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Application of Risk Analysis to Screen Exploration and Development Prospects

By

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American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc.

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INTRODUCTION

The exploration for, and development of oil and gas reserves is one of the major risk ventures undertaken by industry. This characteristic has been recognized, and industry has been willing to accept the risk involved in order to satisfy our nation's needs for energy resources. The existence of this risk is not unique to the oil and gas industry, but its nature is quite interesting and has, therefore, been the subject of much serious study.

To clarify what we mean by risk and risk analysis, let's look at the definitions. Risk is defined as a possibility of loss; analysis is defined as an examination of a complex; therefore, used jointly they would refer to the examination of a complex possibility of loss. Those involved in the search for accumulations of hydrocarbons recognize that this
References and illustrations at end of paper.

search does involve a very complex, and quite possibly loss of time, effort, and investment.

Having recognized the risk and defined risk analysis, the next question is how to apply risk analysis to exploration and development prospects. Prior to discussing this application, it is appropriate to examine the need for risk analysis.

The proper management of any company, regardless of size, involves the establishment of, and reaching for, several goals. These goals which include profit, survival, liquidity, and leadership, must be considered in making capital investment decisions. This is true of all companies but is perhaps amplified in the management of smaller firms where less capital is available for investment.

In the appraisal of potential investments, management has established several criteria for judging

the effectiveness of investments on achieving the firm's goals. These criteria include rate of return, payout, profit, and profit investment ratios. In our evaluation of prospects, it is our duty to furnish the particular economic yardstick our management prefers to use in their appraisal.

In addition to these quantitative measures, evaluation of drilling prospects involves a qualitative analysis using a good deal of judgment. Once the evaluation personnel have analyzed the proposed investment and generated the required economic yardsticks, management can use this information to substantiate or justify financial operations and to select between alternate investment possibilities in view of capital resources available. This careful planning of financial factors contributes toward the reduction of risks and, therefore, in a time of costly money and lower profits, it is imperative that management make more formal analysis in the use of risk capital in drilling ventures. Formal analysis gives management a tool to uniformly choose the drilling prospects that will be consistent with corporate objectives.

Individuals and smaller companies need a fast, relatively simple method of evaluating drilling prospects on a uniform basis. In the method to be presented, "rate of return" is the yardstick used in evaluating prospects. The rate of return approach is an easy way to see if the prospect meets company goals and to develop short and long range plans.

The analysis of development and exploratory drilling prospects, as presented in this paper, is a five step procedure. These steps in chronological order are:

1. Geological Study
2. Data Gathering Process
3. Risk Determination
4. Rate of Return Calculation
5. Year End Review

GEOLOGICAL STUDY

The economic evaluation begins with the geological prospect submitted by the geologists in map form. The map should show the net size of the expected reservoir, and the location and amount of company owned acreage. Also, the location of acreage that could possibly be acquired should be shown.

The acreage situation is important in that it gives some idea of how much of the reservoir's reserves can be attributed to this prospect. If the acreage position is small, there might not be enough reserves attributable to the prospect to satisfy the risk requirements.

DATA GATHERING PROCESS

In this step the engineering data needed to make an economic evaluation is assimilated. This information consists of drilling costs for both a dry hole and a completed well, and operating costs including ad valorem taxes. With taxes continually increasing, this is an important part of operating costs. Also needed are oil and gas prices, anticipated allowances, and average recoveries per acre foot for the prospective zones.

If available, information on nearby fields producing in the prospective zones should be collected. Such items as average pay thickness, average recoveries per well, producing rates and producing characteristics are important. This information gives a measure of control as to whether the geological prospect is poorer than, equal to, or better than other producing fields in the area.

RISK DETERMINATION

This can also be stated as, "how many dry holes have to be drilled before a geological prospect, like the one under consideration, is discovered?" This number is arrived at after studying statistical information that is available on the area, and from the geologist who should

have considerable knowledge of and feel for the area he is working.

