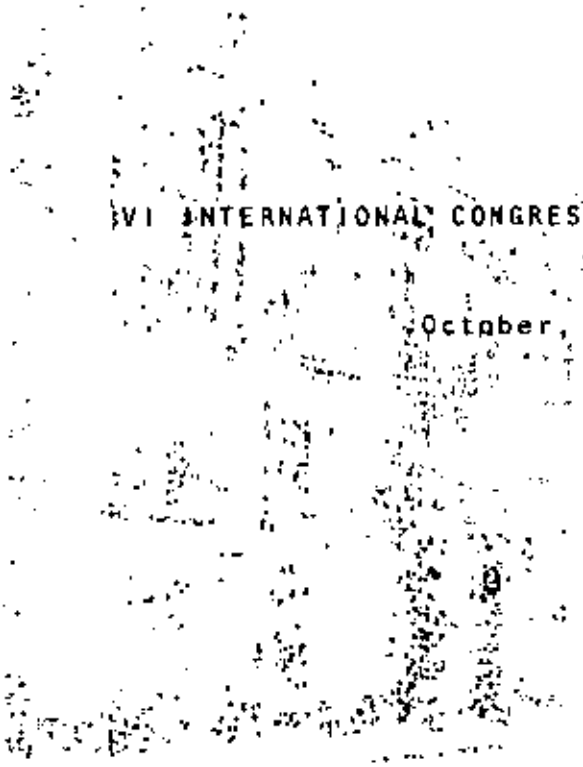
CONTINUING EDUCATION SEMINAR

on

VENTURE AND RISK ANALYSIS



VI INTERNATIONAL CONGRESS OF COST ENGINEERING

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Julian A. Piekarski
Henry C. Thorne

CONTINUING EDUCATION SEMINAR

on

VENTURE AND RISK ANALYSIS

Presented by

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VENTURE AND RISK ANALYSIS

This is an intensive two-day program to provide a broad introduction to project evaluation, with emphasis on discounted cash flow approaches, risk analysis and managerial considerations. Through a case problem worked in class, the student is exposed to some of the complexities and uncertainties common in real-life problems and learns why some form of risk analysis is so important. The seminar is a practical presentation and can be of value to both those working in the field and to those who wish a better understanding of this vital tool to aid sound management decision-making.

Upon completion of this course, the student should:

1. Be familiar with the important concepts and procedures in project evaluation, and have basic competency in discounted cash flow techniques.

2. Understand the true variability in performance results because of competitive and general environmental factors outside a firm's control, and why planning guidelines and some form of risk analysis are so necessary to give management a better measure of project profitability under conditions of uncertainty.

3. Know how to effectively report results of economic studies to management.

4. Know how to apply these principles in normal business situations, through experience gained in the class workshop, with a "real life" case.

5. Understand the procedure for preparing post-installation appraisals, the best available technique for analyzing experience results in past investments.

6. Have a better understanding of the special types of problems encountered in high-risk areas, such as research project ranking, acquisitions, and projects in developing countries.

VENTURE AND RISK ANALYSIS

I. Introduction
   - A. When to Evaluate
   - B. Evaluation Types and Approaches
   - C. Evaluation Contributors
   - D. Economics in Action

II. Practical Profitability
   - A. Cash Flow Table
   - B. Tax Effects
   - C. Cost of Capital
   - D. Savings Account
   - E. Incremental Returns
   - F. Special Topics-graphical shortcuts, varying project lives, multiple solutions, etc.

III. Post-Installation Appraisals
   - A. Lessons Learned
   - B. Typical Procedures
   - C. Three Examples

IV. Workshop No. 1
   - A. Five Short Problems and Solutions
   - B. Begin Major Case

V. Risk Analysis, Part 1
   - A. Sensitivity Analysis
   - B. The Key Marketing Variables
   - C. Experience Results

VI. Workshop No. 2
   - A. Complete Basic Calculations
   - B. Class and Case writer Solutions for Most-likely Alternates
   - C. Continue Sensitivity and Post-audit Calculations

VII. Business Environment
   - A. Energy Problems
   - B. Inflation
   - C. Other Major Uncertanties
   - D. Planning Guidelines

VIII. Risk Analysis, Part 2
   - A. Decision Trees
   - B. Monte Carlo Analyses
   - C. Management Risk Attitudes
   - D. Discounting for Risk

IX. High-Risk Examples
   A. Acquisitions
   B. Developing Country Projects
   C. Research Projects

X. Current Interest Topics
   A. Energy Economics
   B. Class Inquiries

XI. Managerial and Financial Topics
   A. Capital Budgeting
   B. Reporting Results
   C. Evaluation Organizations

XII. Workshop No. 3
   A. Review Sensitivity and Post-audit Calculations
   B. Monte Carlo and Research Ranking Applications to Case
   C. Recommended Action
   D. Appropriation Request

XIII. Wrap-up

XIV. References

XV. Case Solution

BIOGRAPHICAL DATA

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Mr. Thorne was born November, 1929. He received an MBA with distinction from Northwestern University (1958), and a Bachelors in Chemical Engineering, with distinction from Cornell University (1952). He has been employed with Amoco Chemicals Corporation and its affiliates since 1952, and assumed current responsibility as Manager, International Venture Development, in 1974. He is a Certified Cost Engineer. He served as National President, American Association of Cost Engineers, 1967-8 and has been their delegate to International Cost Engineering Council, 1975 to date and is currently vice chairman of this council. He received the AACE Award of Merit, 1976, and was elected AACE Fellow in 1977. He is also a member AIChE, AIIE, ACS, CDA, and is a recognized authority and lecturer in engineering economy. He has written numerous articles and is coauthoring a book "Managing Capital Expenditures--Techniques and Applications." He presents continuing education seminars on this subject for several engineering societies. He is recognized by Who's Who in America, Who's Who in Engineering, and Who's Who in the World.

REMEMBER THESE ECONOMIC GUIDEPOSTS

1. *WHAT ARE THE ALTERNATIVES?*
2. *CONSIDER MUTUALLY EXCLUSIVE ALTERNATIVES, TWO AT A TIME.*
3. *BEWARE OF SUNK COSTS.*
4. *THE COMPANY'S PROFIT GOAL— MAXIMIZE INCOME ABOVE THE COST OF CAPITAL INVESTED TO GENERATE THAT INCOME.*

THE "MUTUALLY EXCLUSIVE" PROBLEM

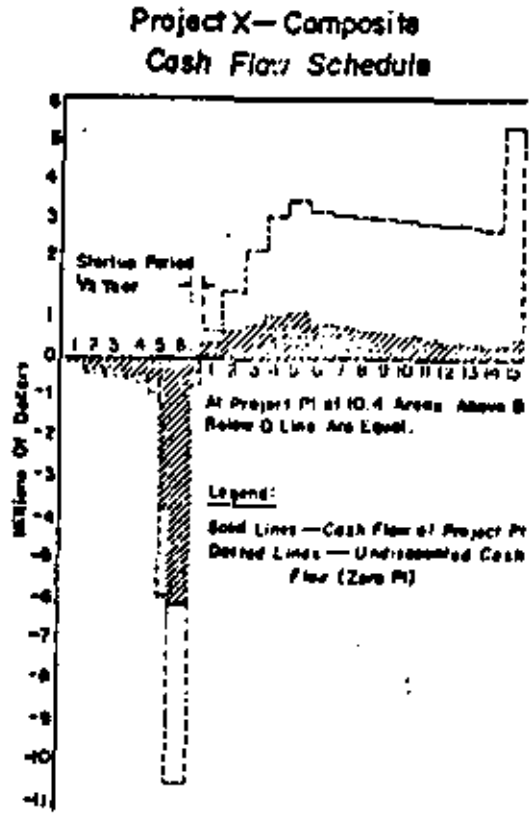
ALTERNATE	*INVESTMENT*	*PROFITABILITY*
A	$1,000,000	18%
B	$2,000,000	16%
B-A	$1,000,000	14%

WHAT IS THE PROFITABILITY INDEX ON A 3-YEAR PROJECT?

End of Year		Cash Flow $	21% PI Discount Factor	21% PI Present Value
0	Investment	-1,000	1.000	-1,000
1	Cash Return	+ 500	.811	+ 405
2	Cash Return	+ 500	.657	+ 328
3	Cash Return	+ 500	.533	+ 266
	Sum			0

TIME, COST AND REVENUE ELEMENTS OF A TYPICAL PROJECT

1. *Costs Incurred Before Construction*
2. *Fixed Capital*
3. *Startup Costs*
4. *Working Capital*
5. *Subsequent Investment*
6. *Sales Price and Volume Trends*
7. *Annual Expenses*
8. *Tax Effects*
9. *Salvage*



Common Evaluation System Weaknesses

1. Failure to recognize competitive pressures- more static than dynamic
2. Basic competitiveness (over investment)
3. Inherent optimism in forecasting
4. Internal comparability
5. Relative Risk
6. Allocation and Planning Difficulties (timing)
7. Lack of understanding by management

PROFITABILITY INDEX FACTORS

R = Profitability Index = I

I Rate in Time Period Involved.

Table A — Factors For Cash Effects Which Occur At A Point in Time After the Reference Point.

R x T	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	1.0000	.9901	.9803	.9706	.9610	.9515	.9420	.9327	.9235	.9143
10	.9053	.8963	.8874	.8787	.8700	.8613	.8528	.8444	.8360	.8277
20	.8197	.8116	.8037	.7958	.7880	.7803	.7727	.7651	.7576	.7502
30	.7428	.7355	.7283	.7211	.7140	.7070	.6999	.6930	.6861	.6792
40	.6725	.6657	.6590	.6524	.6459	.6394	.6330	.6267	.6204	.6142
50	.6080	.6020	.5961	.5902	.5843	.5785	.5728	.5671	.5615	.5559
60	.5504	.5450	.5396	.5342	.5289	.5237	.5185	.5134	.5083	.5032
70	.4982	.4933	.4884	.4835	.4787	.4740	.4693	.4646	.4600	.4555
80	.4509	.4465	.4420	.4377	.4333	.4290	.4248	.4206	.4164	.4123
90	.4083	.4043	.4003	.3963	.3924	.3886	.3847	.3810	.3772	.3735
100	.3679	.3642	.3606	.3570	.3535	.3499	.3465	.3430	.3396	.3362
110	.3329	.3296	.3263	.3230	.3198	.3166	.3135	.3104	.3073	.3042
120	.3012	.2982	.2952	.2923	.2894	.2865	.2837	.2808	.2780	.2753
130	.2725	.2698	.2671	.2645	.2618	.2592	.2567	.2541	.2516	.2491
140	.2466	.2442	.2417	.2393	.2369	.2346	.2322	.2299	.2276	.2254
150	.2231	.2209	.2187	.2166	.2144	.2123	.2101	.2080	.2060	.2039
160	.2019	.1999	.1979	.1959	.1940	.1921	.1901	.1882	.1864	.1845
170	.1827	.1809	.1791	.1773	.1755	.1738	.1720	.1703	.1686	.1670
180	.1653	.1637	.1620	.1604	.1588	.1572	.1557	.1541	.1526	.1511
190	.1496	.1481	.1466	.1451	.1437	.1423	.1409	.1395	.1381	.1367
200	.1353	.1340	.1327	.1313	.1300	.1287	.1275	.1262	.1249	.1237
210	.1225	.1212	.1200	.1188	.1177	.1165	.1153	.1142	.1130	.1119
220	.1108	.1097	.1086	.1075	.1065	.1054	.1044	.1033	.1023	.1013
230	.1003	.0993	.0983	.0973	.0963	.0954	.0945	.0935	.0926	.0916
240	.0907	.0898	.0889	.0880	.0872	.0863	.0854	.0846	.0837	.0829
250	.0821	.0813	.0805	.0797	.0789	.0781	.0773	.0765	.0758	.0750
260	.0743	.0735	.0728	.0721	.0714	.0707	.0699	.0693	.0686	.0679
270	.0672	.0665	.0659	.0652	.0646	.0639	.0633	.0627	.0620	.0614
280	.0608	.0602	.0596	.0590	.0584	.0578	.0573	.0567	.0561	.0556
290	.0550	.0545	.0539	.0534	.0529	.0523	.0518	.0513	.0508	.0503
300	.0498	.0493	.0488	.0483	.0478	.0474	.0469	.0464	.0460	.0455
310	.0450	.0446	.0442	.0437	.0433	.0429	.0424	.0420	.0416	.0412
320	.0408	.0404	.0400	.0396	.0392	.0388	.0384	.0380	.0376	.0372
330	.0369	.0365	.0362	.0358	.0354	.0351	.0347	.0344	.0340	.0337
340	.0334	.0330	.0327	.0324	.0321	.0317	.0314	.0311	.0308	.0305
350	.0302	.0299	.0296	.0293	.0290	.0287	.0284	.0282	.0279	.0276
360	.0273	.0271	.0268	.0265	.0263	.0260	.0257	.0255	.0252	.0250
370	.0247	.0245	.0242	.0240	.0238	.0235	.0233	.0231	.0228	.0226
380	.0224	.0221	.0219	.0217	.0215	.0213	.0211	.0209	.0207	.0204
390	.0202	.0200	.0198	.0196	.0194	.0193	.0191	.0189	.0187	.0185
400	.0183	.0181	.0180	.0178	.0176	.0174	.0172	.0171	.0169	.0167
410	.0166	.0164	.0162	.0161	.0159	.0158	.0156	.0155	.0153	.0151
420	.0150	.0148	.0147	.0146	.0144	.0143	.0141	.0140	.0139	.0137
430	.0136	.0134	.0133	.0132	.0130	.0129	.0128	.0127	.0125	.0124
440	.0123	.0122	.0120	.0119	.0118	.0117	.0116	.0114	.0113	.0112
450	.0111	.0110	.0109	.0108	.0107	.0106	.0105	.0104	.0103	.0102
460	.0101	.0100	.0099	.0098	.0097	.0096	.0095	.0094	.0093	.0092
470	.0091	.0090	.0089	.0088	.0087	.0087	.0086	.0085	.0084	.0083
480	.0082	.0082	.0081	.0080	.0079	.0078	.0078	.0077	.0076	.0075
490	.0074	.0074	.0073	.0073	.0072	.0071	.0070	.0070	.0069	.0068
500	.0067	.0067	.0066	.0066	.0065	.0064	.0064	.0063	.0062	.0062
510	.0061	.0060	.0060	.0059	.0058	.0058	.0057	.0056	.0056	.0055
520	.0055	.0054	.0053	.0053	.0052	.0052	.0051	.0051	.0050	.0050
530	.0049	.0048	.0048	.0047	.0047	.0046	.0046	.0045	.0045	.0044
540	.0044	.0043	.0043	.0042	.0042	.0042	.0041	.0041	.0040	.0040
550	.0039	.0039	.0038	.0038	.0038	.0037	.0037	.0036	.0036	.0036
560	.0035	.0035	.0035	.0034	.0034	.0034	.0033	.0033	.0033	.0032
570	.0032	.0032	.0031	.0031	.0031	.0030	.0030	.0030	.0029	.0029
580	.0029	.0028	.0028	.0028	.0028	.0027	.0027	.0027	.0027	.0026
590	.0026	.0026	.0026	.0025	.0025	.0025	.0025	.0024	.0024	.0024
600	.0024	.0023	.0023	.0023	.0023	.0022	.0022	.0022	.0022	.0021
610	.0021	.0021	.0021	.0021	.0020	.0020	.0020	.0020	.0019	.0019
620	.0019	.0019	.0019	.0018	.0018	.0018	.0018	.0018	.0017	.0017
630	.0017	.0017	.0017	.0016	.0016	.0016	.0016	.0016	.0016	.0015
640	.0015	.0015	.0015	.0015	.0015	.0015	.0014	.0014	.0014	.0014
650	.0014	.0014	.0014	.0013	.0013	.0013	.0013	.0013	.0013	.0013
660	.0012	.0012	.0012	.0012	.0012	.0012	.0012	.0011	.0011	.0011
670	.0011	.0011	.0011	.0011	.0010	.0010	.0010	.0010	.0010	.0010
680	.0010	.0010	.0009	.0009	.0009	.0009	.0009	.0009	.0009	.0009
690	.0009	.0008	.0008	.0008	.0008	.0008	.0008	.0008	.0008	.0008
700	.0008	.0007	.0007	.0007	.0007	.0007	.0007	.0007	.0007	.0007
710	.0007	.0006	.0006	.0006	.0006	.0006	.0006	.0006	.0006	.0006
720	.0006	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005
730	.0005	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004
740	.0004	.0004	.0004	.0004	.0004	.0004	.0004	.0004	.0003	.0003
750	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003
760	.0003	.0003	.0003	.0003	.0003	.0002	.0002	.0002	.0002	.0002
770	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002
780	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002
790	.0002	.0002	.0002	.0002	.0001	.0001	.0001	.0001	.0001	.0001
800	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001
1000	.0000									

For cash flows prior to the ref. pt:
$A_{-R,T} = 1/A_{R,T}$; $C_{-R,T} = C/A$; $D_{-R,T} = D/A$
For higher RxT values: $A_{R,T} = (A_{R,\frac{T}{2}})^2$
C=100/RxT (for RxT>800). D=200(1-C)/RxT

Table C — Factors For Cash Effects Which Occur Uniformly Over A Period of Years Starting With the Reference Point.

R x T	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	1.0000	.9950	.9901	.9851	.9802	.9754	.9706	.9660	.9610	.9563
10	.9516	.9470	.9423	.9377	.9331	.9286	.9243	.9196	.9152	.9107
20	.9063	.9020	.8976	.8933	.8890	.8848	.8806	.8764	.8722	.8681
30	.8639	.8598	.8558	.8517	.8477	.8438	.8398	.8359	.8319	.8281
40	.8242	.8204	.8166	.8128	.8090	.8053	.8016	.7979	.7942	.7906
50	.7869	.7833	.7798	.7762	.7727	.7692	.7657	.7622	.7588	.7554
60	.7520	.7486	.7452	.7419	.7386	.7353	.7320	.7288	.7256	.7224
70	.7192	.7160	.7128	.7097	.7066	.7035	.7004	.6974	.6943	.6913
80	.6883	.6854	.6824	.6795	.6766	.6738	.6709	.6680	.6652	.6624
90	.6596	.6568	.6541	.6513	.6487	.6460	.6433	.6407	.6381	.6354
100	.6329	.6303	.6278	.6253	.6228	.6203	.6178	.6154	.6129	.6105
110	.6081	.6058	.6034	.6011	.5987	.5964	.5941	.5918	.5896	.5873
120	.5851	.5828	.5806	.5784	.5762	.5741	.5719	.5698	.5676	.5655
130	.5634	.5613	.5592	.5572	.5551	.5531	.5511	.5491	.5471	.5451
140	.5431	.5412	.5392	.5373	.5354	.5335	.5316	.5297	.5278	.5260
150	.5241	.5223	.5205	.5187	.5169	.5151	.5133	.5116	.5098	.5081
160	.5063	.5046	.5029	.5012	.4995	.4978	.4961	.4945	.4928	.4912
170	.4895	.4879	.4863	.4847	.4831	.4815	.4799	.4783	.4768	.4752
180	.4737	.4721	.4706	.4691	.4676	.4661	.4646	.4631	.4617	.4602
190	.4588	.4573	.4559	.4545	.4531	.4517	.4503	.4489	.4475	.4462
200	.4448	.4435	.4421	.4408	.4395	.4381	.4368	.4355	.4342	.4329
210	.4317	.4304	.4291	.4279	.4266	.4254	.4241	.4229	.4217	.4205
220	.4193	.4181	.4169	.4157	.4145	.4133	.4122	.4110	.4099	.4087
230	.4076	.4065	.4053	.4042	.4031	.4020	.4009	.3998	.3987	.3976
240	.3965	.3955	.3944	.3934	.3923	.3913	.3902	.3892	.3882	.3872
250	.3862	.3852	.3842	.3832	.3822	.3812	.3802	.3793	.3783	.3774
260	.3764	.3755	.3745	.3736	.3727	.3717	.3708	.3699	.3690	.3681
270	.3672	.3663	.3654	.3645	.3636	.3627	.3618	.3610	.3601	.3592
280	.3584	.3575	.3567	.3558	.3550	.3542	.3533	.3525	.3517	.3509
290	.3501	.3493	.3485	.3477	.3469	.3461	.3453	.3445	.3438	.3430
300	.3422	.3415	.3407	.3400	.3392	.3385	.3377	.3370	.3363	.3355
310	.3348	.3341	.3334	.3327	.3320	.3313	.3306	.3299	.3292	.3285
320	.3278	.3271	.3264	.3258	.3251	.3244	.3238	.3231	.3224	.3218
330	.3211	.3205	.3198	.3192	.3186	.3179	.3173	.3167	.3160	.3154
340	.3148	.3142	.3136	.3130	.3123	.3117	.3111	.3105	.3099	.3093
350	.3087	.3081	.3075	.3069	.3063	.3058	.3052	.3046	.3040	.3034
360	.3029	.3023	.3017	.3012	.3006	.3000	.2995	.2989	.2984	.2978
370	.2973	.2967	.2962	.2956	.2951	.2946	.2940	.2935	.2930	.2924
380	.2919	.2914	.2909	.2903	.2898	.2893	.2888	.2883	.2878	.2873
390	.2868	.2863	.2858	.2853	.2848	.2843	.2838	.2833	.2828	.2823
400	.2818	.2814	.2809	.2804	.2799	.2795	.2790	.2785	.2781	.2776
410	.2771	.2767	.2762	.2758	.2753	.2749	.2744	.2740	.2735	.2731
420	.2726	.2722	.2718	.2713	.2709	.2705	.2700	.2696	.2692	.2687
430	.2683	.2679	.2675	.2670	.2666	.2662	.2658	.2654	.2650	.2645
440	.2641	.2637	.2633	.2629	.2625	.2621	.2617	.2613	.2609	.2605
450	.2601	.2597	.2593	.2589	.2585	.2581	.2577	.2573	.2569	.2565
460	.2562	.2558	.2554	.2550	.2546	.2542	.2539	.2535	.2531	.2527
470	.2523	.2520	.2516	.2512	.2508	.2505	.2501	.2497	.2493	.2490
480	.2486	.2482	.2479	.2475	.2471	.2468	.2464	.2460	.2457	.2453
490	.2449	.2446	.2442	.2439	.2435	.2432	.2428	.2424	.2421	.2417
500	.2414	.2410	.2407	.2403	.2400	.2396	.2393	.2389	.2386	.2382
510	.2379	.2375	.2372	.2368	.2365	.2362	.2358	.2355	.2351	.2348
520	.2345	.2341	.2338	.2335	.2331	.2328	.2325	.2321	.2318	.2315
530	.2311	.2308	.2305	.2301	.2298	.2295	.2292	.2288	.2285	.2282
540	.2279	.2275	.2272	.2269	.2266	.2263	.2259	.2256	.2253	.2250
550	.2247	.2244	.2241	.2238	.2234	.2231	.2228	.2225	.2222	.2219
560	.2216	.2213	.2210	.2207	.2204	.2201	.2198	.2195	.2192	.2189
570	.2186	.2183	.2180	.2177	.2174	.2171	.2168	.2165	.2162	.2159
580	.2156	.2153	.2150	.2147	.2144	.2141	.2138	.2135	.2132	.2129
590	.2126	.2123	.2120	.2117	.2114	.2111	.2108	.2105	.2102	.2099
600	.2096	.2093	.2090	.2087	.2084	.2081	.2078	.2075	.2072	.2069
610	.2066	.2063	.2060	.2057	.2054	.2051	.2048	.2045	.2042	.2039
620	.2036	.2033	.2030	.2027	.2024	.2021	.2018	.2015	.2012	.2009
630	.2006	.2003	.2000	.1997	.1994	.1991	.1988	.1985	.1982	.1979
640	.1976	.1973	.1970	.1967	.1964	.1961	.1958	.1955	.1952	.1949
650	.1946	.1943	.1940	.1937	.1934	.1931	.1928	.1925	.1922	.1919
660	.1916	.1913	.1910	.1907	.1904	.1901	.1898	.1895	.1892	.1889
670	.1886	.1883	.1880	.1877	.1874	.1871	.1868	.1865	.1862	.1859
680	.1856	.1853	.1850	.1847	.1844	.1841	.1838	.1835	.1832	.1829
690	.1826	.1823	.1820	.1817	.1814	.1811	.1808	.1805	.1802	.1799
700	.1796	.1793	.1790	.1787	.1784	.1781	.1778	.1775	.1772	.1769
710	.1766	.1763	.1760	.1757	.1754	.1751	.1748	.1745	.1742	.1739
720	.1736	.1733	.1730	.1727	.1724	.1721	.1718	.1715	.1712	.1709
730	.1706	.1703	.1700	.1697	.1694	.1691	.1688	.1685	.1682	.1679
740	.1676	.1673	.1670	.1667	.1664	.1661	.1658	.1655	.1652	.1649
750	.1646	.1643	.1640	.1637	.1634	.1631	.1628	.1625	.1622	.1619
760	.1616	.1613	.1610	.1607	.1604	.1601	.1598	.1595	.1592	.1589
770	.1586	.1583	.1580	.1577	.1574	.1571	.1568	.1565	.1562	.1559
780	.1556	.1553	.1550	.1547	.1544	.1541	.1538	.1535	.1532	.1529
790	.1526	.1523	.1520	.1517	.1514	.1511	.1508	.1505	.1502	.1499
800	.1496	.1493	.1490	.1487	.1484	.1481	.1478	.1475	.1472	.1469
1000	.1333									

Table D — Factors For Cash Effects Declining in Even of A Constant Rate Over A Period of Years Starting With the Reference Point.

