AAPG International Conference
Barcelona, Spain
September 21-24, 2003

Iubatan Antonio Pinto[1], Saul B. Suslick[2], Ricardo Furtado[3] (1) Petrobras S/A, Rio de Janeiro, Brazil (2) State University of Campinas - Unicamp, Campinas, Brazil (3) State University of Campinas, Campinas, Brazil

An Appraisal of Corporate Risk Tolerance in the Oil Exploration and Production

Abstract

The petroleum industry uses several financial techniques to evaluate the corporate risk tolerance in an exploration portfolio due to the high level of oil prices volatility and the consequent possibility of high capital losses. One of the main techniques used for decision analysis is based on the preference theory, which involves the probability of success, the total exploration costs, potential earnings, among other criteria. This method provides the best participation level for each project of the portfolio considering the firm risk policy and investment ability. In this paper a set of financial performance indicators is used to identify the behavior of risk tolerance for different groups of E&P firms in the 1991-2000 period. The main indicators used are exploration budget, rate of exploratory success, number of exploratory wells, reserve additions, and NPV/boe. The selection of firms is based upon their international oil market share and their participation in the bidding exploration process in the new offshore frontiers (Brazil, West Africa, etc.). The results indicate that risk tolerance shows a downward trend with a positive correlation with cost reductions and an upward trend with a positive correlation with reserve additions. The application of multivariate cluster analysis for all set of operational and financial indicators depicted three groups of firms - majors integrated firms, E&P business oriented, and independent firms - reproducing their size and investment strategy in the oil upstream ventures.

Introduction

Much effort has been devoted in recent years to quantify risks in the petroleum industry. The motivation is obvious, since the measurement and management of risks are critical to the success of oil and gas exploration firms in the competitive and uncertain petroleum market. The petroleum exploration process involves a set of steps and categories that became a reference for the application of decision analysis. One of the great tasks faced by of the majority oil exploration managers is the question of choosing an appropriate measure of risk-taking behavior for the firm and the effects of this choice on firm performance. Considering the differences between exploration investment opportunities in their magnitudes and peculiarities, it is important for managers to be consistent in evaluating the risk-bearing projects.

The use of modern tools such as stochastic analysis and a real option to model uncertainty and to value risky projects demonstrates the importance of risk evaluation and management by the oil firms. Despite important progress created by these for risk management and evaluation, little is known about the firm performance and risk strategy in oil exploration. Studies of risky choice within organizations show that firms display a significant degree of risk aversion. Studies of risk preference among oil industry pointed out that approximately 50% of the responses of the oil executives interviewed were fully consistent with the preference theory and an additional quarter of the executives were within a 10% margin of error (Dougherty and Sarkar, 1993).

In this paper an empirical evaluation of a sample of 17 major and independent oil companies was used to estimate the relationship between risk tolerance, several indicators of risk and business performance, such as exploration budget, rate of exploratory success, number of exploratory wells, reserve additions, NPV/boe, as well as other financial and operational variables. The selection of the firms is based upon firm's international oil market share and participation in the bidding exploration process in the new offshore frontiers (Brazil, West Africa, etc.).

Table 1 – Summary of the main variables used for estimation of Risk Tolerance: Company Petrobras

Variables	1993	1994	1995	1996	1997	1998	1999	2000
Exploration Budget (US$ million)	351.40	337.53	368.93	338.36	419.73	512.37	304.92	440.00
Annual Revenue (US$ billion)	25.07	21.33	23.10	26.01	26.02	23.57	23.30	35.49
Net Profits (US$ million)	1,009.37	2,025.27	662.13	701.31	1,473.09	1,251.88	1,015.01	5,342.00
Reserves (MMboe)	3,888.15	4,093.98	4,898.80	6,801.36	9,038.61	8,114.07	9,402.82	9,366.82
Production (10^3boe/d)	798	829	857	969	1,102	1,249	1,416	1,581
Reserve / Production (yrs)	13.35	13.53	15.66	19.23	22.47	17.80	18.19	16.23
Reserve Addition (MMboe)	200.44	205.84	804.82	1,902.56	2,237.25	0	1,288.75	0
Success Rate (%)	28	37	38	39	33	33	28	22
NPV (US$/boe)	5.76	5.80	5.98	3.22	2.73	-0.55	4.53	-12.22
RT (MM US$)	84.19	75.75	72.57	71.00	79.88	82.41	86.69	104.15