It should be noted that in most areas the success ratio changes with time. When drilling in a new area first begins, the success ratio is low. As more drilling is done and more information and geological control is available, the success ratio improves. However as the area becomes mature, the success ratio decreases because the obvious fields have been found. Therefore, in establishing the expected risk or success ratio, the current status of the area should be considered more than past history alone.

RATE OF RETURN CALCULATION

After the geological and engineering data have been collected, it can be fitted together in an economic evaluation. The following example will illustrate the evaluation process. Basic factors used were:

Dry Hole Costs:	\$40,000 per well
Producer Costs:	\$75,000 per well
Operating Costs:	\$350/well/month
Oil Price:	\$3.20 per barrel
Working Interest:	100 percent
Revenue Interest:	87.5 percent
Production and Ad valorem Taxes:	7% of gross value
Acreage Costs:	\$40,000
Geophysical Costs:	None

Total Cost to Drill One Wildcat Well:

$$\$75,000 + \$40,000 = \$115,000$$

The acreage situation is such that a successful wildcat would have five productive offsets and one development dry hole. So the total cost to develop and define this field would be \$115,000 for acreage and a productive wildcat plus \$415,000 for

five productive development wells and one dry development hole. The geological map indicates the recoverable reserves under the controlled acreage would be approximately 1,200,000 barrels. The results of the economic evaluation, assuming no additional investment for wildcat risk, is shown in Table I below. This is a standard type oil property evaluation which utilizes the trial and error discounted cash flow method of calculating rate of return.

After critical review, it was determined the chances of success on this prospect as mapped, would be one in twelve tries and, therefore, in addition to the cost of the successful wildcat and development wells the prospect must be able to pay for eleven dry prospects and still yield a satisfactory rate of return. In this example the prospect was evaluated for a success ratio of one in five, one in ten, and one in fifteen. These results are shown in tabular form in Tables II, III and IV, and are shown graphically in Figure 1. This is a plot of rate of return versus risk from which it is determined the prospect will generate a rate of return of 15 percent with risk or success ratio of one success out of twelve tries.

If the prospect fails to meet the required criteria, it indicates the prospect is either too small or the controlled acreage position is not large enough. This example has been shown for the case of exploratory projects, however, the same principles would apply to development projects.

Now a word of caution. If an operator enters into only one or two ventures, even though the indicated rate of return is sufficient, his chances of success are reduced. It is required that he drill approximately twelve prospects for his chances of success to be reasonably good. If his capital resources are limited, he should take a smaller interest in each prospect so he can spread his risk.

YEAR END REVIEW

At the end of the year a review of the year's drilling program should be made to see if the drilling results yielded the required minimum rate of return. From this review it can be determined if the geological prospects had been mapped too optimistically or conservatively and if the proper risk factor and engineering data for the area have been applied.

CONCLUSION

The more detailed type of analysis, which are currently being utilized by the industry, deserve mention here since they have served to

advance our understanding of risk analysis. These methods include the application of game theory, probability models, operations research, and linear programming, and when applied to the search for oil and gas, is an extremely interesting area which should improve the decision making process in our industry. However, for a smaller firm to apply these techniques at the present time can be impractical due to the time and the costs involved.

In summary, we have attempted to show that while complex methods of appraising risk are available, the practical application of judgment based upon experience can be used to generate satisfactory aids for decision requirements.

Table 1 - Success ratio = 1/1.