R x T	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	1.0000	.9967	.9934	.9901	.9868	.9835	.9803	.9771	.9739	.9707
10	.9675	.9643	.9612	.9580	.9549	.9518	.9487	.9456	.9425	.9395
20	.9364	.9334	.9303	.9273	.9243	.9213	.9183	.9153	.9124	.9094
30	.9065	.9036	.9007	.8977	.8948	.8920	.8891	.8863	.8834	.8806
40	.8778	.8750	.8723	.8695	.8668	.8640	.8613	.8586	.8559	.8532
50	.8505	.8479	.8452	.8426	.8400	.8373	.8347	.8321	.8296	.8270
60	.8244	.8219	.8193	.8168	.8143	.8118	.8093	.8068	.8043	.8018
70	.7994	.7969	.7945	.7921	.7897	.7873	.7849	.7825	.7801	.7778
80	.7754	.7731	.7708	.7685	.7662	.7639	.7616	.7593	.7570	.7548
90	.7525	.7503	.7481	.7458	.7436	.7414	.7392	.7370	.7349	.7327
100	.7305	.7284	.7262	.7241	.7220	.7198	.7177	.7156	.7135	.7115
110	.7094	.7073	.7053	.7032	.7012	.6992	.6971	.6951	.6931	.6911
120	.6891	.6871	.6852	.6832	.6812	.6793	.6773	.6754	.6735	.6715
130	.6696	.6677	.6658	.6639	.6620	.6601	.6582	.6564	.6545	.6527
140	.6508	.6490	.6472	.6453	.6435	.6417	.6399	.6381	.6363	.6345
150	.6328	.6310	.6292	.6275	.6257	.6240	.6223	.6205	.6188	.6171
160	.6154	.6137	.6120	.6103	.6086	.6069	.6053	.6036	.6019	.6003
170	.5986	.5970	.5954	.5937	.5921	.5905	.5889	.5873	.5857	.5841
180	.5825	.5809	.5793	.5778	.5762	.5746	.5731	.5715	.5700	.5684
190	.5669	.5654	.5639	.5623	.5608	.5593	.5578	.5563	.5548	.5533
200	.5518	.5504	.5489	.5474	.5460	.5445	.5431	.5416	.5402	.5387
210	.5373	.5359	.5345	.5330	.5316	.5302	.5288	.5274	.5260	.5246
220	.5232	.5219	.5205	.5191	.5178	.5164	.5150	.5137	.5123	.5110
230	.5096	.5083	.5070	.5056	.5043	.5030	.5017	.5004	.4991	.4978
240	.4965	.4952	.4939	.4926	.4913	.4900	.4888	.4875	.4862	.4850
250	.4837	.4824	.4812	.4799	.4787	.4775	.4762	.4750	.4737	.4725
260	.4713	.4701	.4688	.4676	.4664	.4652	.4640	.4628	.4616	.4604
270	.4592	.4580	.4568	.4557	.4545	.4533	.4521	.4510	.4498	.4486
280	.4475	.4463	.4452	.4440	.4429	.4418	.4406	.4395	.4384	.4372
290	.4361	.4350	.4339	.4328	.4317	.4306	.4295	.4284	.4273	.4262
300	.4251	.4240	.4229	.4218	.4208	.4197	.4186	.4176	.4165	.4154
310	.4144	.4133	.4123	.4113	.4102	.4092	.4082	.4071	.4061	.4051
320	.4041	.4031	.4021	.4011	.4001	.3991	.3981	.3971	.3961	.3951
330	.3941	.3931	.3921	.3912	.3902	.3892	.3883	.3873	.3863	.3854
340	.3844	.3835	.3825	.3816	.3806	.3797	.3787	.3778	.3769	.3759
350	.3750	.3741	.3732	.3722	.3713	.3704	.3695	.3686	.3677	.3668
360	.3659	.3650	.3641	.3632	.3623	.3614	.3605	.3596	.3587	.3578
370	.3570	.3561	.3552	.3543	.3535	.3526	.3517	.3509	.3500	.3491
380	.3483	.3474	.3466	.3457	.3449	.3440	.3432	.3423	.3415	.3406
390	.3398	.3389	.3381	.3373	.3364	.3356	.3348	.3339	.3331	.3323
400	.3315	.3306	.3298	.3290	.3282	.3274	.3266	.3258	.3250	.3242
410	.3234	.3226	.3218	.3210	.3202	.3194	.3186	.3178	.3170	.3163
420	.3155	.3147	.3139	.3131	.3124	.3116	.3108	.3100	.3093	.3085
430	.3077	.3070	.3062	.3054	.3047	.3039	.3031	.3024	.3016	.3009
440	.3001	.2994	.2986	.2979	.2971	.2964	.2956	.2949	.2941	.2934
450	.2926	.2919	.2912	.2904	.2897	.2889	.2882	.2875	.2867	.2860
460	.2853	.2845	.2838	.2831	.2824	.2816	.2809	.2802	.2795	.2788
470	.2780	.2773	.2766	.2759	.2752	.2745	.2738	.2731	.2724	.2717
480	.2710	.2703	.2696	.2689	.2682	.2675	.2668	.2661	.2654	.2647
490	.2640	.2633	.2626	.2619	.2612	.2606	.2599	.2592	.2585	.2578
500	.2572	.2565	.2558	.2551	.2545	.2538	.2531	.2525	.2518	.2511
510	.2505	.2498	.2491	.2485	.2478	.2472	.2465	.2459	.2452	.2446
520	.2439	.2433	.2426	.2420	.2413	.2407	.2401	.2394	.2388	.2382
530	.2375	.2369	.2363	.2356	.2350	.2344	.2338	.2331	.2325	.2319
540	.2313	.2307	.2300	.2294	.2288	.2282	.2276	.2270	.2264	.2258
550	.2252	.2246	.2240	.2234	.2228	.2222	.2216	.2210	.2204	.2198
560	.2192	.2186	.2180	.2174	.2168	.2162	.2156	.2150	.2144	.2139
570	.2133	.2127	.2121	.2115	.2109	.2104	.2098	.2092	.2086	.2081
580	.2075	.2069	.2064	.2058	.2052	.2047	.2041	.2035	.2030	.2024
590	.2018	.2013	.2007	.2002	.1996	.1990	.1985	.1979	.1974	.1968
600	.1963	.1957	.1952	.1946	.1941	.1935	.1930	.1924	.1919	.1913
610	.1908	.1902	.1897	.1892	.1886	.1881	.1876	.1870	.1865	.1860
620	.1854	.1849	.1844	.1838	.1833	.1828	.1823	.1817	.1812	.1807
630	.1802	.1796	.1791	.1786	.1781	.1776	.1770	.1765	.1760	.1755
640	.1750	.1745	.1740	.1735	.1730	.1724	.1719	.1714	.1709	.1704
650	.1699	.1694	.1689	.1684	.1679	.1674	.1669	.1664	.1659	.1654
660	.1649	.1644	.1639	.1634	.1629	.1624	.1619	.1614	.1609	.1604
670	.1599	.1594	.1589	.1584	.1579	.1574	.1569	.1564	.1559	.1554
680	.1550	.1545	.1540	.1535	.1530	.1525	.1520	.1515	.1510	.1506
690	.1501	.1496	.1491	.1486	.1481	.1477	.1472	.1467	.1462	.1457
700	.1453	.1448	.1443	.1438	.1433	.1429	.1424	.1419	.1414	.1410
710	.1405	.1400	.1396	.1391	.1386	.1382	.1377	.1372	.1368	.1363
720	.1358	.1354	.1349	.1345	.1340	.1335	.1331	.1326	.1322	.1317
730	.1313	.1308	.1304	.1299	.1295	.1290	.1286	.1281	.1277	.1272
740	.1268	.1263	.1259	.1254	.1250	.1246	.1241	.1237	.1232	.1228
750	.1224	.1219	.1215	.1211	.1206	.1202	.1198	.1193	.1189	.1185
760	.1180	.1176	.1172	.1168	.1163	.1159	.1155	.1151	.1146	.1142
770	.1138	.1134	.1130	.1125	.1121	.1117	.1113	.1109	.1105	.1101
780	.1096	.1092	.1088	.1084	.1080	.1076	.1072	.1068	.1064	.1060
790	.1056	.1052	.1048	.1044	.1040	.1036	.1032	.1028	.1024	.1020
800	.1016	.1012	.1008	.1004	.1000	.0996	.0992	.0988	.0984	.0980
1000	.0800									

SAMPLE PI CALCULATION

Basis: Investment - $122 M
Annual Savings - $200 M/yr.
10 - Year Project Life
49% Income Tax; 7% Investment Credit
20 - Year SYD Depreciation
Investment Spent from Time - 1/2 to 0, All Capitalized

	Time Period	Cash Flow (M$) Before Taxes	After Taxes	60% Rate D.F.	60% Rate P.V.	70% Rate D.F.	70% Rate P.V.	80% Rate D.F.	80% Rate P.V.
Investment	-1/2 to 0		(122)	1.17	(143)	1.20	(146)	1.23	(150)
Investment Credit	0		+9	1.00	+9	1.00	+9	1.00	+9
Depreciation	0 - 20		+60	.153	+9	.133	+8	.117	+7
Savings	0 - 10	+2,000	1,020	.166	+169	.143	+146	.125	127
Net Present Value, M$					+44		+17		(7)
P.I.						77%			

TABLE B

Discount Factors For Cash Effects Which Occur Uniformly
Over One-Year Periods After the Reference Point

Year	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%
0-1	.9950	.9901	.9851	.9803	.9754	.9706	.9658	.9610	.9563	.9516
1-2	.9851	.9705	.9560	.9418	.9278	.9141	.9005	.8872	.8740	.8611
2-3	.9753	.9512	.9278	.9049	.8826	.8608	.8396	.8189	.7988	.7791
3-4	.9656	.9324	.9004	.8694	.8395	.8107	.7829	.7560	.7300	.7050
4-5	.9560	.9140	.8737	.8353	.7986	.7635	.7299	.6979	.6672	.6379
5-6	.9465	.8959	.8479	.8026	.7596	.7190	.6806	.6442	.6098	.5772
6-7	.9371	.8781	.8229	.7711	.7226	.6772	.6346	.5947	.5573	.5223
7-8	.9278	.8607	.7985	.7409	.6874	.6377	.5917	.5490	.5093	.4726
8-9	.9185	.8437	.7749	.7118	.6538	.6006	.5517	.5068	.4655	.4276
9-10	.9094	.8270	.7520	.6839	.6219	.5656	.5144	.4678	.4254	.3869
10-11	.9003	.8106	.7298	.6571	.5916	.5327	.4796	.4318	.3888	.3501
11-12	.8914	.7946	.7082	.6312	.5628	.5016	.4472	.3986	.3553	.3168
12-13	.8825	.7788	.6873	.6065	.5353	.4724	.4169	.3680	.3248	.2866
13-14	.8737	.7634	.6670	.5827	.5092	.4449	.3888	.3397	.2968	.2593
14-15	.8650	.7483	.6473	.5599	.4844	.4190	.3625	.3136	.2713	.2347
15-16	.8564	.7335	.6282	.5380	.4608	.3946	.3380	.2895	.2479	.2123
16-17	.8479	.7189	.6096	.5169	.4383	.3716	.3151	.2672	.2266	.1921
17-18	.8395	.7047	.5916	.4966	.4169	.3500	.2938	.2467	.2071	.1739
18-19	.8311	.6908	.5741	.4772	.3966	.3296	.2740	.2277	.1893	.1573
19-20	.8228	.6771	.5571	.4584	.3772	.3104	.2554	.2102	.1730	.1423
20-21	.8147	.6637	.5407	.4405	.3588	.2923	.2382	.1940	.1581	.1288
21-22	.8065	.6505	.5247	.4232	.3413	.2753	.2221	.1791	.1445	.1165
22-23	.7985	.6376	.5092	.4066	.3247	.2593	.2071	.1653	.1320	.1054
23-24	.7906	.6250	.4941	.3907	.3089	.2442	.1931	.1526	.1207	.0954
24-25	.7827	.6126	.4795	.3753	.2938	.2300	.1800	.1409	.1103	.0863
25-30	.7596	.5772	.4386	.3334	.2535	.1928	.1466	.1115	.0849	.0646
30-35	.7226	.5223	.3775	.2730	.1974	.1428	.1033	.0748	.0541	.0392
35-40	.6874	.4726	.3250	.2235	.1538	.1058	.0728	.0501	.0345	.0238
40-45	.6538	.4276	.2797	.1830	.1197	.0784	.0513	.0336	.0220	.0144
45-50	.6219	.3869	.2407	.1498	.0933	.0531	.0362	.0225	.0140	.0087

TABLE B (Continued)

Discount Factors For Cash Effects Which Occur Uniformly Over One-Year Periods After the Reference Point

Year	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
0-1	.9470	.9423	.9377	.9332	.9286	.9241	.9196	.9152	.9107	.9063
1-2	.8483	.8358	.8234	.8112	.7993	.7875	.7759	.7644	.7531	.7421
2-3	.7600	.7413	.7230	.7053	.6879	.6710	.6546	.6385	.6228	.6075
3-4	.6808	.6574	.6349	.6131	.5921	.5718	.5522	.5333	.5150	.4974
4-5	.6099	.5831	.5575	.5330	.5096	.4873	.4659	.4455	.4259	.4072
5-6	.5463	.5172	.4895	.4634	.4386	.4152	.3931	.3721	.3522	.3334
6-7	.4894	.4588	.4299	.4029	.3775	.3538	.3316	.3108	.2913	.2730
7-8	.4385	.4069	.3775	.3502	.3250	.3015	.2798	.2596	.2409	.2235
8-9	.3928	.3609	.3314	.3045	.2797	.2569	.2360	.2168	.1992	.1830
9-10	.3519	.3201	.2910	.2647	.2407	.2189	.1991	.1811	.1647	.1498
10-11	.3152	.2839	.2556	.2301	.2072	.1866	.1680	.1513	.1362	.1227
11-12	.2824	.2518	.2244	.2000	.1783	.1590	.1417	.1264	.1126	.1004
12-13	.2530	.2233	.1970	.1739	.1535	.1355	.1196	.1055	.0932	.0822
13-14	.2266	.1981	.1730	.1512	.1321	.1154	.1009	.0882	.0770	.0673
14-15	.2030	.1757	.1519	.1314	.1137	.0984	.0851	.0736	.0637	.0551
15-16	.1819	.1558	.1334	.1143	.0979	.0838	.0718	.0615	.0527	.0451
16-17	.1629	.1382	.1172	.0993	.0842	.0714	.0606	.0514	.0436	.0369
17-18	.1460	.1225	.1029	.0864	.0725	.0609	.0511	.0429	.0360	.0303
18-19	.1308	.1087	.0903	.0751	.0624	.0519	.0431	.0358	.0298	.0248
19-20	.1171	.0964	.0793	.0653	.0537	.0442	.0364	.0299	.0246	.0203
20-21	.1049	.0855	.0697	.0568	.0462	.0377	.0307	.0250	.0204	.0166
21-22	.0940	.0758	.0612	.0493	.0398	.0321	.0259	.0209	.0169	.0136
22-23	.0842	.0673	.0537	.0429	.0343	.0274	.0218	.0175	.0139	.0111
23-24	.0754	.0596	.0472	.0373	.0295	.0233	.0184	.0146	.0115	.0091
24-25	.0676	.0529	.0414	.0324	.0254	.0199	.0156	.0122	.0095	.0075
25-30	.0492	.0374	.0285	.0217	.0165	.0126	.0096	.0073	.0056	.0043
30-35	.0284	.0205	.0149	.0108	.0078	.0057	.0041	.0030	.0022	.0016
35-40	.0164	.0113	.0078	.0054	.0037	.0025	.0018	.0012	.0008	.0006
40-45	.0094	.0062	.0041	.0027	.0017	.0011	.0008	.0005	.0003	.0002
45-50	.0054	.0034	.0021	.0013	.0008	.0005	.0003	.0002	.0001	.0001

TABLE B (Continued)

Discount Factors For Cash Effects Which Occur Uniformly Over One-Year Periods After the Reference Point

Year	21%	22%	23%	24%	25%	26%	27%	28%	29%	30%
0-1	.9020	.8976	.8933	.8890	.8848	.8806	.8764	.8722	.8681	.8640
1-2	.7311	.7204	.7098	.6993	.6891	.6790	.6690	.6592	.6495	.6400
2-3	.5926	.5781	.5639	.5501	.5367	.5235	.5107	.4982	.4860	.4741
3-4	.4804	.4639	.4481	.4327	.4179	.4037	.3899	.3765	.3637	.3513
4-5	.3894	.3723	.3560	.3404	.3255	.3112	.2976	.2846	.2721	.2602
5-6	.3156	.2988	.2829	.2678	.2535	.2400	.2272	.2151	.2036	.1928
6-7	.2558	.2398	.2247	.2106	.1974	.1850	.1734	.1626	.1524	.1428
7-8	.2074	.1924	.1786	.1657	.1538	.1427	.1324	.1229	.1140	.1058
8-9	.1681	.1544	.1419	.1303	.1197	.1100	.1011	.0929	.0853	.0784
9-10	.1363	.1239	.1127	.1025	.0933	.0848	.0772	.0702	.0638	.0581
10-11	.1105	.0995	.0896	.0807	.0726	.0654	.0589	.0530	.0478	.0430
11-12	.0895	.0798	.0711	.0634	.0566	.0504	.0450	.0401	.0357	.0319
12-13	.0726	.0641	.0565	.0499	.0441	.0389	.0343	.0303	.0267	.0236
13-14	.0588	.0514	.0449	.0393	.0343	.0300	.0262	.0229	.0200	.0175
14-15	.0477	.0413	.0357	.0309	.0267	.0231	.0200	.0173	.0150	.0130
15-16	.0387	.0331	.0284	.0243	.0208	.0178	.0153	.0131	.0112	.0096
16-17	.0313	.0266	.0225	.0191	.0162	.0137	.0117	.0099	.0084	.0071
17-18	.0254	.0213	.0179	.0150	.0126	.0106	.0089	.0075	.0063	.0053
18-19	.0206	.0171	.0142	.0118	.0098	.0082	.0068	.0057	.0047	.0039
19-20	.0167	.0137	.0113	.0093	.0077	.0063	.0052	.0043	.0035	.0029
20-21	.0135	.0110	.0090	.0073	.0060	.0049	.0040	.0032	.0026	.0021
21-22	.0110	.0088	.0071	.0058	.0046	.0038	.0030	.0024	.0020	.0016
22-23	.0089	.0071	.0057	.0045	.0036	.0029	.0023	.0018	.0015	.0012
23-24	.0072	.0057	.0045	.0036	.0028	.0022	.0018	.0014	.0011	.0009
24-25	.0058	.0046	.0036	.0028	.0022	.0017	.0013	.0011	.0008	.0007
25-30	.0032	.0025	.0019	.0014	.0011	.0008	.0006	.0005	.0004	.0003
30-35	.0011	.0008	.0006	.0004	.0003	.0002	.0002	.0001	.0001	.0001
35-40	.0004	.0003	.0002	.0001	.0001	.0001	-	-	-	-
40-45	.0001	.0001	.0001	-	-	-	-	-	-	-

TABLE B (Continued)

Discount Factors For Cash Effects Which Occur Uniformly Over One-Year Periods After the Reference Point

Year	31%	32%	33%	34%	35%	36%	37%	38%	39%	40%
0-1	.8598	.8558	.8517	.8477	.8438	.8398	.8359	.8319	.8281	.8242
1-2	.6307	.6214	.6123	.6034	.5946	.5859	.5774	.5689	.5606	.5525
2-3	.4626	.4512	.4402	.4295	.4190	.4088	.3988	.3891	.3796	.3703
3-4	.3393	.3277	.3165	.3057	.2953	.2852	.2755	.2661	.2570	.2482
4-5	.2488	.2379	.2275	.2176	.2081	.1990	.1903	.1820	.1740	.1664
5-6	.1825	.1728	.1636	.1549	.1466	.1388	.1314	.1244	.1178	.1115
6-7	.1339	.1255	.1176	.1102	.1033	.0968	.0908	.0851	.0798	.0748
7-8	.0982	.0911	.0845	.0785	.0728	.0676	.0627	.0582	.0540	.0501
8-9	.0720	.0662	.0608	.0558	.0513	.0471	.0433	.0398	.0366	.0336
9-10	.0528	.0480	.0437	.0397	.0362	.0329	.0299	.0272	.0248	.0225
10-11	.0387	.0349	.0314	.0283	.0255	.0229	.0207	.0186	.0168	.0151
11-12	.0284	.0253	.0226	.0201	.0180	.0160	.0143	.0127	.0113	.0101
12-13	.0208	.0184	.0162	.0143	.0127	.0112	.0099	.0087	.0077	.0068
13-14	.0153	.0134	.0117	.0102	.0089	.0078	.0068	.0060	.0052	.0045
14-15	.0112	.0097	.0084	.0073	.0063	.0054	.0047	.0041	.0035	.0030
15-16	.0082	.0071	.0060	.0052	.0044	.0038	.0033	.0028	.0024	.0020
16-17	.0060	.0051	.0043	.0037	.0031	.0027	.0022	.0019	.0016	.0014
17-18	.0044	.0037	.0031	.0026	.0022	.0018	.0015	.0013	.0011	.0009
18-19	.0032	.0027	.0023	.0019	.0016	.0013	.0011	.0009	.0007	.0006
19-20	.0024	.0020	.0016	.0013	.0011	.0009	.0007	.0006	.0005	.0004
20-21	.0017	.0014	.0012	.0009	.0008	.0006	.0005	.0004	.0003	.0003
21-22	.0013	.0010	.0008	.0007	.0005	.0004	.0004	.0003	.0002	.0002
22-23	.0009	.0007	.0006	.0005	.0004	.0003	.0002	.0002	.0002	.0001
23-24	.0007	.0005	.0004	.0003	.0003	.0002	.0002	.0001	.0001	.0001
24-25	.0005	.0004	.0003	.0002	.0002	.0002	.0001	.0001	.0001	.0001
25-30	.0002	.0002	.0001	.0001	.0001	.0001	-	-	-	-

TABLE B (Continued)

Discount Factors For Cash Effects Which Occur Uniformly Over One-Year Periods After the Reference Point

Year	41%	42%	43%	44%	45%	46%	47%	48%	49%	50%
0-1	.8204	.8166	.8128	.8090	.8053	.8016	.7979	.7942	.7906	.7869
1-2	.5444	.5365	.5287	.5210	.5135	.5060	.4987	.4914	.4843	.4773
2-3	.3613	.3525	.3439	.3357	.3274	.3194	.3117	.3041	.2967	.2895
3-4	.2398	.2316	.2237	.2162	.2088	.2017	.1948	.1882	.1818	.1756
4-5	.1591	.1522	.1455	.1392	.1331	.1273	.1217	.1164	.1114	.1065
5-6	.1056	.1000	.0947	.0897	.0849	.0804	.0762	.0720	.0682	.0646
6-7	.0701	.0657	.0616	.0577	.0541	.0507	.0476	.0446	.0418	.0392
7-8	.0465	.0432	.0401	.0372	.0345	.0320	.0298	.0276	.0256	.0238
8-9	.0309	.0284	.0260	.0240	.0220	.0202	.0186	.0171	.0157	.0144
9-10	.0205	.0186	.0170	.0154	.0140	.0128	.0116	.0106	.0096	.0087
10-11	.0136	.0122	.0110	.0099	.0089	.0081	.0073	.0065	.0059	.0053
11-12	.0090	.0080	.0072	.0064	.0057	.0051	.0045	.0040	.0036	.0032
12-13	.0060	.0053	.0047	.0041	.0036	.0032	.0028	.0025	.0022	.0020
13-14	.0040	.0035	.0030	.0027	.0023	.0020	.0018	.0015	.0014	.0012
14-15	.0026	.0023	.0020	.0017	.0015	.0013	.0011	.0010	.0008	.0007
15-16	.0018	.0015	.0013	.0011	.0009	.0008	.0007	.0006	.0005	.0004
16-17	.0012	.0010	.0008	.0007	.0006	.0005	.0004	.0004	.0003	.0003
17-18	.0008	.0006	.0005	.0005	.0004	.0003	.0003	.0002	.0002	.0002
18-19	.0005	.0004	.0004	.0003	.0002	.0002	.0002	.0001	.0001	.0001
19-20	.0003	.0003	.0002	.0002	.0002	.0001	.0001	.0001	.0001	.0001
20-21	.0002	.0002	.0001	.0001	.0001	.0001	.0001	.0001	.0000	-
21-22	.0001	.0001	.0001	.0001	.0001	.0001	.0000	-	-	-
22-23	.0001	.0001	.0001	.0001	.0000	-	-	-	-	-
23-24	.0001	.0001	.0000	-	-	-	-	-	-	-
24-25	.0000	-	-	-	-	-	-	-	-	-

TABLE B (Continued)

Discount Factors For Cash Effects Which Occur Uniformly Over One-Year Periods After the Reference Point

Year	51%	52%	53%	54%	55%	56%	57%	58%	59%	60%
0-1	.7833	.7798	.7762	.7727	.7692	.7657	.7622	.7588	.7554	.7520
1-2	.4704	.4636	.4569	.4503	.4438	.4374	.4311	.4248	.4187	.4127
2-3	.2825	.2756	.2689	.2624	.2560	.2498	.2438	.2379	.2321	.2265
3-4	.1696	.1639	.1583	.1529	.1477	.1427	.1379	.1332	.1287	.1243
4-5	.1019	.0974	.0932	.0891	.0852	.0815	.0780	.0746	.0713	.0682
5-6	.0612	.0579	.0548	.0519	.0492	.0466	.0441	.0418	.0395	.0374
6-7	.0367	.0344	.0323	.0303	.0284	.0266	.0249	.0234	.0219	.0205
7-8	.0221	.0205	.0190	.0176	.0164	.0152	.0141	.0131	.0121	.0113
8-9	.0132	.0122	.0112	.0103	.0094	.0087	.0080	.0073	.0067	.0062
9-10	.0080	.0072	.0066	.0060	.0054	.0050	.0045	.0041	.0037	.0034
10-11	.0048	.0043	.0039	.0035	.0031	.0028	.0026	.0023	.0021	.0019
11-12	.0029	.0026	.0023	.0020	.0018	.0016	.0014	.0013	.0011	.0010
12-13	.0017	.0015	.0013	.0012	.0010	.0009	.0008	.0007	.0006	.0006
13-14	.0010	.0009	.0008	.0007	.0006	.0005	.0005	.0004	.0004	.0003
14-15	.0006	.0005	.0005	.0004	.0004	.0003	.0003	.0002	.0002	.0002
15-16	.0004	.0003	.0003	.0002	.0002	.0002	.0002	.0001	.0001	.0001
16-17	.0002	.0002	.0002	.0001	.0001	.0001	.0001	.0001	.0001	.0001
17-18	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0000	-	-
18-19	.0001	.0001	.0001	.0000	-	-	-	-	-	-
19-20	.0000	-	-	-	-	-	-	-	-	-

CONTINUOUS DISCOUNT FACTOR EQUATIONS

Table A - At a Point in Time after the Reference Point

$$f_A = e^{-RT/100}$$

Table B - Uniformly over One-Year Periods after the Reference Point

$$f_B = 100^{-RT/100} \times \frac{1-e^{-R/100}}{R} = f_A \times f_C, \ 1 \text{ yr}$$

Table C - Uniformly over a Period of Years, Starting with the Reference Point

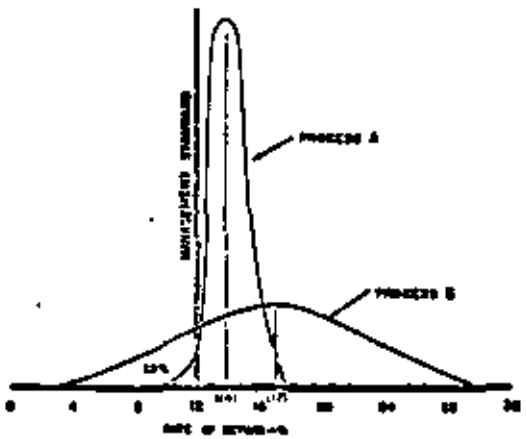
$$f_C = \frac{100}{RT}(1-e^{-RT/100}) = \frac{100\ (1-f_A)}{RT}$$

Table D - Declining to Zero at a Constant Rate over a Period Of Years

$$f_D = \frac{200}{RT}\left[1 - \frac{100(1-e^{-RT/100})}{RT}\right] = \frac{200}{RT}(1-f_C)$$

WHERE R = Rates of return, %,
T = Time, years,
e = 2.71828

RATE OF RETURN PROBABILITY DISTRIBUTION



SESSION NO. 2 - PRACTICAL PROFITABILITY

This session further reviews the fundamentals of project evaluation. It deals with several important concepts including:

1. Project cash flow,
2. Cost of capital,
3. Depreciation methods,
4. Income taxes,
5. The project earning rate (internal rate of return) and the incremental rate of return.

