CHAPTER V

METHODOLOGY

From the literature review in Chapter II, which introduced the methodology on assessing the risk attitude, one of those methods is developed in this study to assess the risk preference of the E&P firm.

There are two mainly methodologies used to estimate the risk preference. First, asking or presenting the decision maker directly with hypothetical questions and second, analyzing from a set of real decisions by analyzing the financial indicators of the firm. The methodology applied in this study is to model the hypothetical investment decisions in the form of questionnaire and then present directly to the decision- maker in the firm. This chapter illustrates the methodology adopted in the research. In this chapter, the assumption, the creation of the questionnaire and the computations are demonstrated in detail.

5.1 The details of the questionnaire

The questionnaire comprises two parts. The first part is the data of the samples. This part needs the samples to specify their job position, the value of the prospect, the probability in both successful and failed outcomes. The second part, the main body of the questionnaire, consists of independently twelve risky investment prospects which are different in probabilities and payoffs with six discrete working interests. The outcome of each prospect leads to success and failure as a final outcome. The value of the outcome is represented in NPV million dollars in order to provide the same comparison unit among the prospects by setting the payoff of the successful outcome as NPV gained and the payoff of failure as the NPV cost of the prospect. Each prospect has six discrete % working interest ranging from 0% to 100% which are 0%, 15%, 25%, 50%, 75% and 100%.

5.2 Sampling

The samples are a group of people in the middle management in E&P firm in Thailand. They are categorized into two groups as the followings:

5.2.1 *Group A* is a group of people in the management level. The personnel in this group experienced in decision making and have the authority to make a decision according to their responsibility in the firm. This group consists of 10 managers with specific budget amount in different department.

5.2.2 *Group B* is a group of people in the technical level. The personnel in this group never experienced in decision making in their normal responsibility and do not have the authority to make a decision in the firm. This group is sampled in order to examine their risk preference behavior since this group is likely to be promoted to the management positions in future. This group consists of 5 analysts, 4 coordinator projects, and 4 engineers.

5.3 Instructions to the samples in test

The samples are presented with twelve risky investment prospects. And then the samples are asked to complete the questionnaire as a corporate decision maker by selecting the preferred working interest participation in each prospect within the given budget. Before completing the questionnaire, the samples are described about the concept of the risk aversion and the objectives of the questionnaire in detail. However, since most people would never sense the distinction between the course of action that a probability of 0.90 of success and another that had of 0.95. Therefore the samples also have to be made clear in this point.

5.4 Assumption

There are extensive studies which have provided strong evidence that the majority of decision makers are risk averse to some degree, so the concave downward preference curves are the most commonly observed in practice (Macmillan, 2000). This concave preference curve can be represented with various mathematical forms as described before in chapter III. Our development is based on the exponential utility function because of its mathematical tractability, the convenient interpretations of degree of risk aversion in the form of risk tolerance parameter, and its common use in practice. Therefore the samples are assumed to have risk aversion preference which can be represented by the exponential utility function.

5.5 Creation of the questionnaire

The methodology of firm's risk tolerance assessment here is adopted from Walls (2005). Walls determined the RT of the group of mangers in E&P firm by using the survey. In this study, the form of the questionnaire is similar to the survey of Walls but the creating method and the computation of RT are totally different. Walls created the questionnaire by imitating the types of risky investment opportunities. The questionnaire of Walls is designed to replicate the types of decisions that the respondent would face. However, how he designed the questionnaire does not know exactly.

In this study, the questionnaire is constructed based on the assumption of exponential utility function. And since the exactly typical projects that the samples face in their normal decision making do not know, so the risky investment projects presented in the questionnaire are modeled based on the assumption of exponential function. The risky project presents to the samples is in a simpler form than the project that the samples deal with in their normal decision making in order to reduce the complications in the thinking of doing the questionnaire.