Corporate Risk Tolerance in E&P

Recent surveys showed that the net present value (NPV) and internal rate of return (IRR) criteria are the most used methods for project evaluation by oil firms (Dougherty and Sarkar, 1993). Despite its simplicity, the NPV and IRR rules present serious deficiencies in the valuation process. These methods present inappropriate separation between risk discounting and time value discounting and they had inconsistencies with respect to risk and valuation for projects having different durations. The expected-value concept, which weights financial outcomes by their probabilities, is another criteria that has been used extensively by many explorationists as a measure of risk. However, using EMV implies that the decision maker is totally indifferent to magnitudes to potential profits or losses exposed to risk.

The preference theory is an extension of the expected-value concept in which the firm's attitude towards money is incorporated in a decision model (Pratt, 1964). This approach provides a consistent mean of expressing the firm's attitude on risky projects using a utility function. One functional form that is used very frequent in the oil exploration is the exponential utility function, $u(x) = -e[-x/RT]$, where x is the variable of interest, RT is the risk tolerance level and e is the exponential constant. An RT value $< \infty$ implies risk-averse behavior and RT $> \infty$ implies risk-seeking behavior, and c approaching zero implies risk-neutral behavior. The certainty equivalent (C_{eq}) is equal to the expected value less a risk discount, known as the risk premium. The C_{eq} is the cash value attribute to a decision alternative that involves uncertain outcome.

Walls and Dyer (1996) assumed that past decisions involving budget allocations in risky projects could be employed for estimation of Ceq, because the majority of oil firms have ex-ante knowledge (objective or subjective) of all possible outcome returns and probabilities. Based upon that approach the risk tolerance (RT) can be expressed in the case of normal distribution of project returns and an exponential utility function:

$$RT = \frac{\sigma^2}{2(EMV - C_{eq})}$$

Where, RT represents the firm's risk tolerance, Ceq is the certainty equivalent, EMV expected monetary value of the distribution that can be estimated through the NPV of reserves addictions, and σ^2 the variance of average NPV.

The use of constant risk tolerance could provoke some systematic errors according to the classical investment risk theory. However, the use of other theories, such as the "S" shaped utility function it treats "loss" and "gain" domains

Table 2 – Risk tolerance level (values expressed in US$ million)

Firms	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Amerada Hess	na	6.52	6.60	4.71	4.69	5.21	6.13	7.60	6.61	5.38	4.82
Arco	na	92.47	48.70	45.73	71.63	40.94	29.49	28.34	24.96	18.98	15.35
Chevron	12.62	11.83	10.40	6.71	5.46	5.68	4.49	5.23	5.39	5.45	5.66
Coastal	na	na	28.64	27.57	49.51	36.02	30.44	23.86	26.29	23.70	na
Enterprise Oil	na	na	na	na	91.00	87.66	65.57	107.43	108.15	90.80	85.79
ExxonMobil	na	167.71	46.92	29.38	24.41	22.31	21.81	21.55	21.80	27.19	19.94
Imperial Oil	na	0.00	0.00	60.70	46.53	37.83	40.34	32.55	21.23	17.05	16.95
Kerr McGee Oryx	na	81.67	54.83	42.65	37.86	49.24	38.17	38.68	36.03	62.41	34.06
Marathon	na	20.50	17.63	14.25	15.79	17.19	14.88	16.40	25.89	14.32	na
Occidental Petro.	na	0.00	142.74	87.36	75.55	62.63	64.31	65.20	82.19	102.58	na
Pan Canadian	2.09	2.91	2.82	3.35	2.90	2.06	1.85	1.67	1.57	1.71	1.35
Petrobras	na	na	na	84.19	75.75	72.57	71.00	79.88	82.41	86.69	104.15
Phillips	na	143.24	53.67	34.24	35.21	34.43	43.20	91.66	277.22	28.89	14.87
Repsol-YPF	na	na	31.79	23.53	23.35	23.57	23.19	23.70	23.45	33.31	na
Shell	66.19	60.37	66.05	52.27	57.09	42.47	44.14	38.95	47.58	49.17	48.12
Texaco	na	38.25	29.71	18.14	19.97	19.17	15.73	15.22	17.77	22.35	22.25
Unocal	na	-28.48	-41.35	34.13	24.34	17.77	16.91	19.30	18.33	14.99	12.91