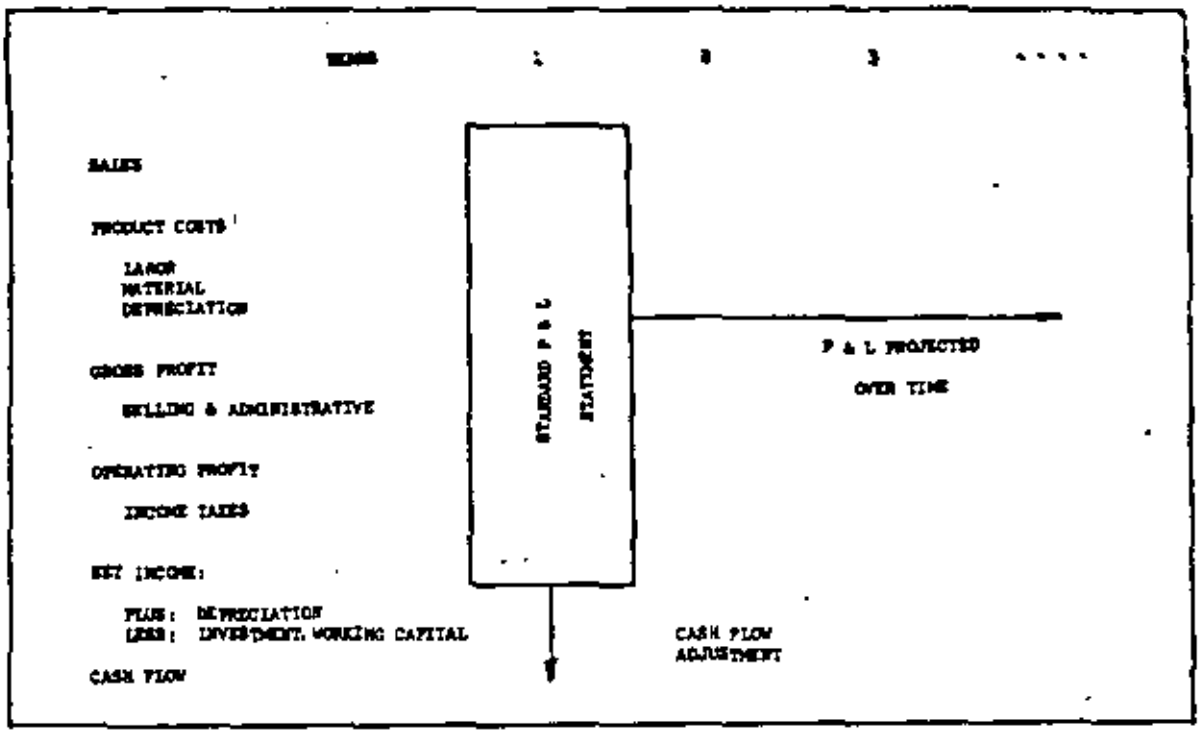
Special topics include graphical shortcuts such as the capital charge chart, which can be used in revenue requirement studies. Other subjects covered are the pros and cons of DCF rates of return versus present value for measuring project attractiveness, comparing projects with different lives, multiple solutions, and minimum acceptable return guidelines.

1. Cash Flow Table

It is necessary to count your cash before you discount it. As a result, when using DCF techniques, a cash flow table is the necessary starting point. It summarizes the forecast investment, operating costs, revenues, and tax effects associated with a given alternate. The final result is the money stream, or cash flow, in and out of the project.

The cash flow table is relatively simple to construct, adaptable to all types of problems, self-checking, and consistent with accounting concepts.

This session reviews the basic concepts. Practice in preparing and using the cash flow table are given in the workshop problems in Session 3.



CASH FLOW TABLE

CASH FLOW TABLE HAS 4 ZONES

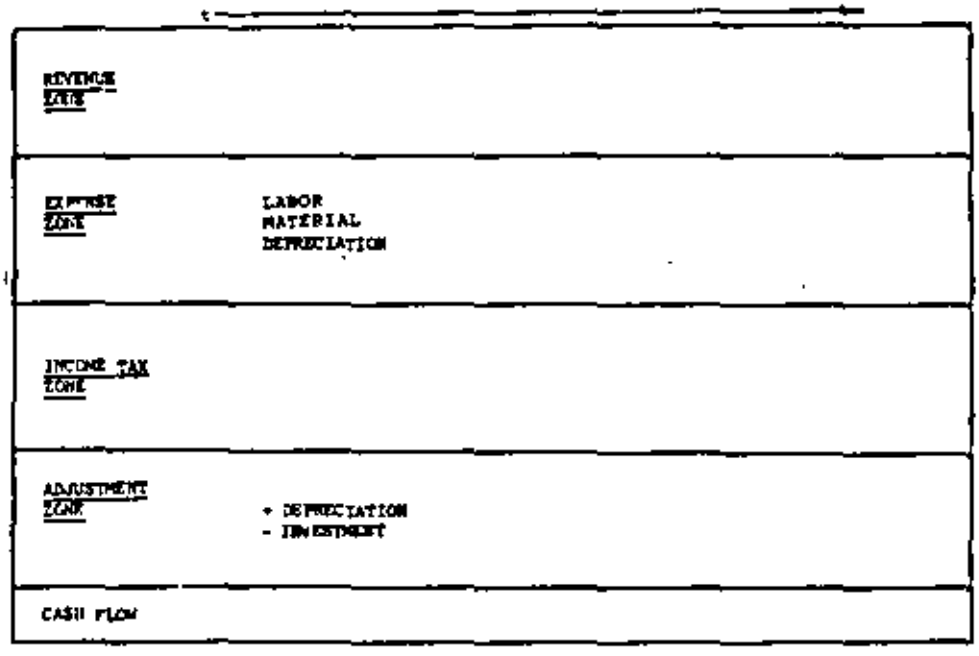


Table 8

Plastic A - Post Installation Appraisal

Condensed Profit & Loss Statement, $M

	Net Sales	Cash Costs(1)	Deprec.	Taxable Net Income	Tax Rate, %	Net Profit A/T	Cash Return	Investment: Fixed Cap.	Investment: Working Cap.	Cash Proceeds: Annual	Cash Proceeds: Cumulative	Memo: Capacity Costs(3)
1949								3,068		(3,068)	(3,068)	-
1950		500(2)		(500)	38%	(310)	(310)	1,537		(1,847)	(4,915)	-
1951	6,120	2,492	307	3,321	38%	2,059	2,366		1,315	1,051	(3,684)	NA
1952	9,900	3,708	307	5,885	38%	3,649	3,956			3,956	92	3,708
1953	9,000	3,813	307	4,880	38%	3,026	3,333			3,333	3,425	3,813
1954	9,000	3,918	307	4,775	54%	2,197	2,504			2,504	5,929	3,918
1955	9,000	4,023	307	4,670	54%	2,148	2,455			2,455	8,384	4,023
1956	7,560	3,900	307	3,353	54%	1,542	1,849		(150)	1,999	10,383	4,128
1957	6,750	3,886	307	2,557	54%	1,176	1,483			1,483	11,866	4,233
1958	5,520	3,627	307	1,586	54%	729	1,036			1,036	12,902	4,338
1959	4,840	3,465	307	1,068	54%	491	798		(150)	948	13,850	4,443
1960	3,800	3,184	307	309	54%	142	449			449	14,299	4,548
1961	3,400	3,022	307	71	54%	33	340		(80)	420	14,719	4,650
End			1,228	(1,228)		(568)	660		(935)	1,595	16,314	
	74,890	39,538	4,605	30,747		16,314	20,919	4,605	0	16,314		

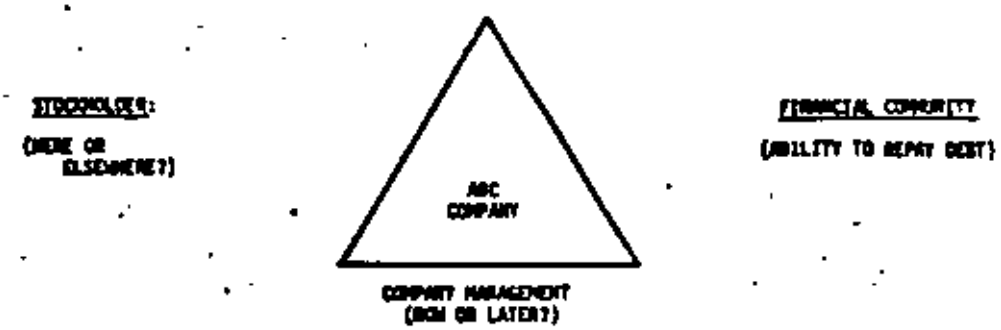
(1) Includes manufacturing, marketing, and general office expense.
(2) Startup expense.
(3) Actual and estimated cash costs, if plant had operated at capacity each year.

2. Cost of Capital

The minimum return standard used in judging a project's attractiveness, is based on a firm's cost of capital. A firm finances its operations through various sources of funds. The cost of capital is the weighted average after-tax cost of these funds. Since most investments are long-term, only long-term funds are normally included in this calculation. These include long-term debt, common and preferred stock, and retained earnings.

The cost of capital varies somewhat from industry to industry, and company to company, depending on the average riskness of the enterprise. In the U.S., a typical value has been in range of 10 per cent, at historic inflation rates. With recent increased inflation, a more typical current value is 12 per cent.

Firms generally select minimum return standards for new investments that are somewhat above their theoretical cost of capital. This allows a margin for adversity, recognizing the uncertainties in all estimates, and the inherent optimism in many.



SOURCES OF CAPITAL

EXTERNAL	INTERNAL
LONG TERM DEBT	DEPRECIATION
COMMON STOCK	RETAINED EARNINGS
PREFERRED STOCK	
SHORT TERM DEBT	
LEASES*	

*ALTHOUGH LEASES STILL ARE JUST FOOTNOTED ON THE BALANCE SHEET THEY ARE REGARDED AS A FORM OF A LONG TERM DEBT.

WEIGHTED COST OF CAPITAL
(ELECTRIC UTILITY)

	DEBT	EQUITY	TOTAL
CAPITAL STRUCTURE, %	50	50	100
COST, %	8	12	
WEIGHTED COST, B.T., %	4	6	10
WEIGHTED COST, A.T., %	2	6	8

WEIGHTED COST OF CAPITAL
(TYPICAL NON-UTILITY)

	DEBT	EQUITY	TOTAL
CAPITAL STRUCTURE, %	30	70	100
COST, %	8	12	
WEIGHTED COST B.T.,%	2.4	8.4	10.8
WEIGHTED COST A.T.,%	1.2	8.4	9.6

Minimum Acceptable Return Guidelines

1. Long term investment should be judged against your general corporate standard of "x" per cent. Disinvestment decisions involving potential disposal of existing assets should also be judged using the general standard.

   Note: "X" typically ranges from 10 per cent to 15 per cent.

2. Investment opportunities which arise having a return below "x" per cent, but above the return from money market securities, should not be foregone if they are also short term, highly liquid, and reversible.

   Note: Close coordination between operating and financial personnel is required for effective decision-making in these matters.

3. Projects with implicit fund-raising decisions are a second exception to the general corporate guidelines of "x" per cent. For such decisions, the interest rate implicit in the proposal should be determined and compared against the best source of raising such funds.

   Note: Examples include leasing, loan guarantees, factoring receivables, and stretching payables.

3. Depreciation Methods

Depreciation for tax purposes is permitted only for assets that have a limited useful life. This cost allocation, over the asset's life, can be made by any reasonable method, as long as the method is consistently applied. The three methods most commonly used in the U.S. are, 1) the straight-line method (SL), 2) the declining-balance method (DB), and 3) sum-of-the-years-digits method (SYD).

In foreign countries the SYD method is seldom used. When accelerated depreciation is allowed, it is generally done either by allowing a shorter life for a straight-line write-off, a one-time above average write-off in the first year, or some form of declining balance write-off.

STRAIGHT LINE DEPRECIATION

YEAR	AMOUNT*
1	1/10
-	-
5	1/10
-	-
10	1/10

* N = 10 YEARS S.L. = 1/10

SYD DEPRECIATION

YEAR	AMOUNT*
1	10/55
2	9/55
3	8/55
-	-
5	6/55
-	-
10	1/55

* N = 10 YEARS SYD = N (N + 1) / 2
= (10 x 11) / 2
= 55

DOUBLE DECLINING BALANCE

YEAR	AMOUNT	REMAINING
1	20%	80%
2	16%	64%
3	12.8%	51.2%
4	10.2%	41.0%

4. Income Taxes

The various local, state, national, and foreign taxes paid by a firm represent an important cost area determined by law. Emphasis here is on income taxes, because of their importance and complexity. The law usually gives the corporate taxpayer some flexibility in determining the amount and timing of the taxes he must pay. Also, the laws change frequently. For example, there have been significant changes in U.S. federal income tax regulations in 1969, 1971, 1975, and 1976. As a result, proper treatment of corporate tax effects is a broad, ever changing problem. A decision made today based on today's tax laws may be invalid tomorrow. Like most problems, a complete and lasting solution to proper tax management cannot be found. However, tax effects based on current tax laws, can be pinned down with more certainty than with many other facets of investment economics.

Major attention in this seminar will be paid to the incremental tax effects from acquiring, cost allocating, and disposing of assets within a large corporation. The tax treatment selected for various business situations should maximize the corporation's present value.

Principal U.S. Income Taxes on Corporations (1976 Basis)

	Per Cent
Normal Tax Rate (on first $25,000 of income)	20
Surtax (on next $25,000 of income)	22
Rate on income above $50,000	48
Capital Gains Tax	30
Tax on Dividends Received--48% of 15%	7.2
Tax Credit on Tangible Investments	10

Changes in U.S. Tax on Ordinary Income

Year(s)	Tax Rate, %
1950	42
1951	50.75
1952-63	52
1964	50
1965-67	48
1968-69	52.8
1970	49.2
1971-76	48

Changes in Investment Credit

1954	Introduced	7%
1966-7	Suspended	
1969	Cancelled	
1971	Restored	7%
1975	"Temporary" Increase	10%

Illustrative Foreign Tax Rates

Country	Effective 1976 Tax	Country	Effective 1976 Tax
Switzerland	9.8%	Australia	46.8%
Hong Kong	17.0%	Brazil	50.1%
Egypt	40.1%	Great Britain	52.0%
Columbia	43.7%	Germany	53.3%
Taiwan	43.7%	Iran	53.1%
Indonesia	45.0%	Nigeria	70.0%

Acquiring A Firm

1. [illegible]

   - stock for stock
   - stock for assets
   - cash for stock
   - cash for assets

2. Tax aspects--very complex

3. Example--immediately taxable or tax-free exchange
   --conflict in buyer and selling interests

Disposing of Assets

1. Various methods, differing tax effects

2. Examples

   o Exchanges
   o Condemnations
   o Sales
   o Normal Retirement
   o Abnormal Retirements

[illegible]

	REVENUE DOLLAR	CASH EXPENSE (OUT OF POCKET)	NONCASH (DEPRECIATION)	CAPITAL DOLLAR
REVENUE	1.00	-	-	-
LESS:				
CASH EXPENSE	-	1.00	-	-
DEPRECIATION	-	-	1.00	-
TOTAL EXPENSES	-	1.00	1.00	-
TAXABLE BALANCE	1.00	(1.00)	(1.00)	-
INCOME TAX	.50	(.50)	(.50)	-
BALANCE AFTER TAX	.50	(.50)	(.50)	-
PLUS: DEPRECIATION	-	-	1.00	-
LESS: INVESTMENT	-	-	-	1.00
CASH FLOW	.50	(.50)	.50	(1.00)

5. Internal Rate of Return

The concept of a project bank is a useful way to visualize the DCF procedure, with cash outlays as deposits, and positive cash flows as withdrawals. The only difference from the normal savings bank is that the project bank doesn't publish its interest rate, and a trial and error procedure is necessary to determine it.

Simple examples illustrate the project bank concept, the corresponding cash flow table, and the discounting procedure. Practice in these calculations is given in the workshop problems in Session 3.

A set of discount factor tables, based on annual compounding, supplements the continuous factors in Session 1.

SAVINGS ACCOUNT

Year	Deposits	Interest	Withdrawals	Balance
0	$100.00	-	-	$100.00
1	-	$ 10.00	$ 30.00	80.00
2	-	8.00	20.00	68.00
3	20.00	6.80	-	94.80
4	-	9.48	20.28	84.00
5	-	8.40	92.40	0
	$120.00	$ 42.68	$162.68	0

PROJECT BANK

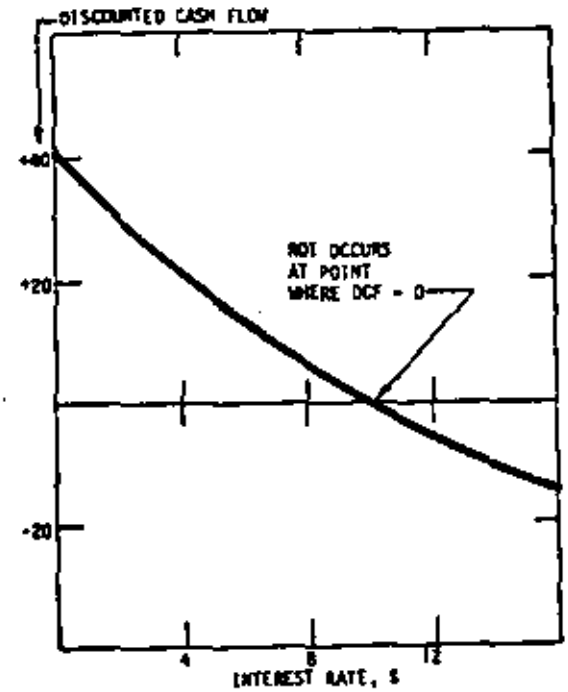
YEAR	DEPOSITS	WITHDRAWALS	CASH FLOW
0	($100.00)		($100.00)
1		$ 30.00	30.00
2		$ 20.00	20.00
3	($ 20.00)		(20.00)
4		$ 20.28	20.28
5		$ 92.40	92.40
	$120.00	$162.68	$ 42.68

EYE SERVICE CO.

	0	1	2	3	4	5
REVENUE		60.00	65.00	70.00	80.00	90.00
LESS: MAINTENANCE			25.00	70.00	39.44	
AD VALOREM TAX		3.00	3.00	3.00	3.00	3.00
DEPRECIATION		3.00	3.00	3.00	3.00	3.00
WRITE OFF						85.00
TOTAL EXPENSES		6.00	31.00	76.00	45.44	91.00
TAXABLE BALANCE		54.00	34.00	(6.00)	34.56	8.80
LESS: INCOME TAX		27.00	17.00	(3.00)	17.28	4.40
BALANCE AFTER TAXES		27.00	17.00	(3.00)	17.28	4.40
PLUS: DEPRECIATION		3.00	3.00	3.00	3.00	3.00
PLUS: WRITE OFF						85.00
LESS: INVESTMENT	100.00			20.00		
CASH FLOW	(100.00)	30.00	20.00	(20.00)	20.28	92.40

DISCOUNTED CASH FLOW

Year	Cash Flow	(5%) Trail #1 P.V.	Amount	(12%) Trial #2 P.V.	Amount	(10%) Trial #3 P.V.	Amount
0	($100.00)	1.000	($100.00)	1.000	($100.00)	1.000	($100.00)
1	30.00	.926	27.80	.893	26.80	.909	27.30
2	20.00	.857	17.20	.797	15.95	.826	16.52
3	(20.00)	.794	(15.90)	.712	(14.25)	.751	(15.02)
4	20.28	.735	14.90	.636	12.91	.683	13.88
5	92.40	.681	62.80	.567	52.30	.621	57.30
Total	$ 42.68		$ 6.80		($ 6.29)		($ .02)


DISCOUNTED CASH FLOW
+40
+20
-20
ROI OCCURS
AT POINT
WHERE DCF = 0
4
8
12
INTEREST RATE, %

PRESENT VALUE OF 1 AT COMPOUND INTEREST

Annual

Period	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	Period
1	.9901	.9804	.9709	.9615	.9524	.9434	.9346	.9259	.9174	.9091	1
2	.9803	.9612	.9426	.9246	.9070	.8900	.8734	.8573	.8417	.8265	2
3	.9706	.9423	.9151	.8890	.8638	.8396	.8163	.7938	.7722	.7513	3
4	.9610	.9239	.8885	.8548	.8227	.7921	.7629	.7350	.7084	.6830	4
5	.9515	.9057	.8626	.8219	.7835	.7473	.7130	.6806	.6499	.6209	5
6	.9421	.8879	.8375	.7903	.7462	.7050	.6663	.6302	.5963	.5645	6
7	.9327	.8706	.8131	.7599	.7107	.6651	.6228	.5835	.5470	.5132	7
8	.9235	.8535	.7894	.7307	.6768	.6274	.5820	.5403	.5019	.4665	8
9	.9143	.8368	.7664	.7026	.6446	.5919	.5439	.5003	.4604	.4241	9
10	.9053	.8204	.7441	.6756	.6139	.5584	.5084	.4632	.4224	.3856	10
11	.8963	.8043	.7224	.6496	.5847	.5268	.4751	.4289	.3875	.3505	11
12	.8875	.7885	.7014	.6246	.5568	.4970	.4440	.3971	.3555	.3186	12
13	.8787	.7730	.6810	.6006	.5303	.4688	.4150	.3677	.3262	.2897	13
14	.8700	.7579	.6611	.5775	.5051	.4423	.3878	.3405	.2992	.2633	14
15	.8614	.7430	.6419	.5553	.4810	.4173	.3625	.3152	.2745	.2394	15
16	.8528	.7284	.6232	.5339	.4581	.3936	.3387	.2919	.2519	.2176	16
17	.8444	.7142	.6050	.5134	.4363	.3714	.3166	.2703	.2311	.1978	17
18	.8360	.7002	.5874	.4936	.4155	.3503	.2959	.2502	.2120	.1799	18
19	.8277	.6864	.5703	.4746	.3957	.3305	.2765	.2317	.1945	.1635	19
20	.8195	.6730	.5537	.4564	.3769	.3118	.2584	.2145	.1784	.1486	20

Accumulated

Period	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	Period
1	.990	.980	.971	.962	.952	.943	.935	.926	.917	.909	1
2	1.970	1.942	1.913	1.886	1.859	1.833	1.808	1.783	1.759	1.736	2
3	2.941	2.884	2.829	2.775	2.723	2.673	2.624	2.577	2.531	2.487	3
4	3.902	3.808	3.717	3.630	3.546	3 465	3 387	3.312	3.240	3.170	4
5	4.853	4.713	4.580	4.452	4.329	4.212	4.100	3.993	3.890	3.791	5
6	5.795	5.601	5.417	5.242	5.076	4.917	4.767	4.623	4 486	4.355	6
7	6.728	6 472	6.230	6.002	5.786	5 582	5.389	5.206	5 033	4.868	7
8	7.652	7.325	7.020	6.733	6.463	6 210	5 971	5.747	5.535	5.335	8
9	8.566	8 162	7.786	7 435	7.108	6 802	6.515	6.247	5.995	5.759	9
10	9 471	8.983	8.530	8.111	7.722	7.360	7.024	6.710	6 418	6.145	10
11	10 368	9.787	9.253	8.760	8.306	7.887	7 499	7.139	6.805	6.495	11
12	11.255	10.575	9.954	9.385	8.863	8 384	7.943	7.536	7.161	6.814	12
13	12.134	11.348	10 635	9 986	8.394	8 853	8.358	7.904	7.487	7.103	13
14	13.004	12.106	11 296	10 563	9.899	9.295	8.745	8.244	7.786	7.367	14
15	13.865	12.849	11.938	11.118	10.380	9.712	9.108	8.559	8.061	7.606	15
16	14.718	13 578	12.561	11.652	10.838	10.106	9.447	8.851	8.313	7 824	16
17	15.562	14.292	13.166	12 166	11.274	10.477	9.763	9.122	8 544	8.022	17
18	16.398	14.992	13.754	12.659	11.690	10.828	10.059	9 372	8.756	8.201	18
19	17.226	15 678	14 324	13 134	12 085	11.158	10 336	9 604	8.950	8.365	19
20	18 046	16.351	14.877	13.590	12.462	11.470	10 594	9.818	9.129	8.514	20