5.5.1 Setting up the data of the questionnaire

First of all, the budget is set as an average of all samples at 30 million dollars since the sum of loss of all risky projects are created to double approximately of this quantity. Next, the scale of the prospects is set in the range 12.5 – 100 million dollars to cover the range of typical risky projects that the samples would face in their normal decision making. And the probability of success is set in between 0.00 – 0.50 because the risky projects fall in exploration and development phase that the probability of success of the project usually does not exceed 0.50 and the probability of failure is *1-probability of success*. Each risky prospect consists of two outcomes which are success and failure. Figure 5.1 shows the characteristic of the hypothetical investment project presented to the sample.

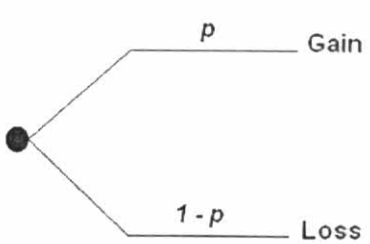

Figure 5.1: The typical risky prospect presents to the sample.

The successful outcome leading to gain certain amount of money whiles the failure leading to lose that cost of the prospect.

5.5.2 Creating questionnaire step by step.

Since the questionnaire is constructed based on the assumption of exponential utility function, so all risky projects presented in the questionnaire are modeled to achieve the concave curve of exponential function. Firstly, we need to set the base prospects to draw the outline of the exponential concave curve, and then the other prospects are modeled to coincide within this preliminary concave curve by setting the probability and payoffs of each prospect within the range that already set before. The successful payoffs are fixed as 12.5, 15, 20, 22, 35, 40, 45, 55, 70, 80, 90,100 million dollars within the range that we set before (12.5 – 100 million dollars).

The first three base prospects are set as a base prospect to obtain the preliminary concave curve by selecting the successful payoff as 12.5, 55, and 100 million dollars as the smallest, medium and largest value of success. And then the probability of success and cost of failure of each successful payoff are varied to give the utility values which when plotting the utility curve result in a concave curve of exponential utility function. The first three base prospects are shown in Table 5.1.

Table 5.1: The data of the three base prospects.

Base Prospect	NPV of Success	Cost of Failure	Probability of Success
A	12.5	-2.5	0.50
B	55	-20	0.50
C	100	-5	0.20

After that, the utility curve of those three base prospects are plotted by calculating the utility values of those base prospects. Since the exponential utility curve is the plot between x_i versus u (x_i) so the value of u (x_i) needs to be computed (from equation 5.2). In order to calculate u (x_i), the RT value is needed. That RT is computed from equation 5.1.

$$CE = -RT \ln\left(\sum_{i=1}^{n} p_i e^{-x_i \cdot WI/RT}\right) \qquad (5.1)$$

$$U(x_i) = RT(1-\exp^{-x_i WI/RT}) \quad (5.2)$$

Base prospect *A* is taken as an example to demonstrate the calculations of RT and CE. At certain working interest, the payoffs and the probabilities of the prospect *A* are plugged in equation 5.1 to compute RT value which gives the highest CE value. The RT is varied until obtaining the RT that yields the highest CE value since the risk aversion decision maker making a decision by maximizing CE value. By this method, the RT and CE are obtained (at certain working interest). Table 5.2 illustrates the RT and CE calculations of prospect *A*. We can see that at each selected % working interest, we obtain the CE and RT value which corresponds to the selected working interest. For example, if the respondent decides to invest in prospect *A* with 75% WI, he values this risky prospect equal to 1.6981 million dollars in his mind and his RT of this prospect at selected 75 %WI equal to 7 million dollars. Therefore we will obtain the RT and CE for each selected %WI of all chosen twelve risky prospects.

Table 5.2: The CE and RT calculations of base prospect A.