YR	WELLS	GR. OIL	NET OIL	OIL PRICE	OIL REV INT	EXPENSE	TANG INV	TOT INTAN	DEPR
1	6	216,000	189,000	\$3.20	.875	\$ 67,536	\$145,000	\$395,000	\$ 20,706
2	6	216,000	189,000	3.20	.875	67,536	0	0	20,706
3	6	198,630	173,801	3.20	.875	64,131	0	0	20,706
4	6	150,076	131,317	3.20	.875	54,615	0	0	20,706
5	6	110,350	96,556	3.20	.875	46,829	0	0	20,706
6	6	79,452	69,521	3.20	.875	40,773	0	0	20,706
7	6	61,796	54,072	3.20	.875	37,312	0	0	20,706
8	6	48,554	42,485	3.20	.875	34,717	0	0	58
9	6	36,194	31,670	3.20	.875	32,294	0	0	0
10	6	27,366	23,945	3.20	.875	30,564	0	0	0
11	6	20,304	17,766	3.20	.875	29,180	0	0	0
12	6	14,125	12,359	3.20	.875	27,968	0	0	0
13	6	12,359	10,814	3.20	.875	27,622	0	0	0
14	6	8,794	7,695	3.20	.875	26,924	0	0	0
TOTAL		1,200,000	1,049,998			\$587,999	\$145,000	\$395,000	\$145,000

YR	GR. INC	DEPLETION	INC TAX	CASH FLOW	10% P.V.	20% P.V.	30% P.V.	40% P.V.	50% P.V.
1	\$ 604,800	\$ 80,779	\$ 40,390	\$ 496,875	\$ 449,594	\$ 406,808	\$368,095	\$333,065	\$301,373
2	604,800	133,056	191,751	345,513	282,883	231,604	189,623	155,250	127,109
3	556,164	122,356	174,485	317,547	235,246	174,275	129,105	95,644	70,855
4	420,213	92,447	126,223	239,375	160,458	107,559	72,099	48,330	32,396
5	308,980	67,976	86,735	175,417	106,397	64,533	39,141	23,740	14,399
6	222,466	48,942	56,022	125,671	68,970	37,852	20,773	11,401	6,257
7	173,029	38,066	38,472	97,245	48,291	23,980	11,908	5,913	2,937
8	135,951	29,909	35,634	65,601	29,477	13,245	5,951	2,674	1,202
9	101,343	22,296	23,377	45,672	18,569	7,550	3,069	1,248	507
10	76,625	16,857	14,602	31,459	11,573	4,258	1,566	576	212
11	56,851	12,507	7,582	20,089	6,687	2,226	741	247	82
12	39,550	5,791	2,895	8,686	2,616	788	237	71	22
13	34,605	3,491	1,746	5,237	1,427	389	106	29	8
14	24,623	0	-1,150	-1,150	-284	-70	-17	-4	-1
TOTAL	\$3,359,994	\$674,474	\$798,763	\$1,973,233	\$1,421,901	\$1,074,991	\$842,400	\$678,184	\$557,357

PAYOUT IN 1.1 YEARS
RATE OF RETURN = 69. PERCENT

Table 2 - Success ratio = 1/5.

YR	WELLS	GR. OIL	NET OIL	OIL PRICE	OIL REV INT	EXPENSE	TANG INV	TOT INTAN	DEPR
1	6	216,000	189,000	\$3.20	.875	\$ 67,536	\$185,000	\$715,000	\$ 26,418
2	6	216,000	189,000	3.20	.875	67,536	0	0	26,418
3	6	198,630	173,801	3.20	.875	64,131	0	0	26,418
4	6	150,076	131,317	3.20	.875	54,615	0	0	26,418
5	6	110,350	96,556	3.20	.875	46,829	0	0	26,418
6	6	79,452	69,521	3.20	.875	40,773	0	0	26,418
7	6	61,796	54,072	3.20	.875	37,312	0	0	26,418
8	6	48,554	42,485	3.20	.875	34,717	0	0	74
9	6	36,194	31,670	3.20	.875	32,294	0	0	0
10	6	27,366	23,945	3.20	.875	30,564	0	0	0
11	6	20,304	17,766	3.20	.875	29,180	0	0	0
12	6	14,125	12,359	3.20	.875	27,968	0	0	0
13	6	12,359	10,814	3.20	.875	27,622	0	0	0
14	6	8,794	7,695	3.20	.875	26,924	0	0	0
TOTAL		1,200,000	1,049,998			\$587,999	\$185,000	\$715,000	\$185,000

