 - +2	-162 - +215
Chance of negative EMV Post-Tax	30%	55%	89%	29%
30% Chance EMV will Exceed (£m.)	13.3	4.25	-2.8	72.3

The results in Table 4 generally indicate that reductions of 30% for exploration and appraisal costs and 20% for development and operating costs can change the exploration investment climate to a fairly dramatic

extent. Mean expected EMVs become positive both before and after tax in the CNS, NNS and W of S regions for the investor in a full tax-paying position, but remain negative in the SNS where there is nevertheless a major improvement. For investors not in a tax-paying position the mean EMVs are positive before and after tax for the fast cycle time in the CNS, NNS and W of S regions. The negative values in the NNS (slow cycle time), and SNS are much less than the position before the cost savings. It should be recalled that the modelling assumptions assumed proportionately less cost reductions for exploration and appraisal in the SNS, given the recent behaviour of rig hiring rates suitable for the different regions of the UKCS.

It is also seen from the results in Table 4 that the chances of a negative EMV are greatly reduced in the CNS, NNS and W of S regions as a consequence of the cost savings. The upside potential is also greatly enhanced. In the CNS there is a 30% chance that the post-tax EMV will exceed £21 million for a current tax-paying investor and exceed £18 million for an investor without tax shelter. In the W of S region there is a 30% chance that the post-tax EMV will exceed £107 million for an investor with tax shelter and 30% chance that it will exceed £98 million without tax shelter. It should be emphasised, however, that these results are on the assumption of a fast cycle time from first exploration to production. This may be ambitious for W of S conditions. Under the slow cycle time scenario in that region there is still a 30% chance that the EMV will exceed £84 million for an investor with tax shelter and exceed £72 million for an investor with no tax shelter.

4. Summary and Conclusions

In this paper the prospective pre-tax and post-tax returns facing an explorationist in the UKCS have been examined. The analysis highlights the risks involved in the cycle of activities through the exploration, appraisal, development and production stages. Extensive use is made of the Monte Carlo technique to acknowledge these risks and measure their consequences for the expected returns.

The analysis requires several assumptions to be made regarding the factors which determine the expected returns. Their values vary across the regions of the UKCS and the modelling was conducted separately for the CNS, NNS, SNS and W of S regions. Exploration and appraisal success rates were based on the experience over the past few years. In one scenario modelled exploration, appraisal and development costs were similarly based on the experience of the last several years in the four regions. In the second scenario cost reductions of 30% for exploration and appraisal costs in the CNS, NNS and W of S and 20% in the SNS were modelled. Reductions of 20% in development and operating costs in all four regions were also made for this second scenario. Two cases regarding the cycle time from first exploration to first production (termed fast and slow) were modelled. A range of oil and gas prices was employed with mean values of $70 and 45 pence in real terms.

For the Monte Carlo simulations the size of field which could be discovered in a region of the UKCS was made a stochastic variable. The distribution was modelled as lognormal, with the mean based on experience over the past few years. The standard deviation selected was designed to incorporate the wide range that could be anticipated based on recent experience. Field development costs were also considered as a

stochastic variable. The distribution was taken to be normal with the mean value determined by experience over the past several years. The standard deviation was selected to reflect the range which could be expected. Oil and gas prices were also modelled as stochastic. The mean oil price was set at $70 per barrel in real terms and the gas price at 45 pence per therm. The distributions were set as normal, with the standard deviations chosen reflecting a wide range of possible values for the oil price and a lesser range for the gas price. The behaviour of both prices was taken to be mean-reverting through time.

The modelling was undertaken with two scenarios regarding the tax position of the investor. In the first he is taken to be in a tax-paying position at the time of the exploration and can thus set off his allowances against income from other fields. In the second scenario it is assumed that the investor is not in a tax-paying position at the time of the exploration, appraisal, and development and thus carries forward his allowances to be set against the income from a discovery.

Key findings of the study in the scenario based on costs at levels incurred in recent years are that the mean expected returns at 10% discount rate both before and after tax are generally negative. This is the case with the fast cycle time and the investor being in a full tax-paying position. The chances of the expected returns being negative are very high, ranging from 60% to 97% across the regions pre-tax. The upside potential is very limited, except in the W of S region. But here there is also a notable chance of making a very big loss. As expected the prospective returns are less with the slow cycle time and when the investor is currently not in a tax-paying position. In that event, and with a slow cycle time, the

chances of negative returns range from 66% to 98% across the four regions post-tax.

If reductions in exploration and appraisal costs of 30% (20% in the SNS), plus reductions of 20% in development and operating costs across the four regions are achieved the prospective returns are greatly enhanced. In the fast cycle time case mean expected returns are clearly positive in the CNS, NNS and W of S regions, (but not necessarily sufficiently attractive), though they remain negative in the SNS. The chances of the returns being negative post-tax fall dramatically in the three regions to within a 14%-22% range for the investor in a tax-paying position and to a 24%-35% range for investors not in a tax-paying position. In the SNS the chance of a negative expected return remains high.

When the case with the slow cycle time is considered the mean expected returns for investors in the CNS, NNS and W of S regions remain positive when the investor is in a tax-paying position, but when this is not the case the investor in the NNS faces a small negative mean expected return. Nevertheless, the chances of a negative return in the CNS, NNS and W of S regions are very much lower than in the scenario with higher costs. In the SNS the mean expected return remains negative, with a very high probability that the value will be negative.

The study has been conducted on the basis of the tax system introduced in Budget 2015. It is possible that further tax incentives to exploration could be introduced. These include (1) a refundable tax credit for exploration to be paid to an investor who has no other current income against which to set his allowances, (2) the granting of eligibility of unsuccessful exploration costs for the investment allowance for

Supplementary Charge, (3) the ability to offset the investment allowance against income other than that to which the new investment relates, and (4) the award of interest (as for the Ring Fence Expenditure Supplement) when the investment allowance, though eligible to be activated, cannot in practice be used because the income available to the investor is insufficient to absorb the allowance. These possible incentives and their consequences will be examined in a forthcoming paper.