PRESENT VALUE OF 1 AT COMPOUND INTEREST 48

Annual

Period	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%	Period
1	.9009	.8929	.8850	.8772	.8696	.8621	.8547	.8475	.8403	.8333	1
2	.8116	.7972	.7831	.7695	.7562	.7432	.7305	.7182	.7062	.6944	2
3	.7312	.7118	.6931	.6750	.6575	.6407	.6244	.6086	.5934	.5787	3
4	.6587	.6355	.6133	.5921	.5718	.5523	.5337	.5158	.4987	.4823	4
5	.5935	.5674	.5428	.5194	.4972	.4761	.4561	.4371	.4191	.4019	5
6	.5346	.5066	.4803	.4556	.4323	.4104	.3898	.3704	.3521	.3349	6
7	.4817	.4524	.4251	.3996	.3759	.3538	.3332	.3139	.2959	.2791	7
8	.4339	.4039	.3762	.3506	.3269	.3050	.2848	.2660	.2487	.2326	8
9	.3909	.3606	.3329	.3075	.2843	.2630	.2434	.2255	.2090	.1938	9
10	.3522	.3220	.2946	.2696	.2472	.2267	.2080	.1911	.1756	.1615	10
11	.3173	.2875	.2607	.2366	.2149	.1954	.1778	.1619	.1476	.1346	11
12	.2858	.2567	.2307	.2076	.1869	.1685	.1520	.1372	.1240	.1122	12
13	.2575	.2292	.2042	.1821	.1625	.1452	.1299	.1163	.1042	.0935	13
14	.2320	.2046	.1807	.1597	.1413	.1252	.1110	.0985	.0876	.0779	14
15	.2090	.1827	.1599	.1401	.1229	.1079	.0949	.0835	.0736	.0649	15
16	.1883	.1631	.1415	.1229	.1069	.0930	.0811	.0708	.0618	.0541	16
17	.1696	.1456	.1252	.1078	.0929	.0802	.0693	.0600	.0520	.0451	17
18	.1528	.1300	.1108	.0946	.0808	.0691	.0592	.0508	.0437	.0376	18
19	.1377	.1161	.0981	.0830	.0703	.0596	.0506	.0431	.0367	.0313	19
20	.1240	.1037	.0868	.0728	.0611	.0514	.0433	.0365	.0308	.0261	20

Accumulated

Period	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%	Period
	.901	.893	.885	.877	.870	.862	.855	.847	.840	.833	1
	1.713	1.690	1.668	1.647	1.626	1.605	1.585	1.566	1.547	1.528	2
	2.444	2.402	2.361	2.322	2.283	2.246	2.210	2.174	2.140	2.106	3
4	3.102	3.037	2.974	2.914	2.855	2.798	2.743	2.690	2.639	2.589	4
5	3.696	3.605	3.517	3.433	3.352	3.274	3.199	3.127	3.058	2.991	5
6	4.231	4.111	3.998	3.889	3.785	3.685	3.589	3.498	3.410	3.326	6
7	4.712	4.564	4.423	4.288	4.160	4.039	3.922	3.812	3.706	3.605	7
8	5.146	4.968	4.799	4.639	4.487	4.344	4.207	4.078	3.954	3.837	8
9	5.537	5.328	5.132	4.946	4.772	4.607	4.451	4.303	4.163	4.031	9
10	5.889	5.650	5.426	5.216	5.019	4.833	4.659	4.494	4.339	4.192	10
11	6.206	5.938	5.687	5.453	5.234	5.029	4.836	4.656	4.487	4.327	11
12	6.492	6.194	5.918	5.660	5.421	5.197	4.988	4.793	4.611	4.439	12
13	6.750	6.424	6.122	5.842	5.583	5.342	5.118	4.910	4.715	4.533	13
14	6.982	6.628	6.302	6.002	5.725	5.468	5.229	5.008	4.802	4.611	14
15	7.191	6.811	6.462	6.142	5.847	5.575	5.324	5.092	4.876	4.675	15
16	7.379	6.974	6.604	6.265	5.954	5.668	5.405	5.162	4.938	4.730	16
17	7.549	7.120	6.729	6.373	6.047	5.749	5.475	5.222	4.990	4.775	17
18	7.702	7.250	6.840	6.467	6.128	5.818	5.534	5.273	5.033	4.812	18
19	7.839	7.366	6.938	6.550	6.198	5.877	5.584	5.316	5.070	4.844	19
20	7.963	7.469	7.025	6.623	6.259	6.929	5.628	5.353	5.101	4.870	20

6. Incremental Rate of Return

An analysis is made of two mutually-exclusive alternates, one with increasing income and one with falling income, to further illustrate procedures and show that the incremental rate of return must be calculated in order to choose the preferred alternative. The preferred choice also varies with the minimum acceptable return standard being used.

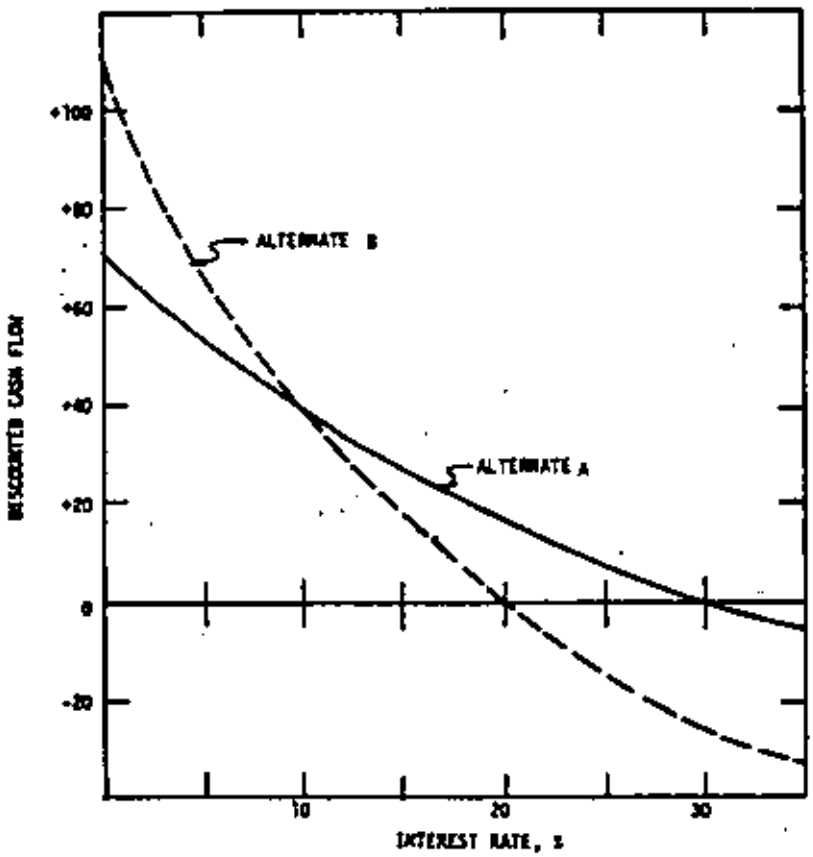
CONSIDER MUTUALLY EXCLUSIVE

ALTERNATIVES TWO AT A TIME ----

GIVEN:	ALTERNATIVES	
YEAR	A	B
0	-113	-115
1	75	15
2	55	20
3	35	45
4	15	60
5	5	85

INCREMENTAL DISCOUNTED CASH FLOW

		Interest Rate, %					
		0	8	11	15	20	30
Alt. A	0	-115	-115	-113	-113	-113	-113
	1	75	69	68	65	63	58
	2	55	47	44	42	38	33
	3	35	28	26	23	20	18
	4	15	11	10	9	7	5
	5	5	3	3	2	1	1
Cash Flow		72	43	38	28	17	0
Alt. B	0	-115	-115	-115	-115	-115	-115
	1	15	14	14	13	13	12
	2	20	17	16	15	14	12
	3	45	34	33	30	26	20
	4	60	44	40	34	29	21
	5	85	28	20	12	6	0
Cash Flow		110	24	8	19	0	-9
Alt. B-A	0	-2	-2	-2	-2	-2	-2
	1	-60	-55	-54	-52	-51	-46
	2	-35	-30	-28	-27	-24	-21
	3	10	6	7	7	6	4
	4	45	33	30	25	22	16
	5	80	23	12	5	2	1
Cash Flow		38	-19	-17	-44	-17	-27


+100
+80
+60
+40
+20
0
-20
DISCOUNTED CASH FLOW
ALTERNATE B
ALTERNATE A
10
20
30
INTEREST RATE, %

What is the Capital Charge Chart for Your Business?

Let I_{FC} = fixed capital, $, spent uniformly over investment period,

I_{WC} = working capital, $, invested at start of sales, and recovered without gain or loss on terminating the project.

t_{FC} = fixed investment period, years

t_{max} = project life, years

Tr = tax rate, % of taxable profits

R = discount rate, %.

P = uniform annual profit, before taxes and depreciation

$\left[f_{A,C,D}\right]_t$ = appropriate discount factor from Table A, C, D, over period t.

Then, capital charge = P/I x 100, %.

Assume:

1. Negligible startup time, i.e., sales begin at end of construction,
2. 10% investment credit at start of sales,
3. Depreciation life equals project life,
4. SYD depreciation of fixed investment, no salvage,
5. Uniform sales and profits over project life,
6. No inflation effects.

A. Capital Charge Calculation for Fixed Capital

At the solution rate R of the DCF equation calculate the annual profit, before taxes and depreciation, which will just cover the net investment, after investment credit, and tax depreciation allowances. The equation of discounted after-tax cash flows has the form:

(1) Required Project Profit = Original Investment - Investment Credit - Depreciation Tax Credit

Taking the reference point at the start of sales, this becomes

$$(2)\quad \left[(1-Tr)\,P\,t_{max}\right]\left[f_c\right]_{t_{max}} = I_{FC}\left[\frac{f_c}{f_a}\right]_{t_{FC}} - 0.1\,I_{FC} - (Tr)\,I_{FC}\left[f_D\right]_{t_{max}}$$

Rearranging,

$$(3)\quad \text{Fixed Capital Charge} = \frac{P}{I_{FC}}(100) = \frac{\left[\frac{f_c}{f_a}\right]_{t_{FC}} - 0.1 - Tr\left[f_D\right]_{t_{max}}}{(1-Tr)_{t_{max}}\left[f_c\right]_{t_{max}}} \times (100)$$

Sample Calculation, at 48% tax rate, 2-year investment period, and 15-year profit life:

Page 3

R	t_{FC}, Yr.	t_{max}, Yr.	$\left[f_c/f_a\right]_{t_{PC}}$	$\left[f_D\right]_{t_{max}}$	$\left[f_c\right]_{t_{max}}$	Capital Chrg. %
0	2	15	1.0	1.0	1.0	5.38
5	2	15	.9516/.9048 = 1.0517	.7906	.7025	10.43
10	2	15	.9063/.8187 = 1.1070	.6428	.5179	17.29
15	2	15	.8639/.7408 = 1.1662	.5333	.3976	26.12
20	2	15	.8242/.6703 = 1.2296	.4555	.3167	36.88
30	2	15	.7520/.5488 = 1.3703	.3468	.2196	64.38

B. Capital Charge Calculation for Working Capital

Since working capital is not depreciable and is not subject to the investment credit, the corresponding working capital equation is:

$$(1) \quad \left[(1-Tr)\, P\, t_{max}\right]\left[f_c\right]_{t_{max}} = I_{WC} - I_{WC}\left[f_A\right]_{t_{max}} = I_{WC}\left(1-\left[f_A\right]_{t_{max}}\right).$$

However, f_c is related to f_A.

$$(2) \quad f_c = \frac{100}{RT}\,(1-f_A)$$

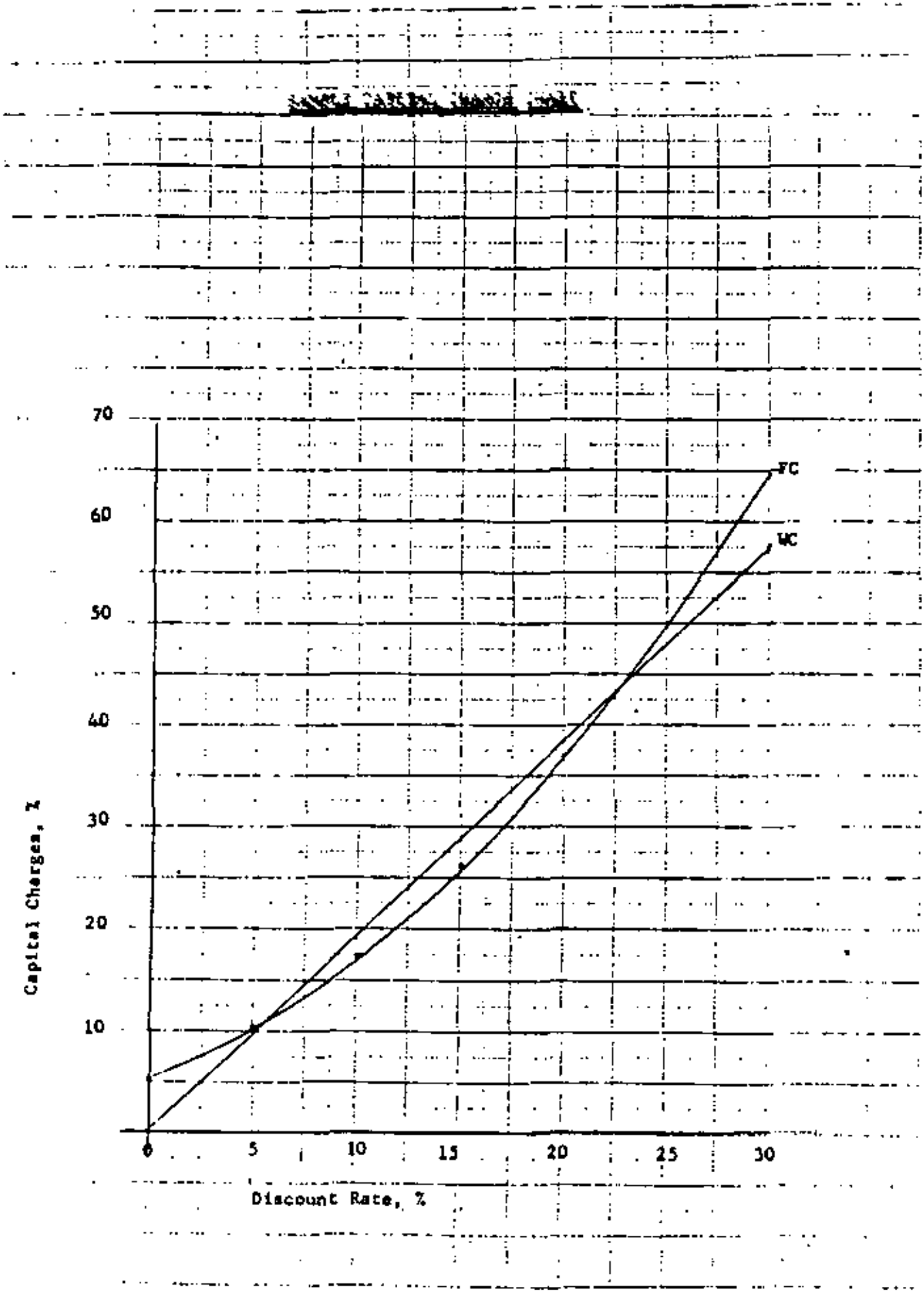
Rearranging and substituting,

$$(3) \quad \text{Working Capital Charge} = \frac{P}{I_{WC}} \times 100 = \left[\frac{1-f_A}{f_c}\right]_{t_{max}} \times \frac{100}{(1-Tr)\, t_{max}}$$

$$= \frac{R}{1\text{-Tax Rate}}.$$

The working capital equation is a straight line through the origin, with a slope of 1/1-Tax Rate.

The corresponding chart of fixed and working capital charges is shown on page 1-24.


70
60
50
40
30
20
10
FC
WC
Capital Charges, %
0
5
10
15
20
25
30
Discount Rate, %

DCF Rate of Return vs. Present Value

(Both useful)

Present Value (at Minimum Acceptable Return)

1. Less chance of error by analyst in selecting preferred alternate (simpler, safer, easier and more direct)

2. Less meaningful to management (need separate calculation to relate to size of investment and relative riskiness and uncertainty in estimates)

DCF Rate of Return

1. Handled correctly, gives same answer as present value method.

2. More meaningful to management since results are reported as a ratio to investment (directly comparable to cost of capital; margin for adversity and risk analyses easier to interpret).

3. Therefore preferred, despite need for greater care in calculations.

4. Multiple solution problems occur infrequently (only when the cumulative cash proceeds change sign more than once), and suitable techniques for eliminating the problem exist.

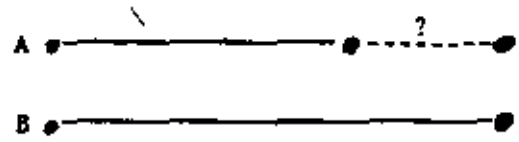
Comparison of Projects with Different Lives

1. Valid comparison must compare terminal values at same point (Preferred option has maximum terminal value, and therefore the maximum present value)

2. Simple approach - total years tabulated is the least common multiple of the estimated lives of the several alternates.

   Example: Project A - 20 year life
   Project B - 30 year life
   Least Common multiple = 60 years.

   Schematic



3. Capitalized Costs - present worth of perpetual service.

4. Will replacement assets repeat the costs and revenues of the initial asset?

5. Apparent Exception - Continue Operations vs. Shutdown

Multiple Solution Problem

A. The DCF equation is a power series

The DCF calculation consists of finding a solution to an equation of the form:

$$0 = A + BC^{-RT_b} + Ce^{-RT_c} + De^{-RT_d} - - -$$

where:

A, B, C, etc., are the amounts of cash which are received or paid out at various times.

e is the base of the natural logarithms,

T_a, T_b, T_c, etc., refer to the times at which the payments are made or the income received.

R is the DCF rate.

B. To solve this for R generally requires trial and error

C. More than 1 solution to this type of power series is possible.

D. We are interested only in positive values of R

E. It can be shown that the number of positive DCF earnings rates cannot exceed the number of changes in sign of the cumulative cash position (CCP).

F. In almost all cases there is only 1 sign change in cumulative cash position. In this case there is one and only one DCF earnings rate.

G. For more than 1 sign change the situation is complicated:

1. For an odd number of sign changes, there is always at least one positive earnings rate, but there can also be more than one solution.

2. For an even number of sign changes, the standard DCF procedure may not lead to any value of earnings rate, or it may lead to several values of earnings rate, or it may lead to 1 meaningless rate.

H. There is a way around this problem.
Use an auxiliary interest rate as a "crutch", for the temporary surpluses in CCP. This was originally proposed by R. I. Reul.

USING AN AUXILIARY INTEREST RATE AS A "CRUTCH"
(per R. I. Reul)

Using a stipulated interest rate of 10% results in the following successful trial.

Timing	Actual Cash Flow	Present Worths Factor @ 10%	Factor @ 19%	Amounts
-1	$+ 50	1.10		+ 55
0	-100		1.00	-100
+2	+ 25		.70	+ 18
+3	+ 25		.59	+ 15
+4	+ 25		.48	+ 12
				0

Answer = 19%

Using a stipulated interest rate of 6% results in the following successful trial.

Timing	Actual Cash Flow	Present Worths Factor @ 6%	Factor @ 17%	Amounts
-1	+ 50	1.06		+ 53
0	-100		1.00	-100
+2	+ 25		.73	+ 18
+3	+ 25		.62	+ 16
+4	+ 25		.53	+ 13
				0

Answer = 17%

CONCLUSION: Earning rate equivalent to other projects earning between 17% and 19%.

NOTE: For this example, the crutch rate assumption was not critical and had little effect on the final answer.

SESSION NO. 3 - POST-INSTALLATION APPRAISALS

Post-installation appraisals are a useful management tool for improving decision-making reliability. They offer three sought-after results: (1) providing management with information on the success of new investments, (2) uncovering areas where improvements can be made to individual projects, (3) determining the soundness of original assumptions, policies, and analyses. Several examples are discussed here.

The use of the technique is illustrated further in Session 5 with the use of experience results to indicate the likely uncertainty in project analyses. Practice in these techniques is given in the Loco Chemicals Company case begun in Session 4. A useful reference article is appended.

Financial Performance Measure

1. Total Company
2. Individual Projects

The Post - Installation Appraisal (PIA)

1. What happened?
2. Why did it happen?
3. What can be done?

Program Objectives

	Relative Difficulty
1. Measure Physical Performance	Easy
2. Review Original Decision Basis	Hard
3. How Improve Existing Operations?	Varies
4. Any Evaluation Procedure Inadequacies?	Varies
5. Provide Future Decision Guides	Varies

Method of Operation

1. Project Scheduling
2. Study Scope
3. Problem Areas
   - —Data
   - —Timing
   - —Who Does Work?
4. Reporting Results

Summary Economics Statement

	Original Evaluation	Post-Installation Appraisal		
		Results To Date	Current Forecast	Total
Time Period	X	X	X	X
Physical Output	X	X	X	X
Investment	X	X	X	X
Profit & Loss	X	X	X	X
Cumulative Task Flow	X	X	X	X
Rate of Return	X			X
Return Sensitivities	X			X

Rate of Return Reconciliation

	Change in Return	Rate of Return
Original Evaluation		X
Revision to base case	X	
Procedural changes	X	
Revised Original Evaluation		X
Investment effects	X	
Startup effects	X	
Annual profit effects		
Expenses	X	
Volume	X	
Price	X	
Current Forecast		X

Three Case Histories

Example 1 Effect of Foreign Competition
Example 2 Need to Push Developments Quickly
Example 3 Many Companies in a Small Market

Example 1 — Summary Economics

	Original Evaluation		Post-Installation Appraisal	
Physical Output				
Capacity, MM lb.	1.2		1.2	
% of Capacity, Year 1	67%		44%	
Investment, $M				
Fixed Capital	550		584	
Working Capital	100		88	
	650		672	
First Year Results	**$M**	**¢/lb.**	**$M**	**¢/lb.**
Revenues	1040	130	658	126
Expenses	950	119	646	124
After - Tax Profit	90	11	12	2
Return on Investment	13.9%		1.8%	

Example 1 — Rate of Return Reconciliation

	Change in Return	Rate of Return
Original Evaluation		13.9
Investment Effects	-0.5	
Sales Volume	-8.0	
Selling Price	-2.5	
Expenses	-1.1	
Actual Result		1.8

Example 2 – Summary Economics

	Original Evaluation		Post-Installation Appraisal	
Physical Output				
Capacity, MM lb.	10		10	
% of Capacity, Year 1	46%		76%	
Investment, $M	1200		823	
First Year Results,	$M	¢/lb.	$M	¢/lb.
Revenues	921	20.0	1500	19.2
Expenses	766	16.6	1140	14.6
After-Tax Profit	155	3.4	360	4.8
Return on Investment	13%		44%	

Example 3 – Summary Economics

	Original Evaluation (Expansion Investment)	Post-Installation Appraisal (Expansion Investment)
Physical Output		
Capacity, tons	9000	9000
% of Capacity, Year 1	18%	3%
Investment, $M		
Fixed Capital	500	630
Working Capital	20	45
	520	675
First Year Results, $M		
Revenues	220	(5)
Expenses	225	65
After-Tax Profit	(5)	(70)
Estimated Return at Capacity	24%	15%
Years to Reach Capacity	5	10

PIA Benefits

1. Measure individual investment success
2. Uncover areas where improvements can be made
3. Feedback for increasing reliability of future decisions

TYPICAL LESSONS FROM PIA'S

1. Important alternates are sometimes forgotten.

2. The original economics are generally high--this is generally over optimism rather than cost omissions.

3. There is often inadequate attention to timing (should it be done now, or later, or has it been put off too long?).

4. Inadequate attention to learning.

5. Inadequate attention to external factors, leading to gross errors in volume and price.

6. Evaluation procedures have been improving.

SESSION NO. 4 - WORKSHOP NO. 1

Several short problems, with solutions, are presented in order to illustrate some of the important points covered in the first two lectures.

Problem 1
Shows that the non-discounted solution methods can wrongly rank project alternatives,

Problem 2
Relates the accountant's book rate of return to the discounted cash flow rate of return,

Problem 3
Illustrates the use of continuous discount factors, the development of present values for unusual patterns and the beginning use of the cash flow table,

Problem 4
Requires the development of a more detailed cash flow table,

Problem 5
Illustrates some of the problems in analyzing a short-life project. It requires another cash flow table and provides a brief introduction to project sensitivities.

Case Problem
In addition to these short problems, a more involved case, Loco Chemicals Company, has been developed to simulate a real-life situation with a number of alternatives. This case has proven itself extremely useful as a common thread for tying the lectures together. The class is divided into smaller groups who work on separate parts of the problem and integrate the results in a fashion that simulates their doing this under the real conditions in industry. A completed post-audit, analysis of a number of alternatives, and appropriate sensitivities permit the group to reach a conclusion as to the preferred course of action, and to complete an appropriation request for necessary funds. Work on the case is continued in Session 6 and completed in Session 12.

Although the numbers have been developed to be reasonably typical of the chemical industry, the type of problem illustrated, and the procedures used are completely general, and can be applied equally in any business.

PROBLEM NO. 1

Effect of Economic Yardsticks on Project Ranking

Three mutually exclusive projects, all with an investment of $1000, five year life and $200/yr. depreciation.