(na): values not estimated

separately - is not worth because it needs detailed project data and analyzes each project alone, what disagrees with the Portfolio Theory. The risk taking behavior parameter, as risk tolerance, provides an useful way of measuring financial risk, once it models the behavior of the firms against potential capital losses and do not disagree with Portfolio Theory ("risk spreading").

Modeling Approach of Risk Tolerance

The methodology for estimation of risk propensities among the oil firms employed in this paper was based on a study developed by Walls and Dyer (1996) and Nepomuceno and Suslick (2000). A sample of 17 oil firms was used to cover a ten-years period (1990-2000). The firms included in the sample are the following: Chevron, Shell, Coastal, Texaco, Amerada Hess, Pan Canadian, Kerr McGee Oryx, ExxonMobil, Repsol-YPF, Petrobras, Occidental Petrolleum, Imperial Oil, Marathon, Arco, Phillips and Unocal. This selection of the firms is based upon their international oil market share and their participation in the bidding exploration process in Brazil. Some companies are included in the sample due to their participation in the new offshore frontiers such as West Africa that could bring new insights for risk tolerance for these regions. The source of the data was originated from public information obtained from annual reports, SEC reports, and from *Oil and Gas Journal*. Data from firms that are merging with other companies are weighting with their respective participation. Table 1 shows the main input variables in the period 1993-2000 for Petrobras.

The main input variables and estimated parameters used for risk tolerance evaluation are presented below:

Input Variables	Estimated Parameters
	E. NPV/BOE
A. Exploration Budget [MM US$]	F. NPV addition [D x E]
B. Rate of exploratory success [%]	G. Adjusted NPV [F/B + A]
C. Number of exploratory wells	H. Average NPV/Well (MM US$)
D. Reserve Addition [MM BOE]	I. Average NPV [B x C x H] = EMV
	J. Variance [((C(1 - B)B)1/2)H]2 (x 10-9) = σ^2
	K. Exploratory Budget [A] (MM US$) = C_{eq}

Results

Table 2 provides a summary of risk tolerance level. The ranking is based upon top ten companies using the year 2000