YR	GR. INC	DEPLETION	INC. TAX	CASH FLOW	10% P.V.	20% P.V.	30% P.V.	40% P.V.	50% P.V.
1	604,800	36,000	-20,077	557,341	504,307	456,313	412,890	373,597	338,048
2	604,800	133,056	188,895	348,369	285,221	233,519	191,191	156,534	128,160
3	556,164	122,356	171,629	320,403	237,362	175,843	130,267	96,504	71,492
4	420,213	92,447	123,367	242,231	162,373	108,843	72,959	48,906	32,782
5	308,980	67,976	83,879	178,273	108,129	65,584	39,778	24,127	14,634
6	222,466	48,942	53,166	128,527	70,538	38,712	21,246	11,660	6,399
7	173,029	38,066	35,616	100,101	49,709	24,685	12,258	6,087	3,023
8	135,951	29,909	35,626	65,609	29,480	13,246	5,952	2,674	1,202
9	101,343	22,296	23,377	45,672	18,569	7,550	3,069	1,248	507
10	76,625	16,857	14,602	31,459	11,573	4,258	1,566	576	212
11	56,851	12,507	7,582	20,089	6,687	2,226	741	247	82
12	39,550	5,791	2,895	8,686	2,616	788	237	71	22
13	34,605	3,491	1,746	5,237	1,427	389	106	29	8
14	24,623	0	-1,150	-1,150	-284	-70	-17	-4	-1
TOTAL	\$3,359,994	\$629,695	\$721,152	\$2,050,844	\$1,487,705	\$1,131,878	\$892,243	\$722,255	\$596,569

PAYOUT IN 2.0 YEARS
RATE OF RETURN = 35. PERCENT

Table 3 - Success ratio = 1/10.

YR	WELLS	GR. OIL	NET OIL	OIL PRICE	OIL REV INT	EXPENSE	TANG INV	TOT INTAN	DEPR
1	6	216,000	189,000	\$3.20	.875	\$ 67,536	\$235,000	\$1,115,000	\$ 33,558
2	6	216,000	189,000	3.20	.875	67,536	0	0	28,766
3	6	198,630	173,801	3.20	.875	64,131	0	0	24,658
4	6	150,076	131,317	3.20	.875	54,615	0	0	21,137
5	6	110,350	96,556	3.20	.875	46,829	0	0	18,119
6	6	79,452	69,521	3.20	.875	40,773	0	0	15,531
7	6	61,796	54,072	3.20	.875	37,312	0	0	13,313
8	6	48,554	42,485	3.20	.875	34,717	0	0	11,412
9	6	36,194	31,670	3.20	.875	32,294	0	0	9,783
10	6	27,366	23,945	3.20	.875	30,564	0	0	8,386
11	6	20,304	17,766	3.20	.875	29,180	0	0	7,188
12	6	14,125	12,359	3.20	.875	27,968	0	0	6,162
13	6	12,359	10,814	3.20	.875	27,622	0	0	5,282
14	6	8,794	7,695	3.20	.875	26,924	0	0	4,528
TOTAL		1,200,000	1,049,998			\$587,999	\$235,000	\$1,115,000	\$207,822
YR	GR. INC	DEPLETION	INC TAX	CASH FLOW	10% P.V.	20% P.V.	30% P.V.	40% P.V.	50% P.V.
1	\$ 604,800	\$ 72,000	\$-141,647	\$ 678,911	\$ 614,309	\$ 555,847	\$502,952	\$455,088	\$411,785
2	604,800	133,056	187,721	349,543	286,182	234,306	191,835	157,061	128,592
3	556,164	122,356	172,509	319,523	236,710	175,360	129,909	96,239	71,296
4	420,213	92,447	126,007	239,591	160,603	107,656	72,164	48,373	32,425
5	308,980	67,976	88,029	174,123	105,612	64,057	38,852	23,565	14,293
6	222,466	48,942	58,610	123,083	67,550	37,072	20,346	11,166	6,128
7	173,029	38,066	42,169	93,548	46,455	23,069	11,456	5,689	2,825
8	135,951	29,909	29,957	71,278	32,028	14,391	6,466	2,905	1,306
9	101,343	22,296	18,486	50,564	20,558	8,358	3,398	1,382	562
10	76,625	16,857	10,409	35,652	13,116	4,825	1,775	653	240
11	56,851	10,242	5,121	22,551	7,507	2,499	832	277	92
12	39,550	2,710	1,355	10,227	3,080	928	279	84	25
13	34,605	850	425	6,558	1,787	487	133	36	10
14	24,623	0	-3,414	1,114	275	68	17	4	1
TOTAL	\$3,359,994	\$657,707	\$595,735	\$2,176,259	\$1,595,765	\$1,228,916	\$980,413	\$802,522	\$669,579
PAYOUT IN 3.0 YEARS									
RATE OF RETURN = 19. PERCENT									