Time	A Declining Income Profit After Taxes	B Steady Income Profit After Taxes	C Increasing Income Profit After Taxes
0			
0-1	275	155	0
1-2	200	155	100
2-3	130	155	260
3-4	70	155	250
4-5	0	155	290
Total Profit	675	775	840
Avg. Profit	135	155	168

Question: How do these projects rank, using return on original investment, payout, PI, present value at 10%?

PROBLEM #2

A project requires an initial investment of $100,000 and yields cash income of $20,000/yr. for a 10-year period. Calculate:

a. Average Book Rate of Return, by year, and for the over-all project, assuming straight line depreciation (Note: average investment is the average of the opening and closing investment, for each time period).

b. Discounted cash flow rate of return.

c. Using trial and error, modify the book depreciation schedule to yield a constant book rate of return over the life of the project (Note: total depreciation is still $100,000).

d. How do you interpret the results obtained?

PROBLEM #3

a. An investment of $20,000 made two years from now with an 8-year depreciation life, will permit before-tax savings of $10,000/yr. for 4 years. What is the present value of this investment today, at 12% PI? Use SYD depreciation and a 50% tax rate. Assume salvage value after 4 years operation is the undepreciated balance.

b. A new facility cost $100,000 (land $40,000; construction, $60,000) and has a 20-year economic life. Sales volume is estimated at $450,000/yr. in the third and subsequent years, with an annual cash return (including depreciation) of $9,000/yr., and associated working capital of $15,000 in these years. In the first and second years, volume is estimated at 1/3 and 2/3 of capacity, respectively. Assume working capital and annual cash return are proportional to volume and assume the depreciable facilities have no salvage value after 20 years. What is the present value at 0%, 5%, 10%? What is the PI?

PROBLEM #4

Economic Summary

Plant Capacity	10 MM lb./yr.
Fixed Capital, $M	3,000
Working Capital, $M	696
Startup Expense, $M	480
	4,176
Variable Costs $M/yr at capacity	1,300
Fixed Costs, $M/yr	900
	2,200

Problem #4 Cont.

Sales Buildup (annual sales level)	20,40, 60, 80, 100% in 5th year on
Sales Price	30¢/lb., constant
Construction Time	1-1/2 years
Startup Time	3 months
Economic Life	15 years
Depreciable Life (STD)	15 years
Tax Rate	50%

a. Prepare a yearly P & L statement.

b. What is the discounted cash flow rate of return?

PROBLEM #5

You are Financial Vice President of Krock Manufacturing Company, a firm which makes a variety of waxes and polishes. Last week a fire completely destroyed the weeble wax blender and management faces the decision whether to replace this unit or discontinue manufacturing the product.

Weeble wax was once a high-volume high-profit product but is now on the way out. The new plastic weeble (which does not require waxing) is gradually replacing the old wooden type, with the result that sales are shrinking each year and will soon disappear entirely. Krock's marketing research people project weeble wax sales as follows:

	M Tons
1964	1100
1965	800
1966	550
1967	350
1968	200
1969	nil

The fire insurance company has already paid Krock $125,000, the book value of the blender that was destroyed.

A new blender will cost $500,000 installed. Although this machine normally has a 10 year life, this one will have no further use at the end of 1968, when it will be scrapped. Salvage value will be about the same as the cost of dismantling. Inventory on hand has a book value (at cost) of $100,000. If Krock decides to discontinue manufacture of weeble wax, this material can be sold at cost. Otherwise, the inventory will be liquidated in the normal course of operations at the end of 1968.

Estimated working capital requirements (including inventories) are $.16/annual ton sales.

Sale of the product nets $2/ton at the plant. Variable costs, amount to $1.30/ton and fixed costs, other than depreciation, to $200,000/year. The company pays a combined federal-state tax rate of 55%. During the past five years, Krock's return on total invested capital has ranged from 8 to 12%. The cost of capital is 10%.

In one hour, Krock's executive committee will meet to decide whether to replace the blender or discontinue the manufacture of waxble wax. The decision will depend largely on your opinion.

1) What is the yearly and average book rate of return that this operation will earn?

2) What is the discounted rate of return?

3) What is the effect of 10¢/ton price reduction?

4) How is the discounted return affected if sales have been overestimated by 20,000 ton/year?

5) What is your recommendation?

Problem No. 1

Effect of Economic Yardsticks on Project Ranking

Three mutually exclusive projects, all with an investment of $1,000, five-year life, and 200/year depreciation.

Yardsticks	A Declining Income	Rank	B Steady Income	Rank	C Increasing Income	Rank
Return on Orig. Inv.	13.5%	3	15.5%	2	16.8%	1
Payout	2.4 yr.	1	2.8 yr.	2	3.2 yr.	3
PI	28.1	1	25.7	2	22.8	3
PV @ 10%	371	3	394	1	389	2

In this example, the two undiscounted methods each gave different rankings, and neither selected project B. The undiscounted methods do have their place, if used with caution. Payout, in particular, is often reported along with a discounted cash flow result to help measure project riskiness; and where very high returns (short payouts) are desired, can often be used satisfactorily as the only criterion.

Notice particularly that the different yardsticks give different ranking when the three projects are compared against a base case of "no business." However, remember the rule given earlier, and compare mutually exclusive alternates two at a time; i.e., B-A and B. The cash flows and discounted cash flows follows:

	B-A Cash Flow	C-B Cash Flow
0	0	0
0-1	-120	-155
1-2	-45	-55
2-3	+25	+45
3-4	+85	+95
4-5	+155	+135
	+100	+65
PV @ 10%	+25	-7
PI	15	9

On this basis, both PI and PV give the same ranking and show B as the preferred project. For those difference calculations return on original investment and payout cannot be calculated in the usual way as there is no investment, just increased and decreased expenses.

Problem 1 Calculations

1. Return on original investment, % = (Average Profit/Original Investment)

Project A ROI = (135/1000) x 100 = 13.5%

Project B ROI = (155/1000) x 100 = 15.5%

Project C ROI = (168/1000) x 100 = 16.8%

Payout Time = years for cash flow to total the original investment.

Assume cash return is uniform over any year.

		Year 1	Year 2	Year 3	Year 4	Total Years
Project A:	1000 =	475 +	400 +	125 +	0	= 2 + 125/330 = 2.4
Project B:	1000 =	355 +	355 +	290 +	0	2 + 290/355 = 2.8
Project C:	1000 =	200 +	300 +	400 +	100	3 + 100/450 = 3.2

PI and Present Value

	Project A				Project B				Project C			
	Cash Flow	Discounted Cash Flow ($)			Cash Flow	Discounted Cash Flow ($)			Cash Flow	Discounted Cash Flow ($)		
TIME	$	10%	25%	30%	$	10%	25%	30%	$	10%	20%	25%
	-1000	-1000	-1000	-1000	-1000	-1000	-1000	-1000	-1000	-1000	-1000	-1000
0-	475	452	420	410	355	338	314	307	200	190	182	178
1-2	400	345	275	256	355	306	244	227	300	259	223	206
2-3	330	257	177	156	355	276	191	168	400	312	242	214
3-4	270	190	113	95	355	250	148	124	450	316	223	188
4-5	200	127	65	52	355	224	116	92	48	312	199	159
	675	371	50	(31)	775	394	13	(82)	840	389	69	(55)
PI			28.1%				25.7%				22.8%	

SOLUTION TO PROBLEMS NO. 2

Part 2a

Rate of Return Using Conventional Depreciation Accounting

Year	Cash Income	Depreciation	Profit	Closing Investment	Average[1] Investment	Rate of[2] Return
1				100,000		
1	20,000	10,000	10,000	90,000	95,000	10.5%
2	20,000	10,000	10,000	80,000	85,000	11.7
3	20,000	10,000	10,000	70,000	75,000	13.3
4	20,000	10,000	10,000	60,000	65,000	15.4
5	20,000	10,000	10,000	50,000	55,000	18.2
6	20,000	10,000	10,000	40,000	45,000	22.2
7	20,000	10,000	10,000	30,000	35,000	28.6
8	20,000	10,000	10,000	20,000	25,000	40.0
9	20,000	10,000	10,000	10,000	15,000	66.7
10	20,000	10,000	10,000	0	5,000	200.0
Total	200,000	100,000	100,000			
Average			10,000		50,000	20.0%

Memo: PI = 16% (See next page)

1 Average of opening and closing investment for each year.

2 Ratio of annual profit to average investment.

Problem No. 2

Part 2b

First Method: By year - Using Table B

Time	Cash Flow, $	Discounted Cash Flow at 16% Table B Factor	Discounted Cash Flow at 16% Present Value	Discounted Cash Flow at 15% Table B Factor	Discounted Cash Flow at 15% Present Value
0	-100,000	1.0000	-1,000,000	1.0000	-100,000
0-1	20,000	.9241	18,482	.9286	18,572
1-2	20,000	.7875	15,750	.7993	15,986
2-3	20,000	.6710	13,420	.6879	13,758
3-4	20,000	.5718	11,436	.5921	11,842
4-5	20,000	.4873	9,746	.5096	10,192
5-6	20,000	.4152	8,304	.4386	8,772
6-7	20,000	.3538	7,076	.3775	7,550
7-8	20,000	.3015	6,030	.3250	6,500
8-9	20,000	.2569	5,138	.2797	5,594
9-1	20,000	.2189	4,378	.2407	4,814
	100,000		(240)		3,580

Second Method: Using Table C

Time	Cash Flow, $	Discounted Cash Flow at 16% Table C Factor	Discounted Cash Flow at 16% Present Value	Discounted Cash Flow at 15% Table C Factor	Discounted Cash Flow at 15% Present Value
0	-100,000	1.0000	-100,000	1.0000	-100,000
-10	+200,000	0.4988	+ 99,760	0.5179	+103,580
			(240)		3,580

In either method: $PI = 16 - \frac{240}{3820} = 15.94\%$

$= 16\%$ (rounded)

Part 2c

To get a constant book rate of return (which equals PI), it is necessary to write off most of the investment in later years, causing steadily decreasing profits—a trend more reasonable than the uniform accounting convention shown in the table of part 2a.

Depreciation Adjusted to Constant Rate of Return (PI)

Year	Cash Income	Depreciation	Profit	Closing Investment	Average Investment	Rate of Return (PI)
0				100,000		
1	20,000	4,400	15,600	95,600	97,800	16.0%
2	20,000	5,160	14,840	90,440	93,020	16.0
3	20,000	6,040	13,960	84,400	87,420	16.0
4	20,000	7,100	12,900	77,300	80,850	16.0
5	20,000	8,320	11,680	68,980	73,140	16.0
6	20,000	9,770	10,230	59,210	64,095	16.0
7	20,000	11,460	8,540	47,750	53,480	16.0
8	20,000	13,450	6,550	34,300	41,025	16.0
9	20,000	15,780	4,220	18,520	26,410	16.0
10	20,000	18,520	1,480	0	9,260	16.0
Total	200,000	100,000	100,000			
Average			10,000		62,650	16.0%

Notes:

(1) PI is return on outstanding investment, after "depreciation." A zero PI project just recovers the original investment, earns no profit.

(2) This "depreciation" however, on a yearly basis, does not represent the accountants typical allocation.

Part 2d

When the depreciation schedule is adjusted to yield a constant book rate of return this return is also equal to the discounted cash flow rate of return, or PI. This illustrates another definition of PI, which is the rate of compound interest at which the outstanding investment in a project is repaid by proceeds from the project.

Solution to Problem No. 3

Part 3a

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Assume a 50% tax rate.

Fraction of 8 year life investment depreciated in 4 years = $\frac{8+7+6+5}{36} = \frac{26}{36}$

Space = Salvage = 10/36 ($20,000) =

Item	Time	Cash Flow		Discounted at 12%	
		Before Tax	After Tax	Factor	Present Value
Investment	2		-20,000	.7866	-15,732
Depreciation	2/6	14,444	7,222	See note below	4,693
Savings	2-6	40,000	20,000	.7866 x .7942	12,494
Salvage	6		5,556	.4868	2,704
					4,159

Note: Method of calculating SYD depreciation (using Table D, Appendix I)

Allowed

Lost

0 2 6 10

Maximum Credit

Depreciation PV = Maximum Possible Less Tax Credit Loss

10,000 x .7866 x .7441 - 2778 x .48684 x .8575 = 5853 - 1160 = 4693

R.T. = 12 x 8 = 96; $^{fd}_{96}$ = .7441

$R.T._2$ = 12 x 4 = 48; $^{fd}_{48}$ = .8575

Part 3b

Year	Cash Return	Fixed Capital	Working Capital[3]	Cash Flow
0		100,000	5,000	-105,000
0-1	3,000			3,000
1			5,000	- 5,000
1-2	6,000			6,000
2			5,000	- 5,000
2-20	$162,000[1]			162,000
20		(40,000)	(15,000)	55,000
	$171,000	$60,000	0	111,000

Time Period	Cash Flow[2] $M	Discounted at 5% Factor	Discounted at 5% PV, $M	Discounted at 10% Factor	Discounted at 10% PV, $M
0	-105	1.0000	-105	1.0000	-105
0-1	3	.9754	3	.9516	3
1	- 5	.9512	- 5	.9048	- 5
1-2	6	.9278	6	.8611	5
2	- 5	.9048	- 5	.8187	- 4
2-20	162	.9048 x .6594	97	.8187 x .4639	62
20	55	.3679	20		7
	111		11		- 37

By linear interpolation approx. PI = $5 - \frac{11}{48}(5)$ PI = 6.1

(1) $9,000/yr. (after tax cash) x 18 = $162,000
(2) 0% Present Value
(3) Assume proportional to sales.

SOLUTION TO PROBLEM NO. 4

Part a

	Constr. (18 Mos.)	Startup (3 Mos.)	1	2	3	4	5	6-10	11-15	Rem.	Tota
	Year-all Figures in M$ (Inflow +; Outflow -)										
Net Sales			600	1,200	1,800	2,400	3,000	15,000	15,000		39,00
Oper. Expense			-260	- 520	- 780	-1,040	-1,300	-6,500	-6,500		
All Other Costs		- 480	-900	- 900	- 900	- 900	- 900	-4,500	-4,500		-30,88
Depr. (15-year SL)			-200	- 200	- 200	- 200	- 200	-1,000	-1,000		- 3,00
Federal Income Tax (48%)		230	365	202	38	- 125	- 288	-1,440	-1,440		- 2,45
Net Profit		- 250	-395	- 218	- 42	135	312	1,560	1,560		2,66
Cash Return		- 250	-195	- 18	158	335	512	2,560			5,66
Cap. Inv.											
Fixed	-3,000										
Working			-140	- 140	- 140	- 140	- 136			696	

Part b

Cash Proceeds											
Year	-3,000	- 250	-335	- 158	18	195	376	2,560	2,560	696	
	-3,000	-3,250	-3,585	-3,743	-3,725	-3,530	-3,154	- 594	-1,966	2,662	
Cash Proceeds by Year, Disc. to Time Zero:											
@ 6%:	-3,185	- 252	- 325	- 145	16	158	287	1,638	1,215	283	-
@ 5%:	-3,160	- 252	- 327	- 147	16	164	300	1,766	1,375	329	

(a) DCF Rate of Return = 5.2%

SOLUTION TO PROBLEM NO. 5

(1) Book Rates of Return

	Start of 1964	Throughout Year 1964	1965	1966	1967	1968	End of 1968	al
Sales, MT	-	1100	800	550	350	200	-	3000
Income Statement, $M								
Revenue	-	2200	1600	1100	700	400	-	6000
Variable Costs	-	1430	1040	715	455	260	-	3900
Fixed Costs	-	200	200	200	200	200	-	1000
Depreciation*	-	91	82	73	64	55	135	500
Taxable Income	-	479	278	112	(19)	(115)	(135)	600
Tax @ 55%	-	(263)	(153)	(62)	11	63	74	(330
Investment Credit**	-	12	-	-	-	-	-	2
Net Profit	-	228	125	50	(8)	(52)	(61)	282
Net Cash Flow from Operations	-	319	207	123	56	3	74	782
Investment, $M								
Plant	(500)	-	-	-	-	-	-	(500
Working Capital	(176)	-	48	40	32	24	32	-
Total Investment	(676)	-	48	40	32	24	32	(500
Total Cash Flow	(676)	319	255	163	88	27	106	282
Book Investment								
Start of Year		676	585	455	342	246		
End of Year		585	455	342	246	167		
Average		630	520	398	294	206		448
Net Profit		228	125	50	(8)	(52)		343
Book Rate of Return		36.2	24.0	12.6	(2.7)	(25.2)		44

*10 year SYD, written off after 1968
**1/3 of 7% of $500M for 5 year life.

(2) Discounted Rate of Return

Year	Cash Flow M $	10% DF	10% PV	18% DF	18% PV	20% DF	20% PV
0	(676)	1.0000	(676)	1.0000	(676)	1.0000	(676)
0-1	319	.9516	304	.9152	292	.9063	289
1-2	255	.8610	220	.7645	195	.7420	189
2-3	163	.7991	127	.6385	104	.6075	99
3-4	88	.7049	62	.5333	47	.4974	44
4-5	27	.6379	17	.4455	12	.4072	11
5	106	.6065	64	.4066	43	.3679	39
			118		17		(5)

DCF Rate of Return = 19.5% for 5 years

But if the investment is approved operations should be reviewed in about 2 years and annually thereafter, as current forecasts indicate the plant should be shut down before complete loss of sales:

Incentive for Shorter Life

Plant Operated	Present Value at 10%, $M	DCF Rate of Return, %
5 years	118	19.5
4 years	145	21.6
3 years	135	22.0
2 years	90	20.0
1 year	(24)	5.4

(3) Lower Price 10¢/ton; DCF Rate of Return = 10.3% (5-year life)

(4) Lower sales 20,000 T/yr.; DCF Rate of Return = 17.8% (5-year life)

Shudown calculations shows the maximum PV_{10}, for operating only four more years. Beyond this, sales decline sufficiently, so that the cash value from salvaging now exceeds the cash value from operating longer and thus salvaging a lesser amount. The base case PI is surprisingly good, but the sensitivities show how small reductions in price or volume can significantly hurt results.

CASE PROBLEM

LOCO CHEMICALS COMPANY

Summary of the Problem

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Loco Chemicals Company is a medium-sized chemical producer which, in a diversification effort after World War II, built a plant in 1949-50 to manufacture Plastic A, their first and, so far, only polymer*.

The process for Plastic A had been based upon internal research and provided a very profitable product in the early years. Partly because of the high profitability, partly because of the loss of a dynamic research director, and partly from the business downturn in 1954, management cut back sharply that year on research and marketing expenditures on Plastic A and decided not to build a technical service laboratory.

Now, in 1961, Loco's sales of Plastic A have declined gradually to 50% of the plant capacity and operations are only slightly above break-even. The quality of Loco's product is now somewhat poorer than that produced by competitive manufacturers. Furthermore, Plastic B has been introduced by other companies, has a large market of its own, and also competes for a portion of Plastic A business.

Alternatives

The situation has become serious enough that Loco's management has called for a careful review and for recommendations as to what their most profitable course of action is. They have narrowed down the choices to the following:

1. Continuing the manufacture and sale of Plastic A.
   a. Continue as is (with an estimated sales life of about 5 years).
   b. Build up sales to plant capacity by extensive marketing effort, construction of technical service facilities, and improvement of the quality of Loco's Plastic A. (The economic life of the present plant is estimated at 10 years.)
   c. Improve manufacturing process and expand Plastic A capacity by 30% (again the estimated useful life of Plastic A is 10 years until the original plant becomes obsolete or uneconomical).
2. Go into the business of manufacturing Plastic B (either continuing or discontinuing manufacture of A).
   a. Purchase commercial plant know-how based on a fixed fee plus running royalty with a maximum.
   b. Continue with research and development by Loco on a process for Plastic B. It is assumed that a successful process will be developed, but it will be 3 years before a plant process will be ready. (The estimated useful life of a Plastic B plant is at least 15 years.)
3. Get out of the plastic business entirely.

*(Although they are not the products involved, it may help in gaining a feel for the problem to think of Plastic A as analogous to polyethylene and Plastic B to polypropylene. Many of their market characteristics are similar to the hypothetical Plastics A and B.)

Available financial and statistical data is given on Tables 1 through 8. 86

Table 1 General Information

Table 2 Forecast Research & Development Costs—Plastic B

Table 3 Estimated Investment & Operating Costs for Major Manufacturing Alternatives

Table 4 Market Information

Table 5 Plastic A Proforma P&L Statements

Table 6 Plastic B Proforma P&L Statements

Table 7 Original 1948 Justification, Plastic A

Table 8 Plastic A Historic P&L Statements

A worksheet for the discounted cash flow calculations is given in Appendix 1 and the suggested format for summarizing a post installation appraisal of Plastic A is given in Appendix 2. The group assignment sheet is also included.

Note: The casewriter's solution will be provided at the end of the seminar.

Table 1

General Information

1. Analysis of accounts shows a tax Book Value on the present Plastic A plant of $1,228,000. Depreciation is scheduled to continue for 4 more years at $307,000/yr. Scrap value of the plant is assumed to be zero. Working capital tied up now in Plastic A, in the form of Receivables, Inventories, and Cash, is $935,000 which is assumed to be totally recoverable.

2. An investment of $100,000 is required for product improvement on the existing Plastic A plant if an aggressive marketing plan is to be adopted. This investment is not needed if the "Do Nothing" marketing plan is followed.

3. Estimated life on the existing 30 MM lb./yr. Plastic A plant is 5 years. A modernization investment of $750,000 is required in 1965 to extend the life to 10 years.

4. Sum-of-the-years-digits depreciation method is used except for facilities installed before 1954 (original Plastic A plant).

5. All overhead costs charged to these projects would be eliminated if Loco were not in the plastics business.

6. Company cost of capital is 10%.

7. Loco in 1962 has a 54% income tax rate.

8. The technical service laboratory investment is $350,000. The timing varies with the option under study. See page 3.

Table 2

Forecast Research and Development Costs - Plastic B

Loco has already spent $800,000 in research effort on Plastic B.

A. Purchased Know-how Terms

A $1,500,000 initial payment (1) is due 1/1/62. A 0.75¢/lb. running royalty is also paid on all production, until the total fee, including initial payment, is $5,000,000. Until Loco's plant is on stream, up to 2 MM lb./yr. of B plastic will be provided for resale at 10% off market price. (Loco believes this margin will be sufficient to just cover the marketing expenses incurred before the start of commercial sales.)

B. Forecast Costs if Loco Continues to Develop its Own Process and Product (2)

a. Development

To prove out new catalyst system and get market acceptance of own product, which is considered equivalent in quality to other commercial production.

	Capital (Semi-works)	Expenses (net after Semi-works sales)
1962	$ 800 M (last 6 mo.)	$ 100 M
1963	$ 400 M (first 6 mo.)	300
1964		800
1965		500
1966		300
	$1200 M	$2000 M

b. Forecast Commercial Plant Benefits

1. Save 10% on plant fixed capital.

2. Save 0.5¢/lb. on catalyst and chemical costs.

(1) Initial payment can be written off over the project life. (Assume SYD depreciatio

(2) Expected to delay commercialization decision 3 years to 1/1/65.

BLR 3

Estimated Costs for Major Manufacturing Alternates

	Plastic A			Plastic B	
	Present Plant		Expansion	Purchase Know-How	Devel-Own Know-How
Plant Capacity	30 MM lb.		10 MM lb.	50 MM lb.	50 MM lb.
Investment - M$					
Fixed Capital					
Plant	1228 (1)		3300	10000	9000
Semi-Works	-		-	-	1200
Royalty	-		-	1500	-
	1228		3300	11500	10200
Working Capital (2)	1315		365	2500	2500
Startup Expense	-		150	1000	1000
	2543		3815	15000	13700
Expenses - M$/Yr.					
Level of Operation	33-1/3%	100% (3)			
Raw Materials	350	1050	350	1550	1550
Utilities	300	900	300	775	775
Catalyst & Chemicals	150	450	150	800	550
Labor	865	1560	270	1750	1475
Maintenance	185	330	110	450	525
Overhead, etc.	185	240	20	300	300
Royalty, Running	-	-	-	375	-
Total Mfg. Cost, ex. Dep.	2035	4530	1200	6000	5175
Investment Period	-		11 Mon	18 Mon	18 Mon
Startup Time	-		1 Month	6 Mon	6 Mon
Economic Life	5 Years		10 Years	15 Years	15 Years

(1) Tax Book Value as of 12/31/61
(2) Requirements for Capacity Operations
(3) Assume costs of operation between 33-1/3 and 100% capacity to be linear.
(4) Marketing Costs given in Table 4.