	A	B	C	H	M	R	W	AB	AG	AL	AQ	AV	BA	BF	BK	BP	BU	BZ	CE	CJ	CO
1		CE and RT calculations																			
2		Base prospect A																			
3		POS		0.50																	
4		POF		0.50																	
5		NPV of Success		12.5 $mm																	
6		NPV of Failure		-2.5 $mm																	
7																					
8		WI	CE when RT equal																		
9			9.5	8.8	8.4	7.9	7.4	7	6.5	6.05	5.6	5.1	4.7	4.2	3.7	3.3	2.8	2.3	1.9	1.4	0.9
10		100%	2.3019	2.1293	2.0203	1.8734	1.7136	1.5755	1.3890	1.2067	1.0097	0.7726	0.5684	0.2948	0.0010	-0.2475	-0.5724	-0.9091	-1.1837	-1.5296	-1.8762
15		95%	2.2965	2.1347	2.0334	1.8966	1.7473	1.6179	1.4424	1.2703	1.0834	0.8573	0.6614	0.3974	0.1118	-0.1313	-0.4514	-0.7854	-1.0591	-1.4046	-1.7512
20		90%	2.2802	2.1312	2.0377	1.9111	1.7725	1.6520	1.4880	1.3265	1.1503	0.9359	0.7492	0.4957	0.2196	-0.0173	-0.3317	-0.6622	-0.9346	-1.2797	-1.6262
25		85%	2.2546	2.1184	2.0327	1.9164	1.7887	1.6773	1.5251	1.3745	1.2096	1.0077	0.8308	0.5891	0.3235	0.0938	-0.2135	-0.5397	-0.8103	-1.1547	-1.5012
30		80%	2.2193	2.0958	2.0179	1.9119	1.7951	1.6929	1.5528	1.4136	1.2604	1.0718	0.9055	0.6767	0.4230	0.2016	-0.0975	-0.4182	-0.6865	-1.0299	-1.3762
35		75%	2.1738	2.0628	1.9926	1.8968	1.7910	1.6981	1.5703	1.4428	1.3018	1.1271	0.9722	0.7573	0.5168	0.3050	0.0159	-0.2980	-0.5631	-0.9050	-1.2512
40		70%	2.1177	2.0189	1.9562	1.8706	1.7757	1.6921	1.5768	1.4612	1.3326	1.1726	1.0296	0.8299	0.6041	0.4032	0.1257	-0.1796	-0.4406	-0.7804	-1.1262
45		65%	2.0505	1.9636	1.9083	1.8326	1.7485	1.6742	1.5713	1.4676	1.3519	1.2069	1.0766	0.8930	0.6834	0.4948	0.2310	-0.0637	-0.3192	-0.6559	-1.0012
50		60%	1.9718	1.8963	1.8482	1.7822	1.7086	1.6434	1.5528	1.4612	1.3585	1.2289	1.1117	0.9453	0.7532	0.5783	0.3305	0.0487	-0.1996	-0.5319	-0.8762
55		55%	1.8812	1.8167	1.7754	1.7187	1.6553	1.5990	1.5205	1.4409	1.3510	1.2372	1.1334	0.9850	0.8117	0.6520	0.4225	0.1564	-0.0826	-0.4085	-0.7513
60		50%	1.7783	1.7241	1.6894	1.6415	1.5879	1.5402	1.4734	1.4054	1.3284	1.2301	1.1401	1.0101	0.8568	0.7138	0.5049	0.2577	0.0306	-0.2862	-0.6264
65		45%	1.6627	1.6181	1.5895	1.5500	1.5057	1.4661	1.4106	1.3537	1.2892	1.2064	1.1300	1.0189	0.8863	0.7610	0.5752	0.3501	0.1383	-0.1658	-0.5017
70		40%	1.5340	1.4982	1.4753	1.4436	1.4079	1.3759	1.3310	1.2848	1.2322	1.1643	1.1013	1.0089	0.8975	0.7910	0.6302	0.4308	0.2379	-0.0487	-0.3773
75		35%	1.3919	1.3642	1.3464	1.3217	1.2939	1.2689	1.2338	1.1975	1.1561	1.1023	1.0522	0.9781	0.8878	0.8005	0.6663	0.4958	0.3257	0.0629	-0.2538
80		30%	1.2360	1.2154	1.2022	1.1838	1.1631	1.1445	1.1181	1.0909	1.0597	1.0190	0.9808	0.9241	0.8543	0.7859	0.6792	0.5402	0.3969	0.1652	-0.1322
85		25%	1.0662	1.0517	1.0425	1.0296	1.0150	1.0018	0.9832	0.9640	0.9418	0.9128	0.8855	0.8447	0.7940	0.7437	0.6642	0.5579	0.4448	0.2524	-0.0150
90		20%	0.8821	0.8728	0.8668	0.8584	0.8490	0.8405	0.8284	0.8159	0.8015	0.7825	0.7646	0.7377	0.7039	0.6702	0.6161	0.5421	0.4608	0.3151	0.0923
95		15%	0.6835	0.6783	0.6749	0.6702	0.6648	0.6600	0.6531	0.6460	0.6377	0.6269	0.6166	0.6011	0.5815	0.5618	0.5298	0.4852	0.4348	0.3396	0.1778
100		10%	0.4704	0.4681	0.4666	0.4645	0.4621	0.4599	0.4568	0.4536	0.4499	0.4451	0.4404	0.4334	0.4245	0.4155	0.4007	0.3798	0.3557	0.3080	0.2181