Table 4 - Success ratio = 1/15.

YR	WELLS	GR. OIL	NET OIL	OIL PRICE	OIL REV INT	EXPENSE	TANG INV	TOT INTAN	DEPR
1	6	216,000	189,000	3.20	.875	\$ 67,536	\$285,000	\$1,515,000	\$ 40,698
2	6	216,000	189,000	3.20	.875	67,536	0	0	40,698
3	6	198,630	173,801	3.20	.875	64,131	0	0	40,698
4	6	150,076	131,317	3.20	.875	54,615	0	0	40,698
5	6	110,350	96,556	3.20	.875	46,829	0	0	40,698
6	6	79,452	69,521	3.20	.875	40,773	0	0	40,698
7	6	61,796	54,072	3.20	.875	37,312	0	0	40,698
8	6	48,554	42,485	3.20	.875	34,717	0	0	114
9	6	36,194	31,670	3.20	.875	32,294	0	0	0
10	6	27,366	23,945	3.20	.875	30,564	0	0	0
11	6	20,304	17,766	3.20	.875	29,180	0	0	0
12	6	14,125	12,359	3.20	.875	27,968	0	0	0
13	6	12,359	10,814	3.20	.875	27,622	0	0	0
14	6	8,794	7,695	3.20	.875	26,924	0	0	0
TOTAL		1,200,000	1,049,998			\$587,999	\$285,000	\$1,515,000	\$285,000
YR	GR. INC	DEPLETION	INC. TAX	CASH FLOW	10% P.V.	20% P.V.	30% P.V.	40% P.V.	50% P.V.
1	\$ 604,800	\$108,000	\$-263,217	\$ 800,481	\$ 724,311	\$ 655,380	\$ 593,014	\$536,579	\$485,522
2	604,800	133,056	181,755	355,509	291,067	238,305	195,109	159,742	130,786
3	556,164	122,356	164,489	327,543	242,651	179,761	133,169	98,655	73,085
4	420,213	92,447	116,227	249,371	167,159	112,051	75,110	50,348	33,749
5	308,980	67,976	76,739	185,413	112,460	68,210	41,372	25,093	15,220
6	222,466	48,942	46,026	135,667	74,456	40,862	22,426	12,308	6,754
7	173,029	38,066	28,476	107,241	53,255	26,445	13,132	6,521	3,238
8	135,951	29,909	35,606	65,629	29,489	13,250	5,954	2,675	1,202
9	101,343	22,296	23,377	45,672	18,569	7,550	3,069	1,248	507
10	76,625	16,857	14,602	31,459	11,573	4,258	1,566	576	212
11	56,851	12,507	7,582	20,089	6,687	2,226	741	247	82
12	39,550	5,791	2,895	8,686	2,616	788	237	71	22
13	34,605	3,491	1,746	5,237	1,427	389	106	29	8
14	24,623	0	-1,150	-1,150	-284	-70	-17	-4	-1
TOTAL	\$3,359,994	\$701,695	\$435,152	\$2,336,844	\$1,735,433	\$1,349,400	\$1,084,984	\$894,086	\$750,387
PAYOUT IN 4.4 YEARS									
RATE OF RETURN = 10. PERCENT									