TABLE 4

Market Information

	1948	1949	1950			1953	1954	1955	1956	1957	1958	1959	1960	6.	...66	1967
PLASTIC A																
Industry																
Actual & Forecast Consumption - MMlb.	62	105	125	158	210	250	263	291	325	370	366	415	442	465	4%/yr.	3%/
Capacity - MMlb.	90	135	220	280	280	360	400	430	430	430	510	550	550	550	growth	6%/
Actual & Forecast Selling Price ¢/lb.	40	37	37	34	33	30	30	30	27	25	23	22	20	20	20	2
Loco Sales, Historical MMlb.				10	30	30	30	30	28	27	24	22	19	17		

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971 & On
Future Marketing Plans														
Plan 1 - Do Nothing														
Quantity, MMlb.					15	13	12	11	10					
Expense, M$					120	115	115	110	110					
Plan 2 - Aggressive Mkt.														
Quantity, MMlb. - No Plt. Expan.					18	25	30(3)	30	30	30	30	30	30	30
- 10 MMlb./yr. Expan.					18	25	35	37	40(3)	40	40	40	40	40
Expense, M$ - No Plt. Expan.					760	850	900	900	900	900	900	900	900	900
- 10 MMlb./yr. Expan.					780	850	950	970	1000	1000	1000	1000	1000	1000
Tech. Serv. Lab. Invest. - M$					350									
PLASTIC B														
Industry														
Forecast Growth, % of Prev. Yr. Volume				40	30	25	20	15	10	10	10	10	10	10
Actual & Forecast (1) Consumption, MMlb.	38	58	75	105	137	172	206	237	261	288	318	351	387	426
Actual & Forecast Selling Price, ¢/lb.	50	50	45	38	35	33	31	29	27	25	25	25	25	25
Future Marketing Plans														
Plan 1 - Purchase Know-how														
Forecast Market Share							10%	12%	14%	16%	18%	20%	22%	24%
Quantity (2) MMlb.							21	28	37	46	50(3)	50	50	50
Expense, M$							1150	1255	1345	1450	1500	1500	1500	1500
Tech. Serv. Lab. Invest. M$					350									
Plan 2 - Develop Own Process														
Forecast Market Share										4%	6%	8%	10%	12%
Quantity (2) MMlb.										12	19	28	37	50
Expense, M$										1045	1130	1235	1370	1500
Tech. Serv. Lab. Invest. M$								350						
PLASTIC A & PLASTIC B COMBINED (4)														
Plastic A, Plan 2 and Plastic B, Plan 1														
Marketing Expense - M$ - Plastic A, 30 MMlb.					780	850	1900	1945	2010	2070	2100	2100	2100	2100
- Plastic A, 40 MMlb.					780	850	1920	1970	2045	2110	2150	2150	2150	2150
Tech. Serv. Lab. Invest. - M$					350									
Plastic A, Plan 2 and Plastic B, Plan 2														
Marketing Expense - M$ - Plastic A, 30 MMlb.					780	850	900	900	900	1795	1850	1905	2000	2100
- Plastic A, 40 MMlb.					780	850	930	970	1000	1875	1925	1970	2050	2150
Tech. Serv. Lab. Invest. - M$					350									

(1) Calculated from 1961 Estimate and Forecast growth rates
(2) Calculated from Forecast Growth rates and market share
(3) Limited by plant capacity
(4) No savings through shared marketing expense if Plastic A, Plan 1, is

TABLE 5

PLASTIC A
PRO FORMA P&L STATEMENT FOR VARIOUS CASES
(thousands of dollars)

Problem 13, Table 1

Continue As Is	Net Sales	S.M., Util., Cat.& Chem.	Labor, Maint., Ovhd.,etc.	Depr.	Mktg. Exp.	Taxable Net Income	Net Profit After Tax - 54%	Cash Returns	Invest.	Cash Proceeds Annual	Cash Proceeds Cumulative	Close at Yr.End Closing Adjust.	Close at Yr.End Cash Proc.
Beginning				(1228)(1)		1228	568	(660)	935	(1595)	(1595)		
1962	3000	1200	1459	307	120	(86)	(40)	267		267	(1328)	1433	107
63	2600	1040	1369	307	115	(231)	(106)	201		201	(1127)	1266	139
64	2400	960	1325	307	115	(307)	(141)	166		166	(961)	1101	140
65	2200	880	1280	307	110	(377)	(173)	134		134	(827)	933	108
66	2000	800	1235		110	(145)	(67)	(67)		(67)	(894)	933	41
End									(933)	933	41		
	12200	4880	6668	-	570	82	41	41	-	41			
Present Plant-Aggressive Marketing													
Beginning				(1228)(1)		1228	568	(660)	935	(1595)	(1595)		
1962	3600	1440	1593	369	780	(582)	(268)	101	450	(349)	(1944)		
63	5000	2000	1907	364	850	(121)	(56)	308	165	143	(1801)		
64	6000	2400	2130	359	900	211	97	456	215	241	(1560)		
65	"	"	"	354	"	216	99	453	750	(297)	(1857)		
66	"	"	"	179	"	391	180	359		359	(1498)		
1967	"	"	"	160	"	410	189	349		349	(1149)		
68	"	"	"	141	"	429	198	339		339	(810)		
69	"	"	"	123	"	447	206	329		329	(481)		
70	"	"	"	104	"	466	215	319		319	(162)		
71	"	"	"	86	"	484	223	309		309	147		
End				189		(189)	(87)	102	(1315)	1417	1564		
	56600	22640	20540	1200	8830	3390	1564	8764	1200	1564			
10 MM lb/yr Expansion													
1962													
63		150(2)				(150)	(69)	(69)	3300	(3369)	(3369)		
64	1000	400	400	600	50	450	(807)	393	185	808	(3161)		
65	1400	560	"	540	70	170	(78)	462	70	392	(2769)		
66	2000	800	"	480	100	820	101	581	110	471	(2298)		
1967	"	"	"	420	"	880	189	549		549	(1749)		
68	"	"	"	360	"	340	156	516		516	(1233)		
69	"	"	"	300	"	600	184	484		484	(749)		
70	"	"	"	240	"	660	212	452		452	(297)		
71	"	"	"	180	"	520	239	419		419	122		
72	"	"	"	120	"	580	267	387		387	509		
73	"	"	"	60	"	640	294	354		354	863		
End									(363)	363	1226		
	18400	7510	4000	3300	580	8670	1828	6528	3300	1228			

(1) Tax Book Value of Existing Plant
(2) Start-up Expense

Included to show effect of continuation relative to shut-down.

TABLE 6

Plastic B
Pro Forma P&L Statements for Various Cases

Purchase Knowhow	Net Sales	R.M., Util. Cat. & Chem.	Labor, Maint., Ovhd., Etc.	Running Royalty	Depres.	Main. Exp.	Taxable Net Income	Net Profit A/T	Cash Return	Invest.	Cash Proceeds Annual	Cash Proceeds Cumulative
1962										7,850	(7,850)	(7,850)
63		1,000(1)			763		(1,763)	(812)	(49)	4,000	(4,049)	(11,899)
64	6,510	1,313	2,500	158	1,490	1,850	(41)	(19)	1,481	1,050	361	(11,538)
65	8,170	1,750	2,500	210	1,331	1,215	1,094	503	1,834	350	1,484	(10,054)
66	9,990	2,310	2,500	277	1,232	1,345	2,326	1,070	2,302	450	1,852	(8,202)
1967	11,500	2,875	2,500	345	1,133	1,450	3,197	1,470	2,603	450	2,153	(6,049)
68	12,500	3,125	2,500	375	1,034	1,500	3,966	1,826	2,860	200	2,660	(3,389)
69	12,500	3,125	2,500	375	935	1,500	4,065	1,870	2,805		2,805	(584)
70	12,500	3,125	2,500	375	836	1,500	4,164	1,919	2,755		2,755	2,171
71	12,500	3,125	2,500	375	737	1,500	4,263	1,965	2,702		2,702	4,873
1972	12,500	3,125	2,500	375	638	1,500	4,362	2,008	2,646		2,646	7,519
73	12,500	3,125	2,500	375	540	1,500	4,460	2,055	2,595		2,595	10,114
74	12,500	3,125	2,500	260	441	1,500	4,674	2,150	2,591		2,591	12,705
75	12,500	3,125	2,500	-	342	1,500	5,033	2,315	2,657		2,657	15,362
76	12,500	3,125	2,500	-	243	1,500	5,132	2,361	2,604		2,604	17,966
1977	12,500	3,125	2,500	-	144	1,500	5,231	2,406	2,550		2,550	20,516
78	12,500	3,125	2,500	-	71	1,500	5,304	2,440	2,511		2,511	23,027
End				-						(2,500)	2,500	25,527
	173,620	43,623	37,500	3,500	11,850	21,680	55,467	25,527	37,377	11,850	25,527	
Develop Knowhow												
1962				100			(700)	(46)	(46)	800	(846)	(846)
63				300	75		(375)	(172)	(97)	400	(497)	(1,343)
64				800	145		(945)	(435)	(290)	-	(290)	(1,633)
65				500	135		(635)	(492)	(357)	6,350	(6,507)	(8,140)
66		1,000(1)		300	1,452		(2,752)	(1,265)	187	3,000	(2,813)	(10,953)
1967	3,000	690	2,300		1,128	1,045	(2,163)	(995)	133	600	(467)	(11,420)
68	4,750	1,092	2,300		1,050	1,130	(822)	(378)	672	350	322	(11,098)
69	7,000	1,610	2,300		972	1,215	883	406	1,378	450	928	(10,170)
70	9,750	2,241	2,300		894	1,320	2,945	1,355	2,249	550	1,699	(8,471)
71	12,500	2,875	2,300		816	1,500	5,009	2,304	3,120	550	2,570	(5,901)
1972	12,500	2,875	2,300		738	1,500	5,087	2,340	3,078		3,078	(2,823)
73	12,500	2,875	2,300		660	1,500	5,165	2,376	3,036		3,036	213
74	12,500	2,875	2,300		583	1,500	5,242	2,411	2,994		2,994	3,207
75	12,500	2,875	2,300		505	1,500	5,320	2,447	2,952		2,952	6,159
76	12,500	2,875	2,300		428	1,500	5,397	2,483	2,911		2,911	9,070
1977	12,500	2,875	2,300		350	1,500	5,475	2,519	2,869		2,869	11,939
78	12,500	2,875	2,300		273	1,500	5,554	2,555	2,828		2,828	14,765
79	12,500	2,875	2,300		194	1,500	5,631	2,590	2,784		2,784	17,549
80	12,500	2,875	2,300		116	1,500	5,709	2,626	2,742		2,742	20,290
81	12,500	2,875	2,300		38	1,500	5,787	2,662	2,700		2,700	22,990
End										(2,500)	2,500	25,490
	162,000	38,258	34,500	2,000	10,550	21,280	55,412	25,490	36,040	10,550	25,490	

(1) Startup Expense
(2) Development Costs

TABLE 7

Original 1948 Justification, Plastic A

Fixed Capital		$ 4,600,000
Working Capital		1,315,000
Total Investment		$ 5,915,000
Sales 30 MM Lb./Yr. @ 35¢/Lb.		10,500,000
Manufacturing Costs, $/Yr.		
Raw Materials		855,000
Processing Costs		
Utilities	$730,000	
Catalyst & Chemicals	365,000	
Labor	813,000	
Maintenance	189,000	
Overhead, etc.	126,000	2,223,000
Depreciation, Straight Line		307,000
Total Manufacturing Cost		$ 3,385,000
Gross Profit		7,115,000
Marketing & General Office Overhead		630,000
Net Profit Before Tax		$ 6,485,000
Federal Income Tax (38%)		$ 2,465,000
Net Profit After Tax		$ 4,020,000
Economics:		
Net Profit as % Sales		38.2
Payout--Years (Net Profit on Total Capital)		1.5

Table 8

Plastic A - Post Installation Appraisal

Condensed Profit & Loss Statement, $M

	Net Sales	Cash Costs(1)	Deprec.	Taxable Net Income	Tax Rate, %	Net Profit A/T	Cash Return	Investment: Fixed Cap.	Investment: Working Cap.	Cash Proceeds: Annual	Cash Proceeds: Cumulative	Memo: Capacity Costs(3)
1949								3,068		(3,068)	(3,068)	-
1950		500(2)		(500)	38%	(310)	(310)	1,537		(1,847)	(4,915)	-
1951	6,120	2,492	307	3,321	38%	2,059	2,366		1,315	1,051	(3,684)	NA
1952	9,900	3,708	307	5,885	38%	3,649	3,956			3,956	92	3,708
1953	9,000	3,813	307	4,880	38%	3,026	3,333			3,333	3,425	3,813
1954	9,000	3,918	307	4,775	54%	2,197	2,504			2,504	5,929	3,918
1955	9,000	4,023	307	4,670	54%	2,148	2,455			2,455	8,384	4,023
1956	7,560	3,900	307	3,353	54%	1,542	1,849		(150)	1,999	10,383	4,128
1957	6,750	3,886	307	2,557	54%	1,176	1,483			1,483	11,866	4,233
1958	5,520	3,627	307	1,586	54%	729	1,036			1,036	12,902	4,338
1959	4,840	3,465	307	1,068	54%	491	798		(150)	948	13,850	4,443
1960	3,800	3,184	307	309	54%	142	449			449	14,299	4,548
1961	3,400	3,022	307	71	54%	33	340		(80)	420	14,719	4,650
End			1,228	(1,228)		(568)	660		(935)	1,595	16,314	
	74,890	39,538	4,605	30,747		16,314	20,919	4,605	0	16,314		

(1) Includes manufacturing, marketing, and general office expense.
(2) Startup expense.
(3) Actual and estimated cash costs, if plant had operated at capacity each year.

ize rs)	Cash Flow	5% Discount Factor	5% Present Value	10% Discount Factor	10% Present Value	15% Discount Factor	15% Present Value	20% Discount Factor	20% Present Value
-1		.9754		.9516		.9286		.9083	
-2		.9278		.8611		.7993		.7021	
-3		.8826		.7791		.6879		.6075	
-4		.8395		.7050		.5921		.4974	
-5		.7986		.6379		.5096		.4072	
-6		.7596		.5772		.4386		.3334	
-7		.7226		.5223		.3775		.2730	
-8		.6874		.4726		.3250		.2235	
-9		.6538		.4276		.2797		.1830	
-10		.6219		.3869		.2407		.1498	
0-11		.5916		.3501		.2072		.1227	
1-12		.5629		.3168		.1783		.1004	
2-13		.5353		.2866		.1535		.0822	
3-14		.5092		.2593		.1321		.0673	
4-15		.4844		.2347		.1137		.0551	
5-16		.4608		.2123		.0979		.0451	
6-17		.4333		.1921		.0842		.0369	
7-18		.4168		.1739		.0725		.0303	
8-		.3966		.1573		.0624		.0248	
9-		.3772		.1423		.0537		.0203	
0-21		.3588		.1288		.0462		.0166	

Appendix 2

Recommended PIA Format

Rate of Return Reconciliation

	Change in Return	Rate of Return	Suggested Calculation Order
Original Evaluation		[ ]	1
Tax Rate Change	X		
Revised Original Evaluation		[ ]	2
Increased Manufacturing Costs	X		4
Below Capacity Sales	X		5
Decreased Price	X		6
Current Forecast		[ ]	3

Group Assignments - Loco Chemical Company

Individual	Alternate	Calculation Day 1	Day 2
1. 2.	A_1, as is	Base PI	Sensitivities*
3. 4.	A_2, aggressive marketing	" "	"
5. 6.	A_3, 10MM Lb/Yr expansion	" "	"
7. 8.	B_1, purchase knowhow	" "	"
9. 10.	B_2, develop own process	" "	"
X	Savings Contribution $B_1 + A_2$,	Calculate PV of savings; restate project PI of A_2 assuming all saving could be so assigned**.	
11. 12.	B_1 vs B_2	Calculate yearly cash proceeds for difference and discount, 0%, 5%, 10%, 15%***plot PV's + interpret.	
13. .	Post Audit of Plastic A	What was original PI? What is PI if get out of business now? What factors explain the difference: (1) tax rate change, (2) increased manufacturing costs, (3) below capacity sales, (4) decreased price.	
16.			

*±1c/lb. in cost or price, ±10% in fixed capital, 20% in volume (sales demand 20% below original forecast, but lining out at original plant capacity).

**For those assigned this case, ask instructor for present values to use for A_2.

***To avoid problem of different lines, assume sales of plastic B continued for 3 years after project termination, without profit or loss.

SESSION NO. 5 - RISK ANALYSIS--PART 1

There are a number of different ways of measuring risk--of varying sophistication and usefulness. This session will discuss sensitivity analysis, the most commonly used technique. Session 7 will continue the general subject with a discussion of decision trees, Monte Carlo analyses, and management attitude towards risk.

This session includes a discussion of experience results, which demonstrates conclusively the importance of the marketing variables on project returns. Practice in calculating economic sensitivities is covered in Session 6, as part of the Loco Chemicals Company case study.

I. The Marketing Variables

1. Hardest to pin down

2. Most important to economics

II. Risk Analysis

. Sensitivities

. Likely Uncertainty

. Monte Carlo

III. The Power of Important Factors--at 15% ROI (Per Twaddle)

	Case A	Case B	Case C
Turnover Ratio, $ sales/$ Fixed Capital	1.2	1.0	0.8
Required Variability per 1% change in ROI			
Sales Price, %	1.8	2.8	4.3
% Idle Capacity in 2nd Year (single year only)	17.7	25.5	37.4
Fixed Capital, %	7.9	9.1	10.3
Startup Expense % of Fixed Capital	12.9	15.1	17.1
Construction Period, Months Extension	4.8	5.6	6.5
Startup Period, Months Extension	3.8	4.5	5.1

IV. Summary Economics--Project X

	Rate of Return	Change in Return
Expected Value	15.3%	
Effect of 10% Change in:		
(1) Investment		± 1.3
(2) Raw Materials		± 2.8
(3) Operating Costs		± 1.3
(4) Marketing Volume (depending on pattern)		(0.8) to (9.3)
(5) Market Price		(2.1) to (16.3)

V. Industry Experience

- 40 Projects
- $5 MM Investments
- 15 Year Investment Period
- 2 Years Operation

VI. Variables Analyzed

1. Volume
2. Margin
3. All Other
4. Total

VII. Observations

1. All variables show scatter
2. Prices primary factor affecting margins
3. Margin and price forecasts optimistic
4. Other variables average close to original estimates

VIII. Typical Rate of Return Distributions

IX. Effect of Volume Uncertainty on Rate of Return

X. Effect of Margin Uncertainty on Rate of Return

XI. Effect of All Other Uncertainty on Rate of Return

XII. Total Effect of Uncertainty on Rate of Return

XIII. Rate of Return Uncertainty

Category		Range			Standard Deviation (1)
		Minimum	Maximum	Mean	
1	Volume Effect	-10.0	+ 8.2	-0.1	± 4.0
2	Margin Effect	-15.6	+ 4.0	-3.8	± 4.8
3	All Other Effects	-5.9	+ 9.0	+0.2	± 3.0
4	Total Effect	-20.0	+15.3	-3.6	± 6.5

XIV. Reliability of Original Profitability Estimate

	One Chance in Three
Marketing Uncertainties Only	± 5 units
Including Technical Uncertainties	± 7 units

PI SENSITIVITIES FOR A TYPICAL PROJECT

Basis: 20-year project life, 20-year SYD depreciation (0/20), 54% income tax rate, investment spent uniformly from -1-0, 100% capitalized, constant annual income from 0-20, zero salvage value.

Basis PI:		10	30	50	100
Factor Changed	% Change	Change in PI from Basis			
Annual Income	-10	-1	-2	-4	-7
	-50	-6	-13	-20	-37
	+10	+1	+2	+4	+6
	+50	+5	+11	+17	+27
Zero income at time zero, build-up from time 0 to 5 yrs.		-2	-10	-20	-50
No income in first year		-1	-5	-12	-35
Investment Cost	-10	+1	+3	+4	+7
	-50	+9	+21	+31	+48
	+10	-1	-2	-3	-6
	+50	-4	-8	-13	-23
Portion of Investment Expensed					
10%		+1	+2	+3	+5
50%		+3	+10	+17	+25
Investment Timing					
Changed to Time 0		+1	+5	+15	+70
Changed to Time -2-0		-1	-4	-8	-25
Project Life					
10 Years		-4	-1	0	0
5		-11	-8	-4	0
3			-16	-13	-3
2			-26	-26	-11
Salvage Value, % of Investment					
50%; 20-year project life		0	0	0	0
50%; 10-year project life		-2	-1	0	0
50%; 5-year project life		-6	-6	-3	0
Tax Rate					
Changed to 44%; 20-year proj. life		+1	+4	+7	+12
Changed to 44%; 10-year proj. life		-3	+4	+7	+12
Changed to 44%; 5-year proj. life		-11	-3	+5	+11
" " 0 ; 20-year proj. life		+7	+21	+34	+59
Depreciation Period					
16 years SYD		< 1			
8 years SYD		+2	+3	+4	+3

SESSION NO. 6 - WORKSHOP NO. 2

This session continues the analysis of the Loco Chemicals' case begun in Session No. 4. The basic calculations will be completed and the sensitivity and post-installation appraisal calculations will continue. There will also be a review of class and case writer solutions for the work so far. The remainder of the work will be completed and reviewed in the third workshop, Session 12. The case writer's solutions are presented as a permanent record at the end of the seminar.

Supplementary Comments on Loco Chemical Company

Day 1

1. Case Background - Originally developed to show for a "real-life" case how different evaluation methods give different rankings of alternates. First used by Commercial Development Association.

2. Brief oral description of case.

3. Overall Goals - Develop (discover) alternates, develop cash flow tables, calculate DCF rates of return (PI) and sensitivities, prepare appropriation request, and a post audit of the original investment.

4. Simplifications - No data gathering required; no learning or inflation effects; only DCF analysis--no ROI or payout calculations; cash flow tables developed for several cases.

5. Points to clarify in tables and text.

6. Supplementary Handouts.

7. Recommended Approach - Read entire case (15 minutes); study P&L for assigned alternate (try to check numbers for a typical year, expect problems); finish calculations for base case today.

8. Divide into working groups.

Day 2

1. Day 1 review - Case brings you down to earth. We recognize difficulty in seeing whole case in perspective when it is broken into so many parts, but it is necessary with limited time.

2. P&L Discussion - Typical, useful format and self-checking; discuss each P&L briefly (tricky points, alternate compared against, what is discounted?).

3. Put class results on board and compare with case writer's.

4. Many possible alternates - Some were mutually exclusive, some were not. They represented many different kinds of problems (abandonment, process modification, plant expansion, alternate ways of entering new business). These included sunk costs, differing project lives, cost-sharing projects, varying development costs and times, and a multiple solution problem.

5. Handouts

6. Conclusions based on "most likely" economics.

7. Continue Workshop - Sensitivities; post installation appraisal.

8. Judgment aspects of decision.

9. Appropriation Request.

LOCO Chemical Company
Sensitivity Analysis

Sensitivity Calculated: Discount Rate:	0	5	10	15	PI
A_2, Base Case	1,564	424	(311)	(787)	7.8
Sensitivity					
Revised A_2					
				Δ PI =	
B_1, Base Case	25,527	10,847	2,981	(1,476)	13.1
Sensitivity					
Revised B_1					
				Δ PI =	
A_2+B_1, Base Case	28,679	12,550	3,584	(1,534)	13.2
Sensitivity					
Revised, A_2+B_1					
				Δ PI =	

SESSION NO. 7 - BUSINESS ENVIRONMENT

Projects are subject to many uncertainties outside the direct control of the firm. The importance of the key marketing variables was discussed in Session 5, mainly from the standpoint of a given product or product line, and the impact of competition in this area. Equally important, and equally uncontrollable, are broader business environment factors. These can affect investment and operating costs as well as revenues and outputs.

Some of these factors are worldwide--such as the present and future energy problems, which will affect the cost of nearly everything. Inflation is also a worldwide problem, although its impact varies significantly from country to country. A government's attitude towards and rules for investment, and the likelyhood of political or military changes in that country or area of the world also have a very significant bearing on the attractiveness and riskiness of investments.

This session will briefly discuss several of these broader risks to show the importance of these problems, and how quickly supposedly reliable forecasts can be outdated. Planning guidelines based on one or more probable futures can be of help in making individual project studies more realistic.

BUSINESS ENVIRONMENT COMMENTS

Any business decision is based on certain assumptions about the future environment, explicit or implicit. While most companies do some medium/long-term planning and forecasting, the time horizon varies widely among industries, with the more capital-intensive industries under greater pressure for longer-term planning.

A frequent pattern is an overall five-year business plan that is backed by longer-term planning for capital investments and/or research and development programs, and in some cases by longer-term forecasts of key trends in the market place.

Whatever the time horizon, there is a good deal of skepticism on the accuracy of forecasts, based on their dismal track record in the past few years.

Some companies are experimenting with new approaches, such as multiple scenarios, in an effort to cope with uncertainty and quantify its impact on plans.

Some important areas of change are noted below:

1. Economic growth
   Growth rates in the developed countries in the 1980's are almost universally expected to be slower than in the 1960's and early-1970's, although not so depressed as in the past five years. From slow growth stems a series of other adverse factors--tightening competition, reluctance to invest in expanded capacities, higher unemployment, and the resulting job-preservation and work-sharing policies pursued by many governments and labor unions, and mounting pressure to protect industries against import competition.

2. Changing Demand Patterns
   There will be a slow-growing and aging population, the evolution of consumer demand away from basic needs toward more service intensive needs, and relative future growth rates of demand for consumer goods, services, and capital goods.

3. Industry Perspectives
   Slower growth means an intensified battle for market share, efforts to achieve higher productivity will be an essential element in competitive success; modernizing existing plants will take priority over expanding capacities. Many firms may try to increase overseas growth, as a substitute for slower domestic growth. Slow growth may also encourage acquisition and diversification efforts.

4. Unstable Currencies
This is a very important factor for multinationals. The gyrations of exchange markets in a world of floating rates, which are expected to continue, are clearly affecting corporate policies in such key areas as financial planning ("borrow locally"), product strategies (concentrate on price-inelastic lines") and plant location ("spread your risks").

5. Inflation and Price Controls
The general expectation is that inflation will remain an endemic problem in the coming years. While forecasting in this area is particularly uncertain, continued upward pressure on price levels is expected to come from the rising costs of energy and other limited resources, the need to restore profitability through higher prices in basic industries, and an intensifying struggle for income distribution in an era of slow economic growth. Some companies feel that inflation is a neutral factor in their investment planning. Others, view it as a definite deterrent. All agree that price controls are a negative factor; the likelihood of controls being imposed in the future is a significant consideration in investment decisions.

6. Labor Problems
There are three interrelated problems--rising labor costs, the impact of high unemployment, and labor participation in management.

7. Energy and Raw Materials
There is reasonable assurance as to the adequate availability of energy and supplies, but greater worry over rising costs. The importance of these factors varies from industry to industry.

8. The Regulatory Climate
The progressive tightening of government regulation in general, and environmental and consumer protection in particular, will continue to have significant impact on most industries. The main concerns are their effect on investment costs and product innovation. In Europe, a more pragmatic approach to environmental and consumer protection may prevent these movements going to such extremes as in the U.S.