Then that RT which yields the greatest CE combined with payoffs of the prospect *A* at selected working interest, let's say at 75%, are plugged in equation 5.2 to compute a utility value.

Therefore, by the method demonstrated above, we obtain the values of CE, RT and u (x_i) at each selected working interest of all prospects. The utility values of all three base prospects are shown in Table 5.3.

Table 5.3: The utility values of the base prospects.

Base Prospect	Payoff	Probability	RT at 75% WI	U (x_i)
A	12.5	0.50	7	5.1658
	-2.5	0.50		-2.1501
B	55	0.50	55.51	29.1059
	-20	0.50		-17.2227
C	100	0.20	49	38.3562
	-5	0.80		-3.8972

After obtaining the utility value of all three base prospects, the preliminary exponential utility curve of those base prospects is plotted. Figure 5.2 shows the preliminary utility curve of those base prospects.

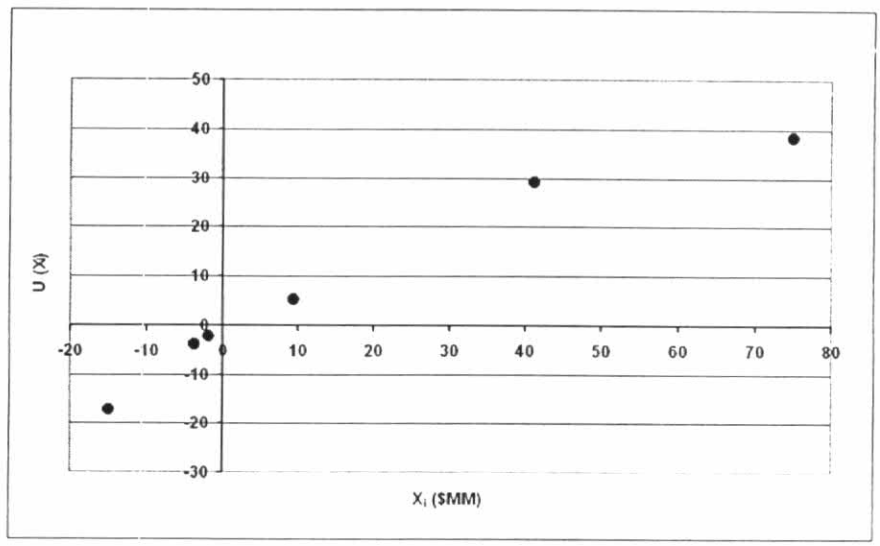

Figure 5.2: The preliminary exponential utility curve of three base prospects.

After the base prospects are set, we achieve the outline of the exponential utility curve. The rest of the prospects are modeled to contain within this outline curve by varying the value of failure or in some cases the probability of success of the prospects at each fixed successful outcome which we already set at the beginning until the concave utility curve of all modeled prospects are achieved.

Table 5.4 illustrates the summary of all twelve created prospects of the questionnaire.

Table 5.4: The complete twelve risky projects of the questionnaire.

Prospect	Value of Success (MM$)	Value of Failure (MM$)	Probability of Success	Probability of Failure
1	12.5	-2.5	0.50	0.50
2	15	-2.5	0.20	0.80
3	20	-7.5	0.40	0.60
4	22	-7.5	0.25	0.75
5	35	-15	0.50	0.50
6	40	-11.5	0.35	0.65
7	45	-5	0.20	0.80
8	55	-20	0.50	0.50
9	70	-5	0.15	0.85
10	80	-7.5	0.20	0.80
11	90	-8	0.25	0.75
12	100	-5	0.20	0.80

At this point the complete questionnaire is already designed which when we plot the utility curve of all created prospects at each working interest, we will obtain the utility curves as shown in Figure 5.3 (the summary of RT, CE and u (x_i) values of all twelve created prospects are summarized in APPENDIX B).