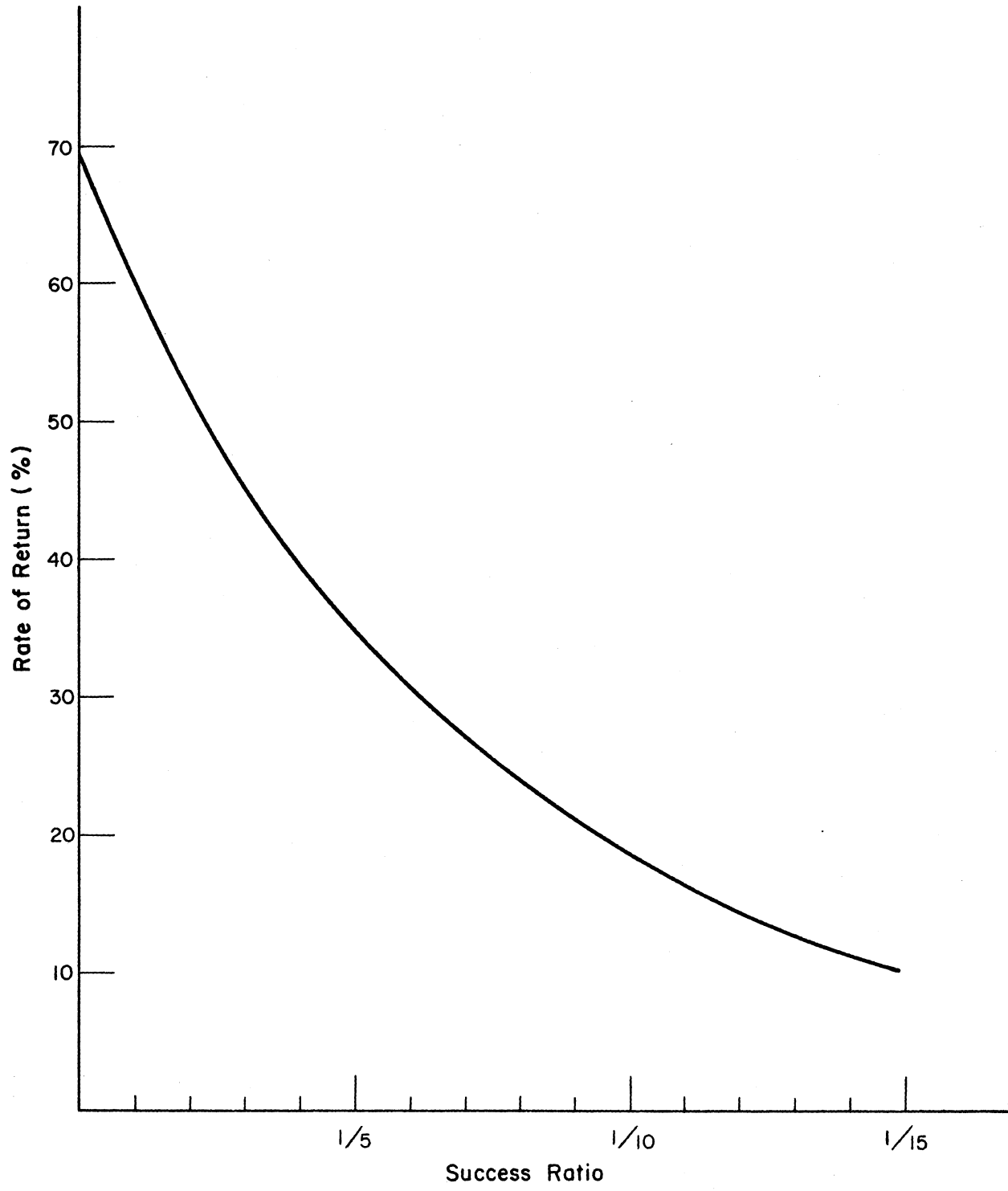


Fig. 1 - Rate of return vs success ratio.