9. Political Factors
It is often said that so much of the economic environment is political. Firms may not be able to quantify political factors but they do have to make assumptions and consider risks in this area. Socio-political uncertainties are a major concern of companies in continental Europe. By contrast, North American firms are more worried about "anti-business attitudes". Conflicting political and social pressures at the national level will make it increasingly difficult for multinational companies to exercise control over their subsidiaries and implement coherent global strategies. In many parts of the world, the weakness of governments is expected to hamper strong actions to remedy their

economic problems. A particular political problem for many companies is the prospect of increasingly difficult competition from state-owned or subsidized producers not subject to the same profit discipline as healthy private firms.

Overall the picture is one of increasing difficulty in evaluating future returns and risks, and growing complexity in the whole investment decision process.

Unraveling the Mysteries of Corporate Profits
(Fortune, 8/27/79, pp 90-96)

"The real shocks of regulation, inflation, and high energy prices have lowered the average profitability of capital. The implications are unpleasant. If the average profitability has fallen, capacity and real incomes will grow more slowly because fewer investments will offer sufficiently high returns. Once our industrial capacity has been restructured to reflect the new realities of regulation and expensive energy, we should be able to return to a more normal rate of growth and begin recapturing lost ground."

TOWARD AN ENERGY GAP?

The most comprehensive and detailed study thus far of the world's energy prospects is the WAES report, issued in May 1977.* It represents two years' work by 75 experts from 15 countries, coordinated by the Massachusetts Institute of Technology. The unanimous conclusions of these experts can be summarized as follows:

Oil production in the non-Communist world will level off sometime between 1985 and 1995—or sooner if OPEC (i.e. Saudi Arabia) restricts its supply. WAES' projections assume annual increases of 10-20 billion barrels in proven reserves.

Energy demand will continue to grow notwithstanding slower economic growth and vigorous energy-conservation policies. Therefore the supply of oil will fail to meet increasing demand, probably between 1985-95, even if energy prices have risen a further 50% in real terms.

The lead time for developing alternatives to oil is 5-15 years. The period 1985-95 will thus be a transition period in which the energy balance will shift from oil to the three major alternative sources: coal, natural gas and nuclear fission. (Nuclear fusion is something for the 21st Century, and other non-conventional sources such as solar, wave or wind power will remain marginal until then.) Each of these three presents major problems that have yet to be resolved:

- coal—reserves are abundant, but there are serious environmental problems (strip mining, smoke emissions), and a need for changes in consumer preferences and user equipment, as well as for huge investment programs for development of mines plus transport and conversion facilities.
- natural gas—incentives are needed to encourage development of costly intercontinental gas transport systems (pipelines or LNG tankers).
- nuclear power—development is being held back in many countries by popular concern over environmental, safety, waste-disposal and nonproliferation questions.

Energy-conservation measures can and will be important. But they take time to work through; to change over a country's stock of automobiles takes 10 years, its industrial plant 20-30 years, its housing stock a century or more.

The conclusion is thus that the world is heading for a true energy crisis, with repercussions going far beyond those of the 1973 oil price increase. Since demand cannot exceed supply in the real world, the gap will be closed by what WAES euphemistically terms "constrained integrations" of supply and demand—e.g. reduced economic growth and living standards, more rigorous conservation measures, still higher prices or involuntary changes in energy consumption patterns.

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* *Workshop on Alternative Energy Strategies*, Energy: Global Prospects 1985-2000 *(McGraw-Hill, New York 1977)*.

Energy Quotations

1.	WAES, p. 43 (1977)	"Policies and actions anticipated in our forecasts require hard and costly decisions soon if the increases in energy supply and decreases in energy demand are to be realized."
2.	A U.S. Firm (1979)	"Something has to give. The U.S. cannot expect on the one hand some measure of independence from oil imports and on the other a great deal of environmental purity."
3.	WSJ, 8/6/79	"The constraints arising from Europe's excessive dependence on energy call for a rapid rise in industrial investment, and the restriction of consumption and thus of the growth of real incomes. Europe has entered a decade of austerity in economic policy."
4.	WSJ, 8/8/79	"Japan's Economic Planning Agency has compiled a new seven-year economic plan to replace a similar plan submitted in January, mainly because of oil price increases. Japan's growth will slow even more, while prices will rise even faster."
5.	Fortune, 8/27/79	"Higher energy prices also have made capital less productive relative to labor. The adjustment to new energy costs may go a long way toward explaining the meager increases in capacity and the slump in productivity growth during the last five years."

Legal Factors in Project Studies

The legal requirements for doing business are complex and frequently play an important part in determining how a new venture should be structured. From the standpoint of a project appraisal, legal factors influence prices, costs, alternates available, and various intangibles affecting risk. They often, because of red tape, slow a project down substantially, which can also affect its attractiveness.

In the U.S., prices--both absolute level, and allowable discounts frequently are subject to careful scrutiny. Tax considerations are always important and frequently determine the preferred corporate organization. Knowledge of antitrust, pollution control and other government regulations are often vital and can significantly affect costs and profits.

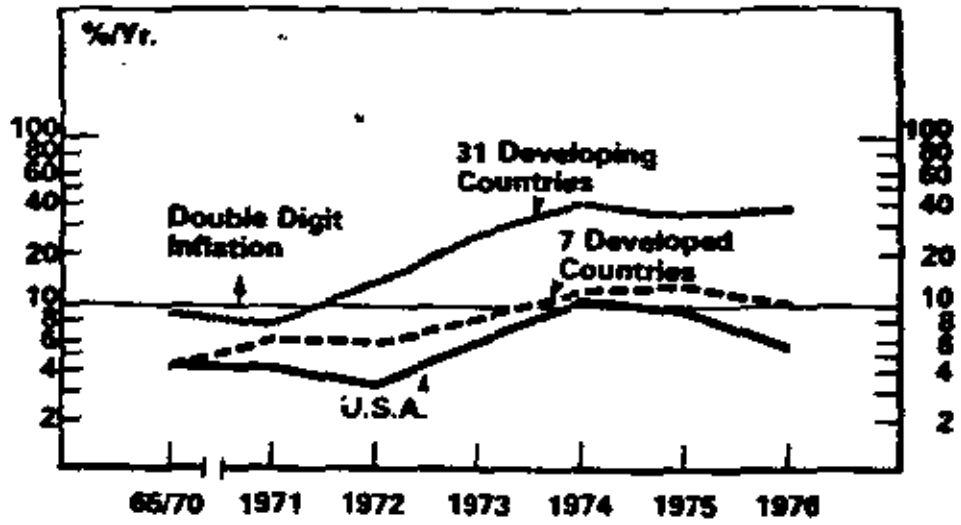
In foreign countries, many laws and decrees must be considered, which frequently can make or break the economics of the proposed venture. Local ownership requirements, incentive programs for depressed areas, importation of equipment and raw materials, price controls, export incentives, repatriation of dividends, royalties, and capital, all must be considered carefully.

Throughout the world, knowledge of the law is a necessary first step in the development of viable projects and must be understood by the evaluators in order to achieve a realistic appraisal of a proposed investment.

The law is not only complex, but also changes frequently in some countries, with little or no notice. These changes can be very significant--changing a favorable business environment to an unfavorable one, or vice versa. Since these changes are often unpredictable much in advance of their occurrence, they will also contribute to the uncertainties in any project appraisal.

Perhaps the best that can be done is to show the economic impact of any significant changes which can be anticipated, use planning guidelines to help develop alternate scenairos to cover the unknowables and recognize that the business environment, like everything else, is subject to change, for many reasons.

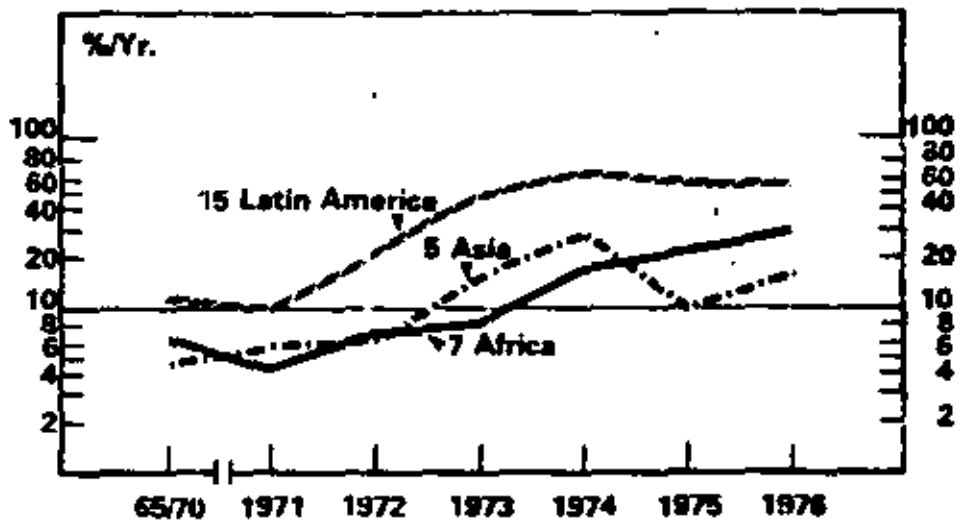
Typical Inflation Rates, 1965-76



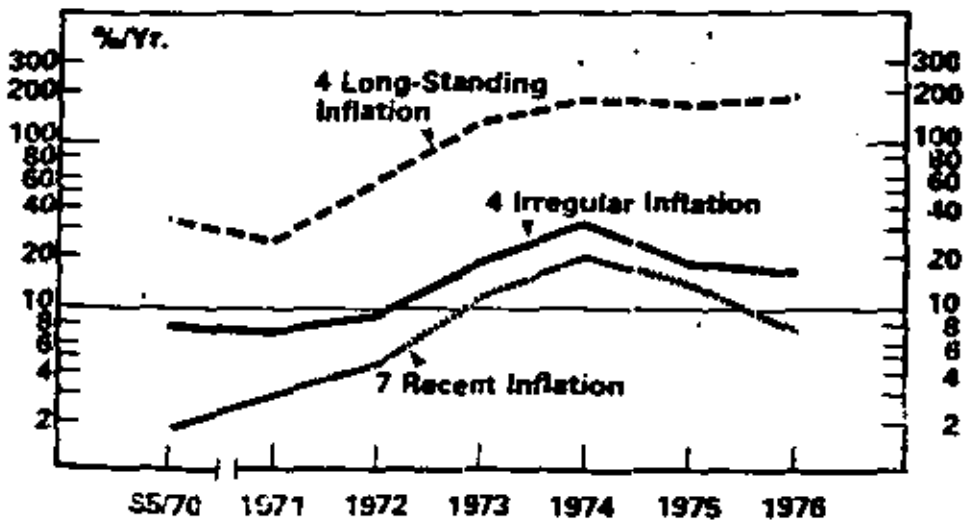
Slide 2

Regional Inflation Rates, 1965-76

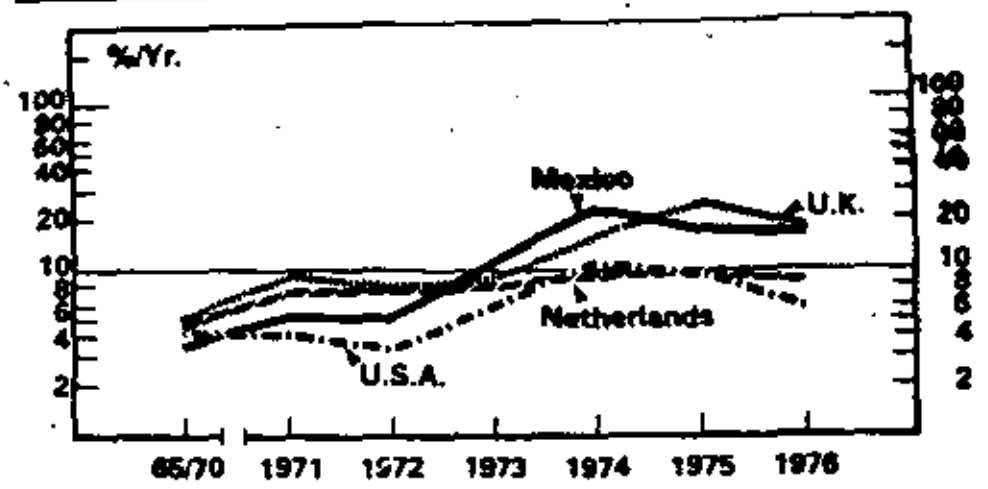
Slide 3



Latin American Inflation Rates, 1965-76

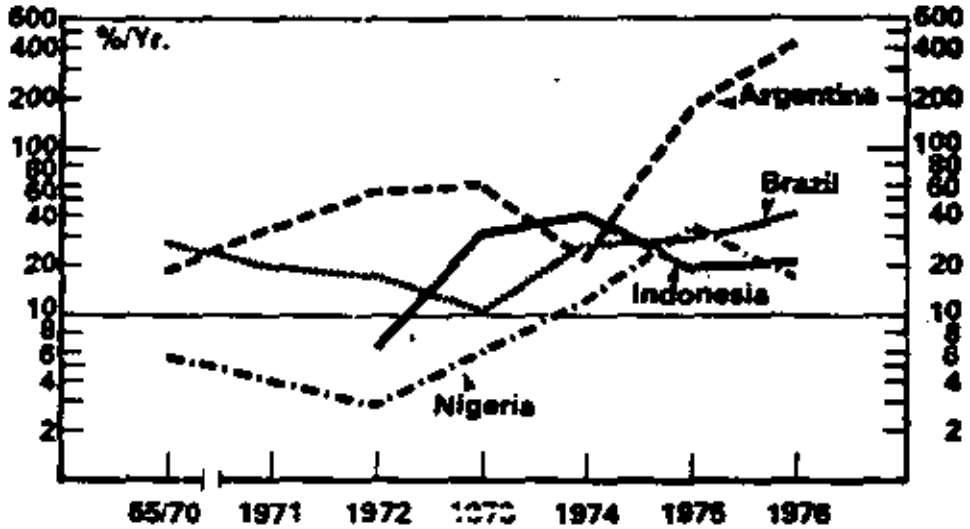


Slide 4



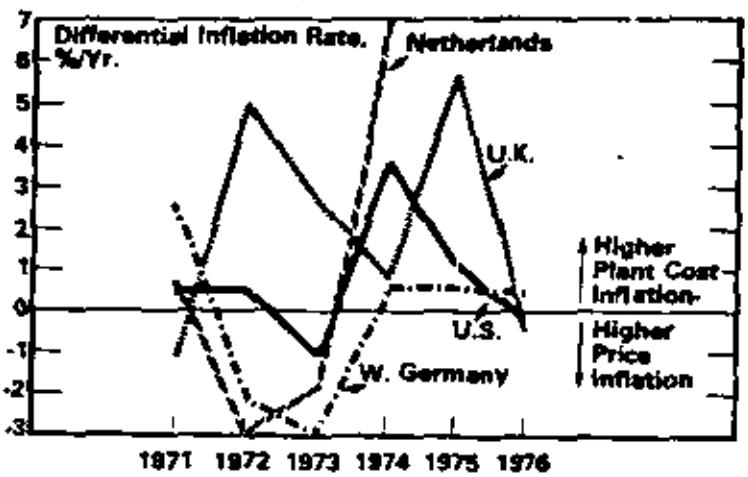
Slide 5

Selected Country Inflation Rates, 1965-76



Slide 6

Lead-Lag Effect in Inflation Rates (Plant Construction Costs Vs Consumer Prices)



Slide 9

Slide 8

Effect of Inflation on Cash Flows

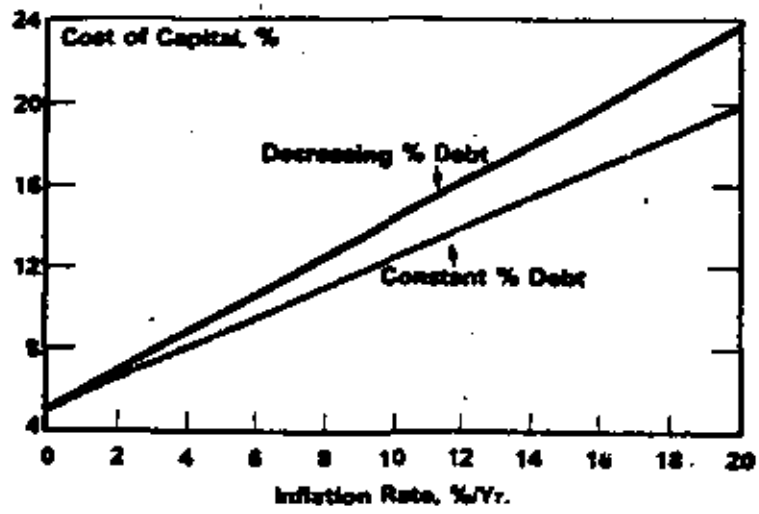
	U.S. Inflation Rates, %/Yr.	
	1962-72	1972-78
Prices	0.4%-3.4%	6.3%-15.5%
Construction	3.2%-6.9%	6.5%-7.5%
Misc. Expenses	2.4%-3.9%	3.0%-7.7%

Effect of Inflation on Cost of Capital

Case	Source of Funds	Ratio	After-Tax Cost, %	Weighted Cost	Memo: No Change in Debt/Equity
No Inflation					
	Debt	50	2	1.0	
	Equity	50	8	4.0	
				5.0	5.0
Mild Inflation (6%)	Debt	40	5	2.0	2.5
	Equity	60	14	8.4	7.0
				10.4	9.4
High Inflation (20%)	Debt	25	12	3.0	6.0
	Equity	75	28	21.0	14.0
				24.0	20.0

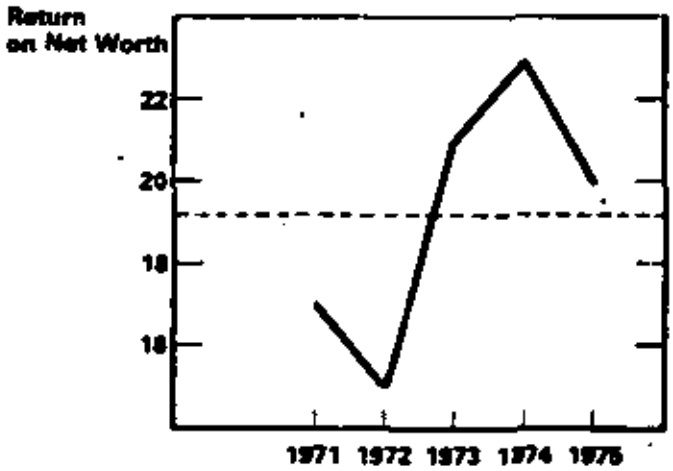
Page 5

Effect of Inflation on Cost of Capital



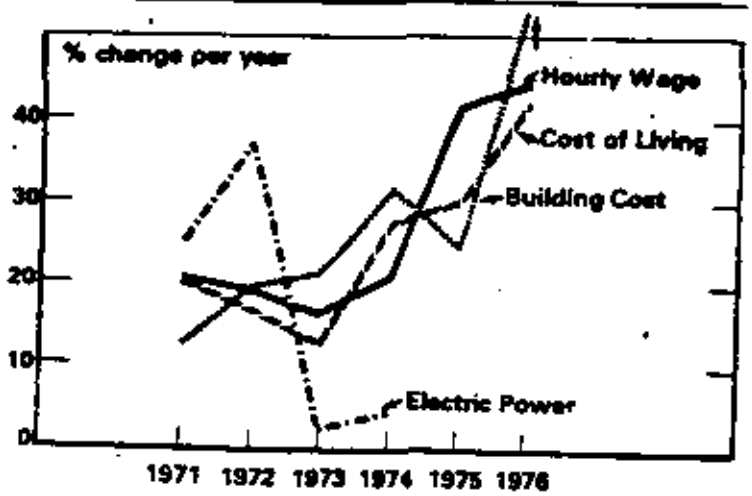
Slide 11

Profitability of 500 Brazilian Firms



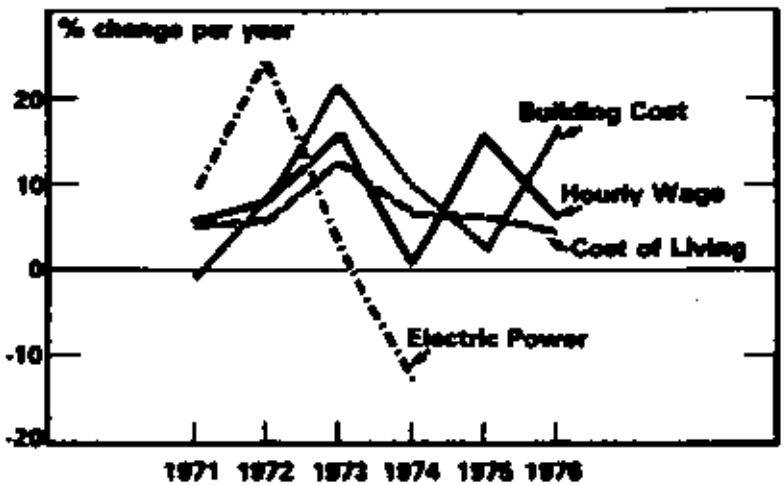
Slide 12

Brazilian Cost Inflation — (in Cruzeiros)



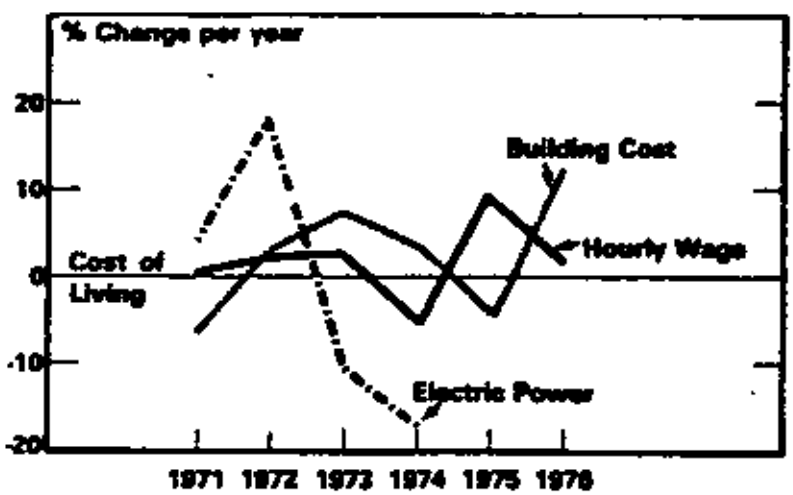
Slide 13

Brazilian Cost Inflation — (In Dollars)



Slide 14

Brazilian Cost Inflation — (In Constant Cruzeiros or Dollars)



Slide 15

Selected Strategic Planning Comments

1. New products help cope with the profit-pressure of inflation.
2. As investment intensity rises, gross margin stays relatively flat and net margin declines.
3. High capital intensity and small market share equals disaster.
4. A broad product line is most useful in capital-intensive businesses.
5. R&D is most profitable in mature, slow-growth markets.
6. Sensitivity analyses of proposed strategies are important, to evaluate the effect of alternate environmental forecasts, and nominate strategies for intensive exploration.

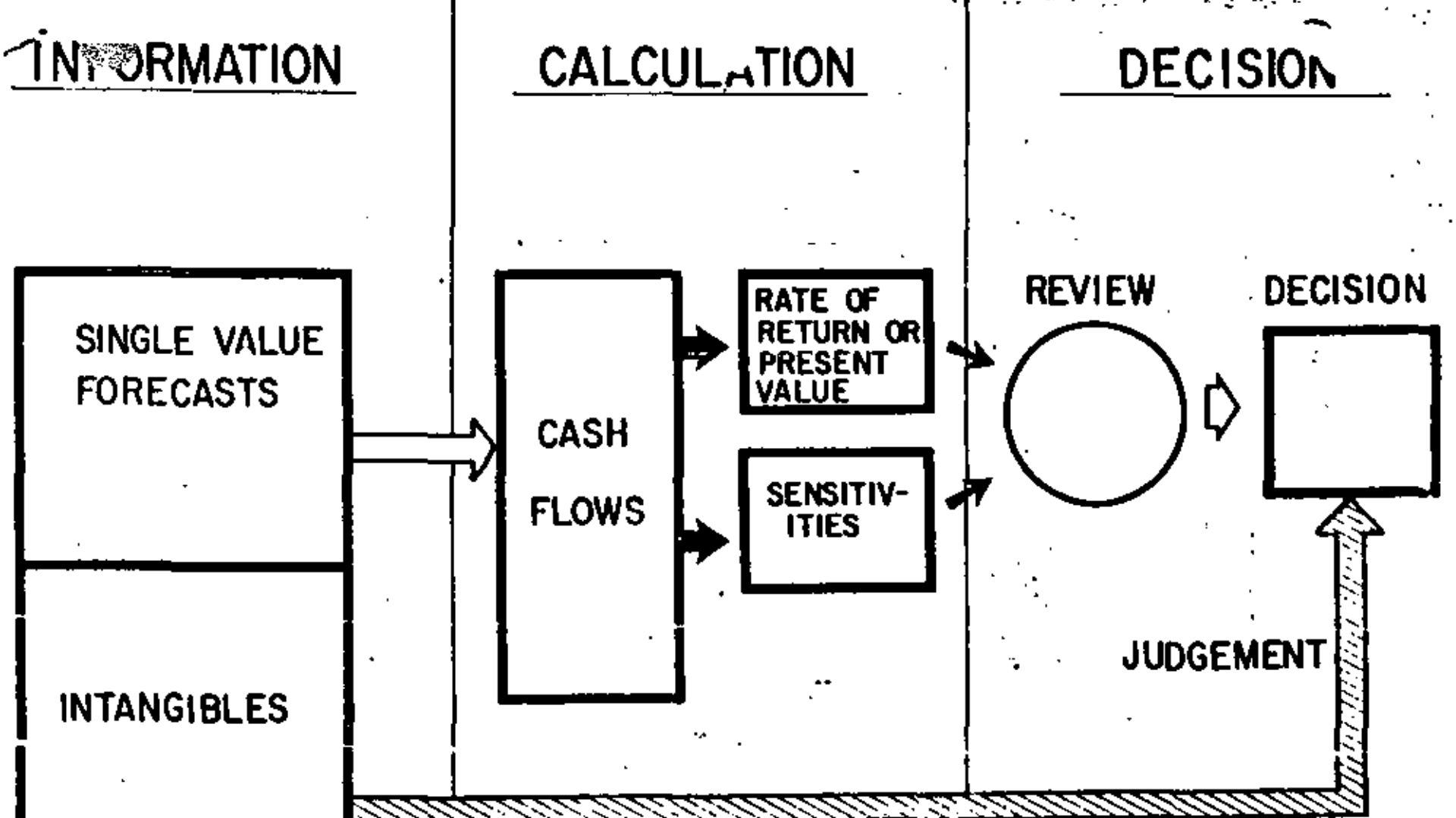
Strategic Planning Institute, 1977.