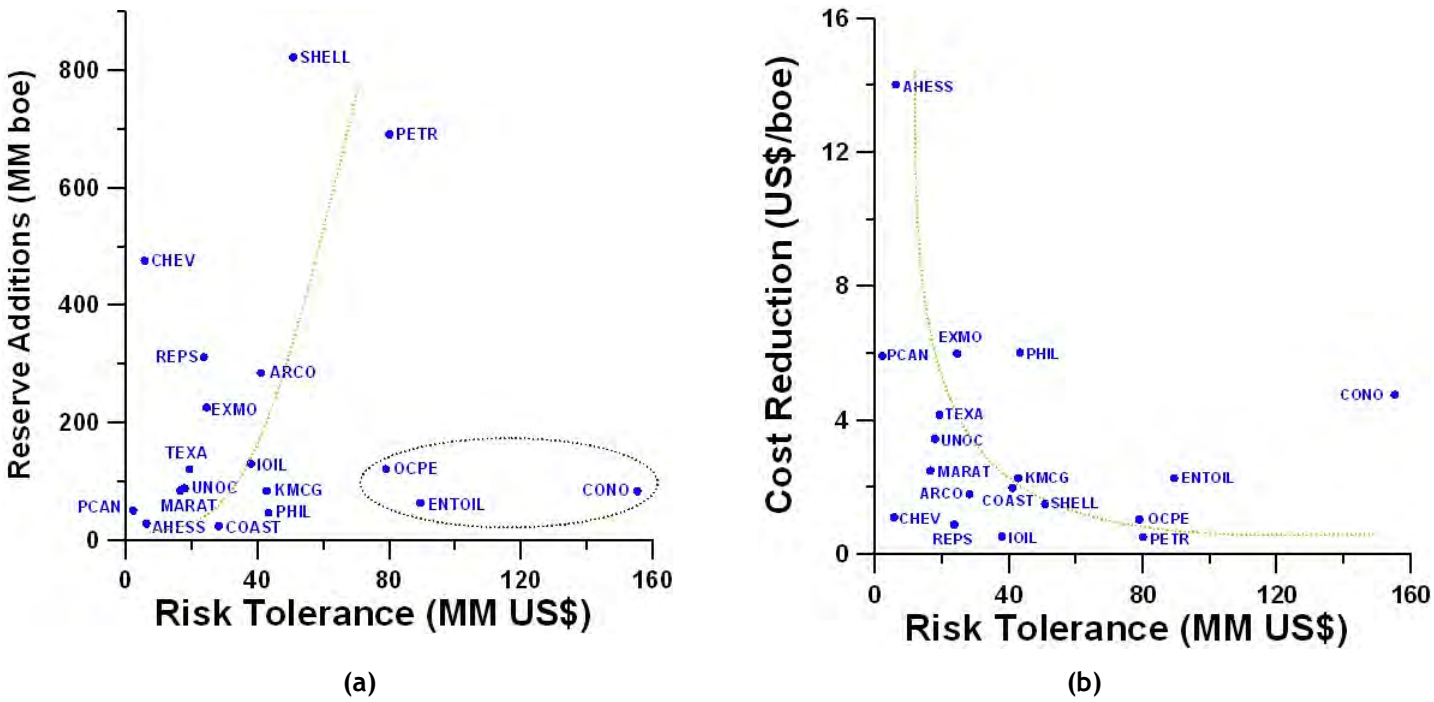

Figure 1 : Reserve Additions (a) and Cost Reduction (b) x Risk Tolerance

exploration and production investments.

According to Walls e Dyer (1996), the behavior of petroleum firms can be defined as risk averse and modeled by a utility function. The obtained empirical results agree with this tendency and shows that, in petroleum E&P, business risk inducts firms risk aversion despite the capital amount exposed to risk due to capital loss possibility allocated in projects with low success probabilities.

Figure 1 shows the relationship between cost reduction and reserve additions with risk tolerance. Results indicate that risk tolerance shows a downward trend with a positive correlation with cost reductions and indicates an upward trend with a positive correlation with reserve additions.

A multivariate exploratory analysis using cluster and principal component analysis (PCA) was performed in the data set. The PCA is estimated through linear combinations of polynomial coefficients (adjusted for each time series of the initial variables) that generate a new group, called principal components (variables that are not correlated and posses the exploratory power of the total variability of the set). Similar principal components values allow the definition of groups, what can be confirmed by the cluster analysis method, based upon the evaluation of the similarity and distances among the data (Jonhson and Wichern, 1992). The analyses proposed for the identification of the groups is shown in Figure 2 and indicates the mean values of risk tolerance from the sample and cluster analysis results.

Shell and ExxonMobil, Group 1, can be considered major integrated firms and posses similar characteristics for the analyzed variables (values). These companies participate all petroleum stream and, consequently, can counterbalance the E&P investments by the entire value chain, what makes their risk behavior more similar. Group 2 firms have similar values of reserves and production, for example, what makes it possible for them to be joined in the same group. But they present different values for risk tolerance, despite close financial and operational variables, showing different risk taking behaviors in the oil market. The other companies, joined as Group 3, can be considered independent firms, present lower values of the financial and operational variables compared with Group 1 and 2. As