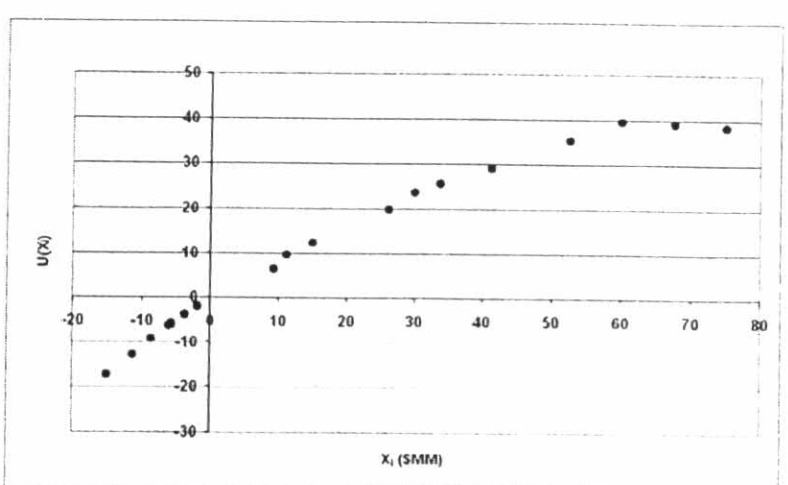

Figure 5.3: The exponential utility curves of the created questionnaire.

It is noted that the utility curve shown in Figure 5.3 is the plot of 75 %WI. The utility curve of other working interests can be plot in the same way as described above. Those utility curves at different working interests when plotted, have the same shape as the utility curve of 75 %WI except that the slope is changed. That is how the questionnaire is designed in this study. The questionnaires of both groups (Group A and B) are in the same format but the scale and the probabilities of the projects are different.

5.6 Calculations of risk tolerance (RT) and consistency measure (CM)

5.6.1 Calculation of Risk Tolerance (RT)

After obtaining the replied questionnaire from the respondents, the RT and CM values of each sample are computed. The calculation of RT here is totally different from Walls (2005). According to Walls, the RT is computed by calculating the central tendency of all RT values obtained from each selected %WI of the prospects to represent the RT value of the respondent. But in this study the RT is determined by plotting the preference curve of each respondent, and then the RT is determined from that curve fitting to the exponential utility model. By this method we obtained the preference curve to represent the risk attitude of each respondent with the RT value which represent the degree of risk aversion of the respondent and also the degree of curvature of the exponential utility curve. An example of calculating RT is demonstrated with replied questionnaire from sample B3. Figure 5.4 is the replied questionnaire while Table 5.5 is the results from the replied questionnaire of sample B3.

Prospect	Outcome	Probability	Value of Outcome (millions dollar)	Choice (Participation Level)					
1	Success	0.15	70	100%	75%	50%	25%	15%	0%
	Failure	0.85	-5						
2	Success	0.25	22	100%	75%	50%	25%	15%	0%
	Failure	0.75	-7.5						
3	Success	0.50	35	100%	75%	50%	25%	15%	0%
	Failure	0.50	-15						
4	Success	0.20	15	100%	75%	50%	25%	15%	0%
	Failure	0.80	-2.5						
5	Success	0.20	45	100%	75%	50%	25%	15%	0%
	Failure	0.80	-5						
6	Success	0.50	55	100%	75%	50%	25%	15%	0%
	Failure	0.50	-20						
7	Success	0.20	100	100%	75%	50%	25%	15%	0%
	Failure	0.80	-5						
8	Success	0.40	20	100%	75%	50%	25%	15%	0%
	Failure	0.60	-7.5						
9	Success	0.25	90	100%	75%	50%	25%	15%	0%
	Failure	0.75	-8						
10 *	Success	0.50	12.5	100%	75%	50%	25%	15%	0%
	Failure	0.50	-2.5						
11	Success	0.35	40	100%	75%	50%	25%	15%	0%
	Failure	0.65	-11.5						
12	Success	0.20	80	100%	75%	50%	25%	15%	0%
	Failure	0.80	-7.5						

Figure 5.4: The replied questionnaire of sample B3.