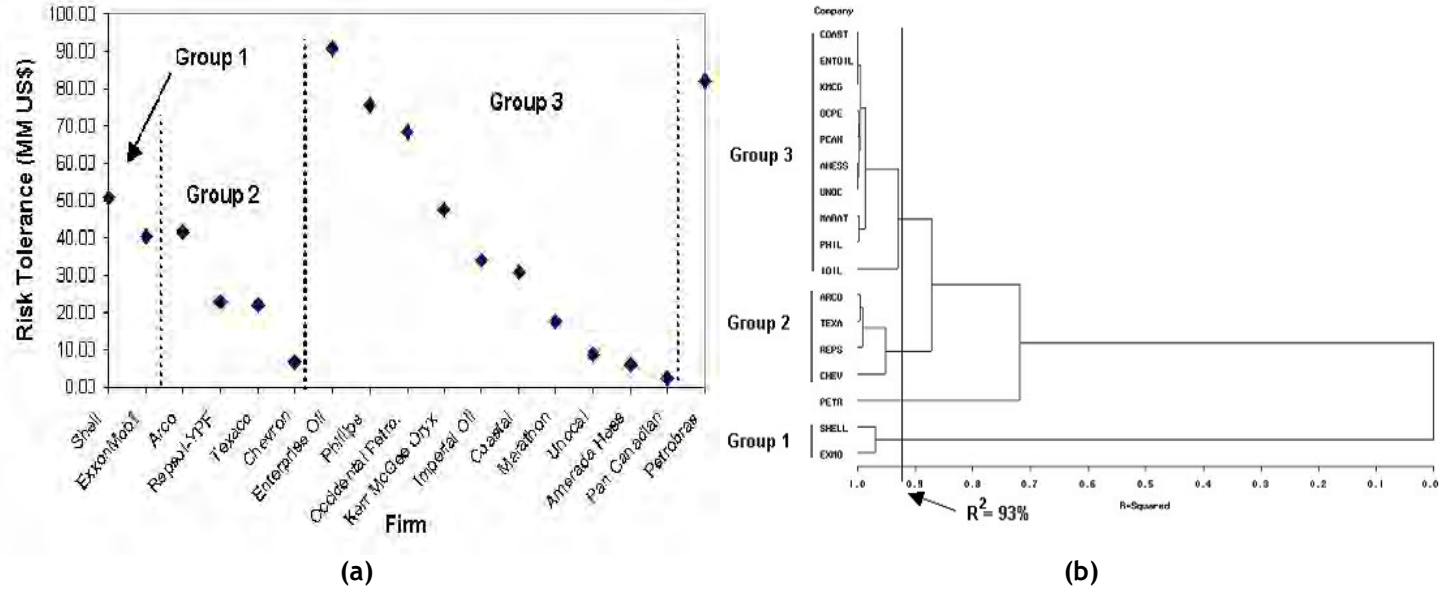

Figure 2: Mean Risk Tolerance of the firms used in the sample (a) and cluster analysis results (b)

Group 2, risk tolerance values are in a large range that shows different risk-taking behaviors for firms of same size.

Petrobras was not joined in any group what shows that its financial and operational variables are not similar to any firms or group of the sample. This fact can be explained by its characteristics of state company that acted, until 1997, in a closed market. But, since then, Petrobras is showing that can be competitive as the other firms that are coming to Brazilian market, what can be expressed by its high risk tolerance level.

Conclusions

The investigation of firms risk tolerance behavior along the last decade is an important source of information that can be used by the firms to design future investment strategies. The combination of operational and financial indicators of firm's performance can be used as a tool for planning purposes and quality analysis of past and ex-ante decisions for the firm in E&P scenario. An important conclusion of the group's risk tolerance is that firms with the same characteristics show different risk taking behaviors. This is an important information because can indicate who are the firm's real competitors, analyzing similar risk taking behaviors and, consequently, predicting future actions. It is necessary to emphasize that the data reflect a worldwide risk behavior but actual risk corporate estimation framework and analysis could be designed considering the risk behavior in a regional basis for specific regions and operational peculiarities applying PCA/cluster analysis methodology and RT evaluation.

Acknowledgements: The authors would like to thank the support of ANP/PRH (Brazilian National Petroleum Agency) and CNPq for the financial support for this research and Doneivan F. Ferreira with helpful comments in the manuscript.

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