Table 5.5: Results of replied questionnaire of sample B3.

Prospect	B3. Analyst						
	x_i	p_i	WI	RT	$U(x_i)$	CE	EU
1	70 -5	0.15 0.85	25%	21.0	11.8734 -1.2880	0.6977	0.6863
2	22 -7.5	0.25 0.75	0%			0.0000	
3	35 -15	0.50 0.50	0%			0.0000	
4	15 -2.5	0.20 0.80	0%			0.0000	
5	45 -5	0.20 0.80	25%	15.5	7.999 -1.302	0.5687	0.558
6	55 -20	0.50 0.50	75%	55.5	29.106 -17.223	6.284	5.942
7	100 -5	0.20 0.80	50%	32.5	25.5219 -2.5987	3.1757	3.0254
8	20 -7.5	0.40 0.60	0%			0.0000	
9	90 -8	0.25 0.75	50%	37.0	26.0351 -4.2242	3.5011	3.3406
10 *	12.5 -5	0.50 0.50	25%	4.8	2.2968 -1.4279	0.4554	0.4345
11	40 -11.5	0.35 0.65	0%			0.0000	
12	80 -7.5	0.20 0.80	25%	22.0	13.1364 -1.9572	1.0880	1.0615
RT	37.56						
CM	0.50						

- The CE column is the CE values of each selected %WI of each prospect calculating from equation 5.1.

- The U (x_i) column is the utility values of each selected %WI of each prospect computed from equation 5.2.
- The EU is the expected utility values of each selected %WI of each prospect which are computed from equation: $EU = \sum p_i u(x_i)$

With selected % working interest, the implied RT and CE at that selected WI of the project are assessed. It is noted that in the case of chosen 100 %WI, this causes an unbounded solution. We cannot specify the exact value of RT in this case since the respondent is 100% sure in that project with fearless to the money he would lose if that project fails. In this case the solution is bounded by increasing the amount of loss in the prospects that the respondent selected 100 %WI until he changed his choice to a bounded solution. In this case, sample B3 selected 100 %WI in prospect 10, so the failed payoff of this prospect increased to -5 million dollars and then sample B3 changed his mind to participate only 25 %WI in this prospect. Therefore, the RT, CE and u (x_i) are calculated based on this changed payoff of the prospect.

And in the case of 0 %WI, this causes a value of CE equal zero. This can be illustrated by considering the following calculation of selected 0 %WI in prospect 2.

$$
\begin{aligned}
CE &= -RT \ln\left(\sum_{i=1}^{n} p_i \, e^{-x_i WI/RT}\right) \\
&= -RT \ln\left[(0.25 e^{-22 \times 0\%/RT}) + (0.75 e^{7.5 \times 0\%/RT})\right] \\
&= -RT \ln\left[(0.25 e^{0}) + (0.75 e^{0})\right] \\
&= -RT \ln\left[(0.25 \times 1) + (0.75 \times 1)\right] \\
&= -RT \ln(1) \\
&= 0
\end{aligned}
$$

Evidently, selected 0% causes CE equal zero. However, in this case we cannot determine the RT since the sample does not participate in this project.

Next, a preference curve of the sample is modeled by fitting the results from the replied questionnaire to the exponential utility function by means of nonlinear regression technique. The risk preference curve of B3 is drawn by plotting the values of x_i versus u (x_i) and CE versus EU in the same graph as the risk aversion utility curve shown in Figure 3.4 in chapter III. There are many available programs in the market used to perform the data fitting. In this study, we utilize the SOLVER function

of Excel program as a tool to do the nonlinear regression fitting exponential model. The SOLVER function can fit data with nonlinear functions by employing an iterative least squares fitting routine to produce the optimal goodness of fit between data and function. The SOLVER (Brown, 2001) fits the data with the exponential utility function model which has the mathematical form defined before (equation 5.2) by determining the value of RT fits with the data. Figure 5.5 is the curve fitting of sample B3 with SOLVER function (actually, the nonlinear regression of SOLVER technique is verified with the DATAFIT program to assure the results from SOLVER method. The results from both methods are really close together).

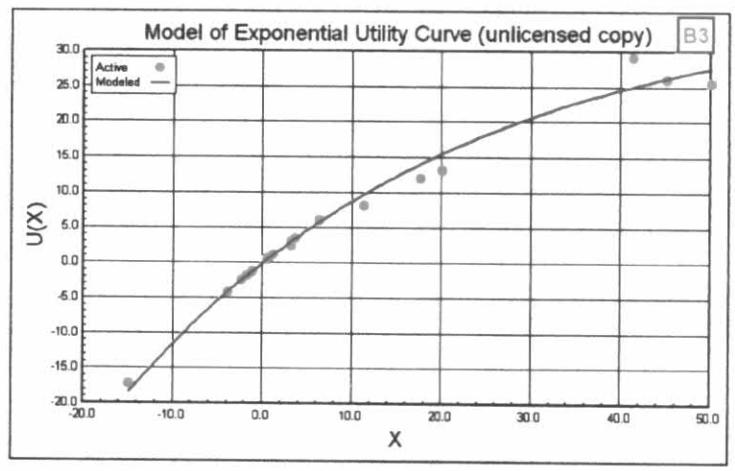

Figure 5.5: The fitted curve of the exponential utility model of the sample B3.

Therefore, the preference curve[1] of the sample is drawn by curve fitting model with exponential utility function. Then the result of RT, which is assessed by curve fitting method, is 38 million dollars. However, by using Walls' method, the value of RT is computed by calculating the central tendency of all RT values obtained from selected WI of each selected prospect. The RT calculated from Walls' method is 22 million dollars. The values of RT determined from these two methods are relatively quite different. However, Walls' method is kind of an average way which is based on

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[1]The preference curves of all respondents are shown in APPENDIX C.

linear algorithm but in this study the RT is determined based on the exponential utility model which is a concave curve.

5.6.2 Calculation of Consistency Measure (CM)

The CM is calculated to determine how a person can preserve in his financial risk taking. The CM is similar to a statistical term known as a coefficient variation. It is a measure of a dispersion of data points around the mean calculated from standard deviation divided by mean. Since in this study the RT is assessed from the curve fitting method, therefore we utilized that RT value to compute CM rather than using mean RT. The CM can be used to compare the degrees of variation of RT values to compare the relative consistency in risk-taking by the respondents in this study. The CM in this study is calculated as follows:

$$CM = \frac{SD\ of\ RT\ (from\ curve\ fitting)}{RT\ (from\ curve\ fitting)} \tag{5.3}$$

From sample B3, the standard deviation of RT is 18.61 and the RT from nonlinear regression is 38 million dollars, therefore the CM is approximate 0.50. The calculation of CM in this study is quite similar to Walls's, except that the RT is acquired from the curve fitting and then utilized in equation 5.3 to compute CM value rather than using the mean RT in the Walls's method.

In summary, the questionnaire is created to determine RT of the samples in E&P firm as well as their CM. The questionnaire is constructed based on the assumption of exponential utility function. The samples divided into two groups which are the group of managers and the group of analysts, coordinators and engineer. In term of decision making, group B has never experienced nor has authority in making a decision. This is some limitations of sampling. However, we can think of this group in term of future potentiality of being a manager in advance. The questionnaire consists of twelve risky prospects with six discrete %working interests. Of each selected % working interest participation in each prospect, the RT and CE of each selected working interest in the selected prospects are obtained. And then the RT of each sample is assessed by fitting the preference curve to the exponential utility function. The results are modeled to the exponential utility curve by utilizing

SOLVER function to do the nonlinear regression model. Finally, the CM is computed from the standard deviation of *RT* divided by the *RT* determined from curve fitting. Therefore, the next chapter concentrates on the results of study which are the risk tolerance and consistency measure of the groups of samples in E&P firm.