SESSION NO. 8--RISK ANALYSIS, PART 2

There are two steps in project risk management: (1) measuring risk, (2) interpreting risk.

Measuring risk involves such techniques as sensitivity analyses, decision trees, and Monte Carlo analyses. Sensitivity analyses were covered in Sessions 5 and 6. The practical aspects of generating, interpreting, and using the other risk analysis techniques are discussed here.

Interpreting risk requires a knowledge of management attitudes towards risk. Usually these attitudes have been subjective and inconsistent. A consistent interpretation of risk requires a quantitative statement of management risk attitudes. This is a problem that has not been completely solved. Some interesting aspects of work in this area are also covered in this session. The objective is to develop a reliable, generally-accepted, and practical method of discounting for risk, converting a Monte Carlo probability distribution to a single-valued certainty equivalent.



NORMAL RISK ANALYSIS

FIGURE I. TYPICAL PROJECT ANALYSIS

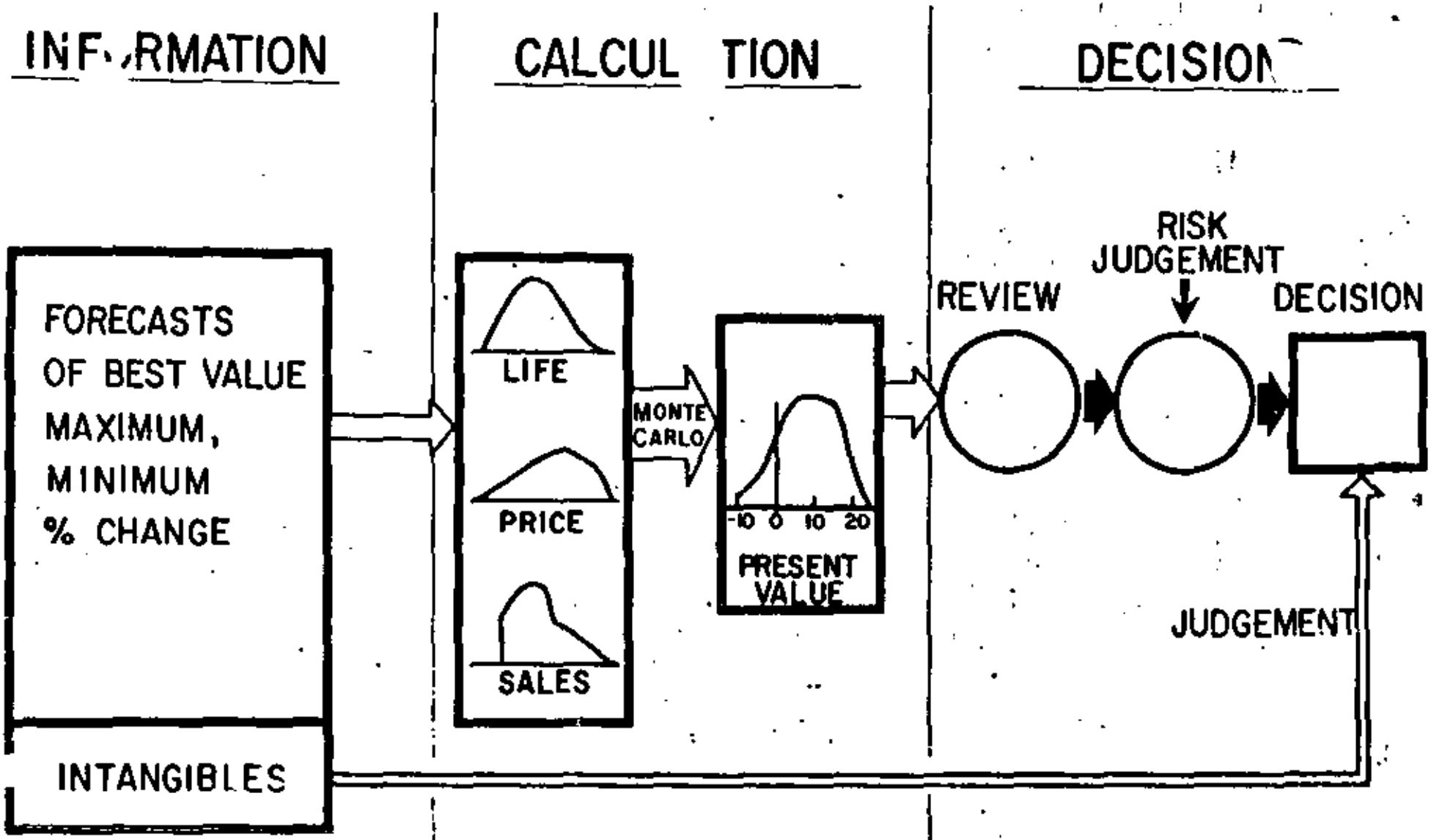
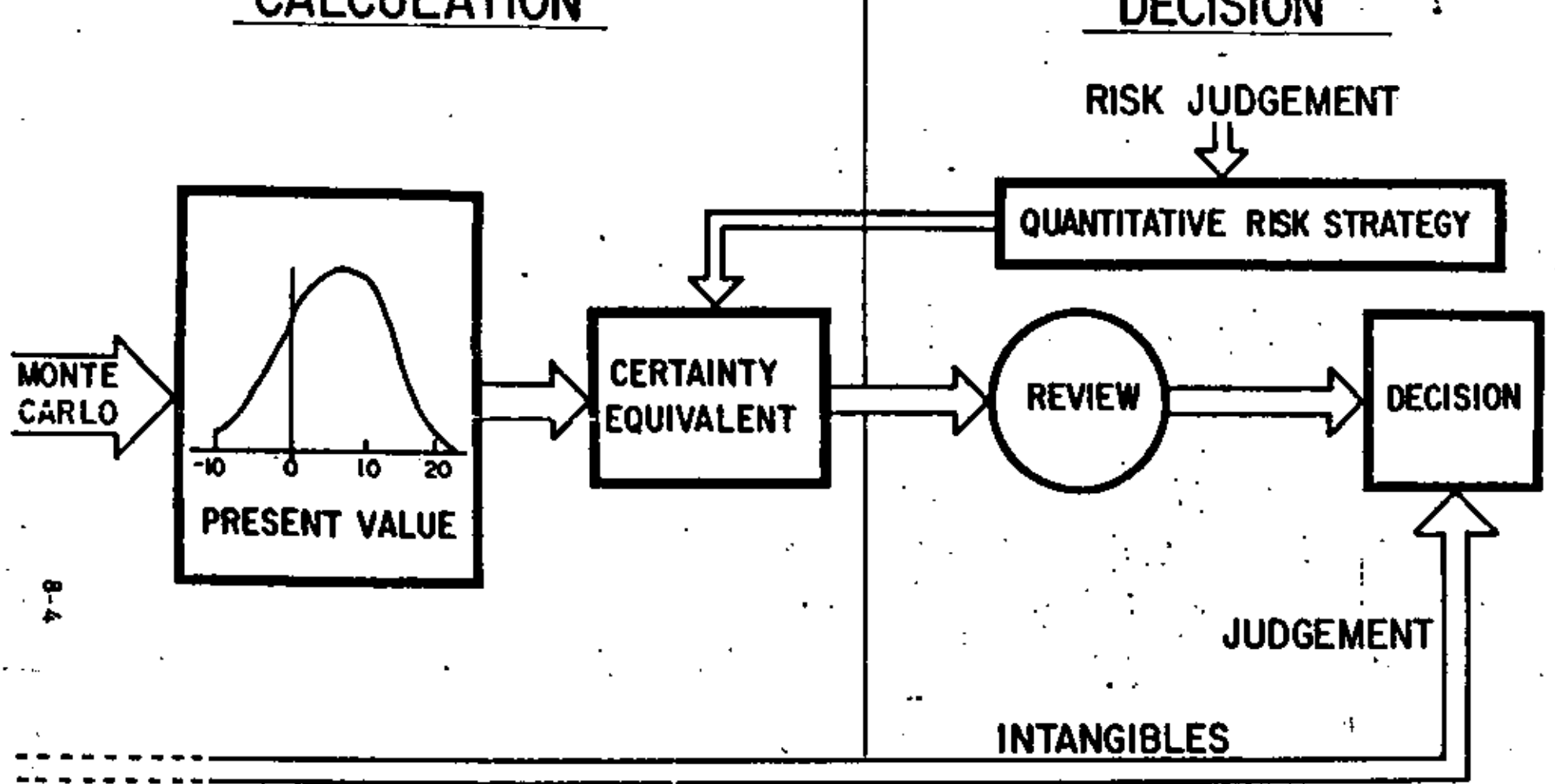


FIGURE II. RISK ANALYSIS

SOPHISTICATED ANALYSIS



B-4

FIGURE III. THE CERTAINTY EQUIVALENT (CE) METHOD

VERY SOPHISTICATED RISK ANALYSIS

THE STATES OF KNOWLEDGE

1. KNOWNS: THINGS BELIEVED AND ALREADY RESOLVED.
2. KNOWN-UNKNOWNS: THINGS WE KNOW THAT WE DON'T KNOW.
3. UNKNOWN-UNKNOWNS (UNK-UNKS): THINGS THAT WE DON'T KNOW WE DON'T KNOW.

SOPHISTICATION IN THE USE OF MODELS

- Don't ignore what the model says
- Don't believe what the model says

RELEVANCE IN MODELS

OR:

"ITS BETTER TO BE ROUGHLY RIGHT — THAN EXACTLY WRONG"

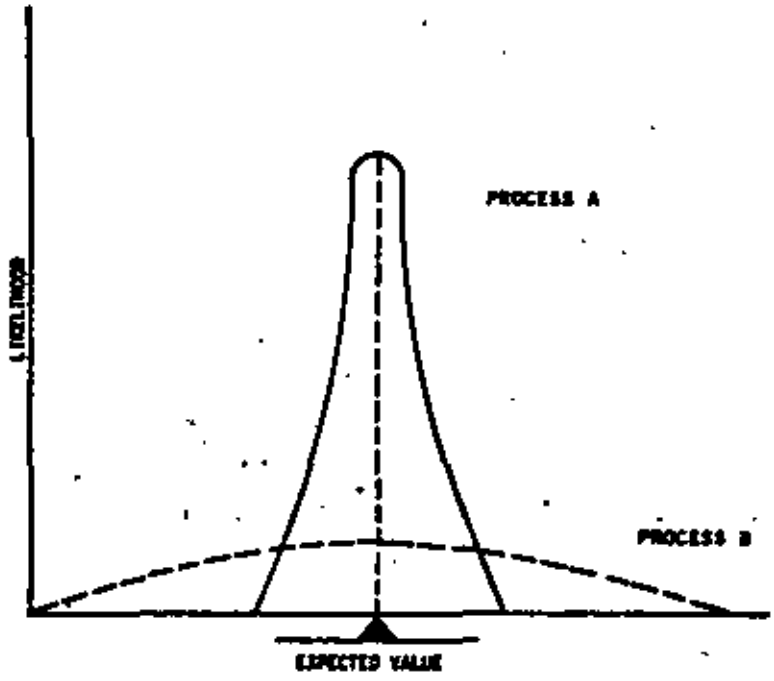
2-A. STATISTICS

EXPECTED VALUE

THE EXPECTED VALUE OF AN UNCERTAIN QUANTITY IS THE AVERAGE VALUE THAT CAN BE EXPECTED ON THE LONG RUN.

VARIANCE

VARIANCE IS A MEASURE OF THE DISPERSION OF POSSIBLE VALUES ABOUT THE EXPECTED VALUE. AND THUS IT IS A MEASURE OF UNCERTAINTY



STANDARD DEVIATION

STANDARD DEVIATION IS A MEASURE OF DISPERSION OR UNCERTAINTY AND IS EQUAL TO THE SQUARE ROOT OF THE VARIANCE

2-B. PROBABILITY

AXIOMS

1. EVERY PROBABILITY WILL BELONG TO AN INTERVAL BETWEEN 0 AND 1.
2. SUM OF ALL POSSIBLE OUTCOMES OF A GIVEN EXPERIMENT MUST EQUAL ONE.

PROBABILITY IN FIVE RANDOM CARDS

TWO OF A KIND (PAIR)	0.4237
THREE OF A KIND	0.02128
FULL HOUSE	0.001441
FOUR OF A KIND	0.0002401
STRAIGHT FLUSH	0.00001385
ROYAL FLUSH	0.000001539

THE MATHEMATICS OF UNCERTAINTY

- CENTERS AROUND THE CONCEPT OF PROBABILITY
- WHERE PROBABILITY IS DEFINED AS A LONG-TERM REGULARITY THAT UNDERLIES RANDOM EVENTS
- HOWEVER BUSINESS PROBLEMS USUALLY DO NOT PROVIDE SUFFICIENT DATA THEREFORE JUDGMENT MUST BE USED IN FORMULATING THE PROBLEM.
- THIS LEADS US TO SUBJECTIVE PROBABILITY WHICH IS NOT FORMALLY DERIVED BUT RATHER BASED ON "QUANTIFIED JUDGMENT"

UNCERTAINTY

NO INFORMATION AT ALL IS AVAILABLE WHICH WOULD PERMIT AN EVALUATION OF THE CHANCES OF AN EVENT

PURE RISK

THIS IS THE SITUATION WHERE ACTUAL PROBABILITIES OR CHANCES OF AN EVENT TAKING PLACE CAN BE DETERMINED EXPERIMENTALLY OR THEORETICALLY.

e.g.. A TOSSING OF A COIN

SUBJECTIVE RISK

THESE ARE SITUATIONS WHERE ESTIMATES CAN BE MADE OF THE PROBABILITIES INVOLVED.

e.g.. FORECASTS OF FUTURE PRICES OR VOLUMES. ETC.

TWO PROBABILITY RELATIONSHIPS BASIC TO FINANCIAL RISK ANALYSIS

1. PROBABILITIES OF MUTUALLY EXCLUSIVE EVENTS ARE ADDITIVE:

$$P(E \text{ or } F) = P(E) + P(F)$$

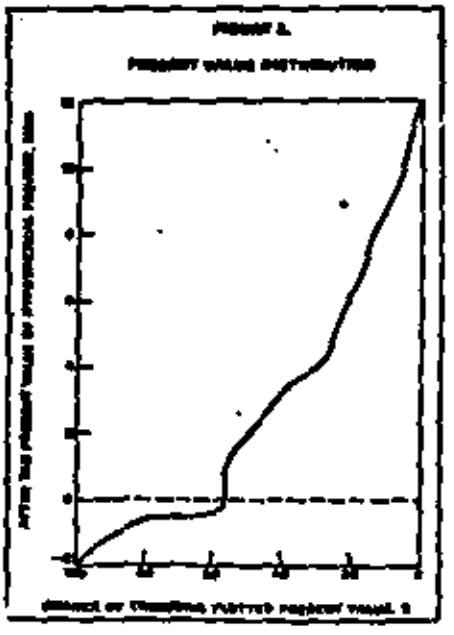
2. PROBABILITY OF INDEPENDENT EVENTS ARE MULTIPLIED:

$$P(E \text{ and } F) = P(E) \times P(F)$$

DECISION TREES

RESEARCH PROJECT EXAMPLE

STAGE	PROBABILITY OF SUCCESS	INVESTMENT
BENCH SCALE RESEARCH	80%	200M
PILOT PLANT RESEARCH	85%	500M
MARKET DEVELOPMENT	85%	750M
COMMERCIALIZATION	HIGH - 20% MED - 60% LOW - 20%	



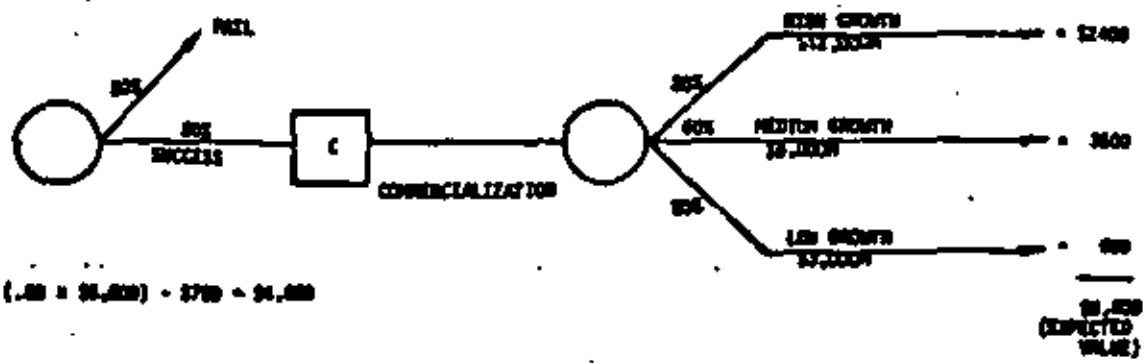
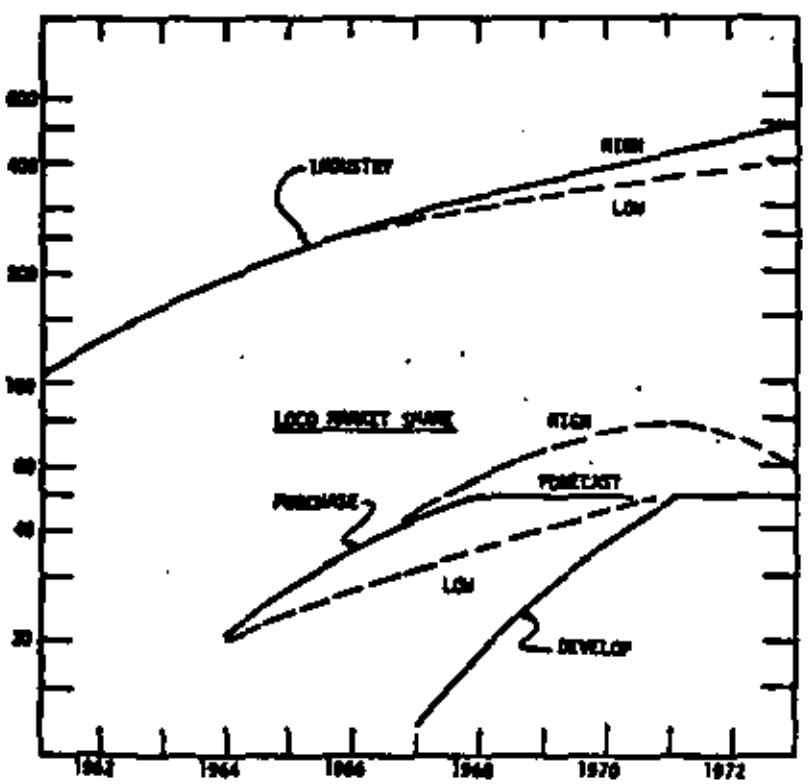


*FIGURE 1 - CHANCE & COSTS

PLASTIC "P" PENETRATION



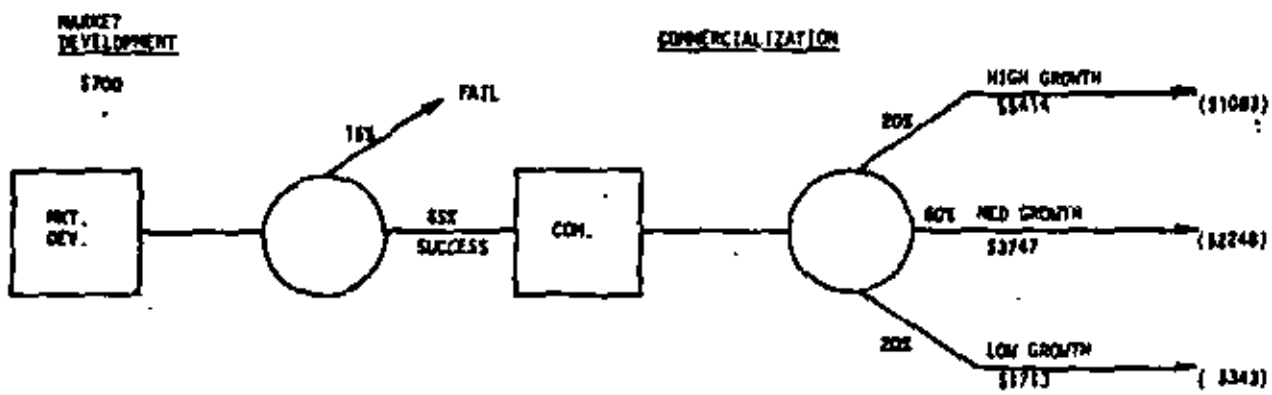
LOCD SENSITIVITY ANALYSIS

PLASTIC B PURCHASE FROM HOW

I. MARKET:	HIGH GROWTH		MEDIUM GROWTH (AS CALCULATED)	LOW GROWTH	
MM LBS.	796	(16%)	682	626	(8%)
REVENUE (THOUSANDS)	$202,120		$173,620	$161,330	
DISCOUNTED CASH FLOW (THOUSANDS)	$4,870		$3,143	$1,100	
ROI	14.7%		14.0%	11.8%	
II. COSTS:	ESCALATED		AS CALCULATED		
DISCOUNTED CASH FLOW (THOUSANDS)	-$1,387		$3,143		
ROI	6.2%		14.0%		
III. INVESTMENT:	25% INCREASE		AS CALCULATED		
DISCOUNTED CASH FLOW (THOUSANDS)	$1,206		$3,143		
ROI	11.7%		14.0%		

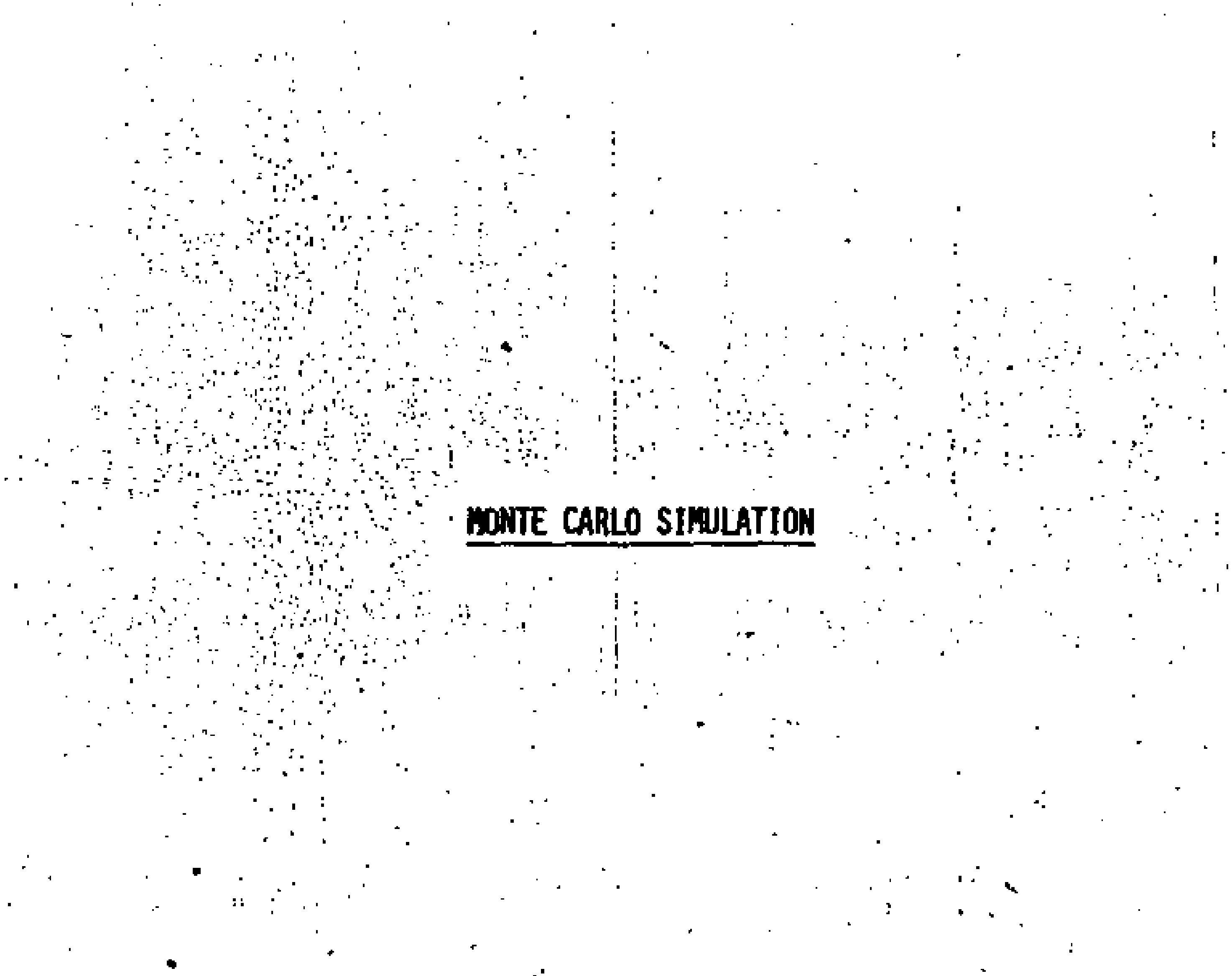
LOCD DECISION TREE

PLASTIC B PURCHASE FROM HOW
(THOUSAND DOLLARS)



EXPECTED VALUE - DCF

$2423 $3132 $3674



MONTE CARLO SIMULATION

8-18

Steps in Monte Carlo Analysis

1. Probability Values for Significant Factors
2. Randomly select sets of these factors based on chance of occurance.
3. Determine profitability for each combination.
4. Repeat many times to get probability distribution of profitability results.

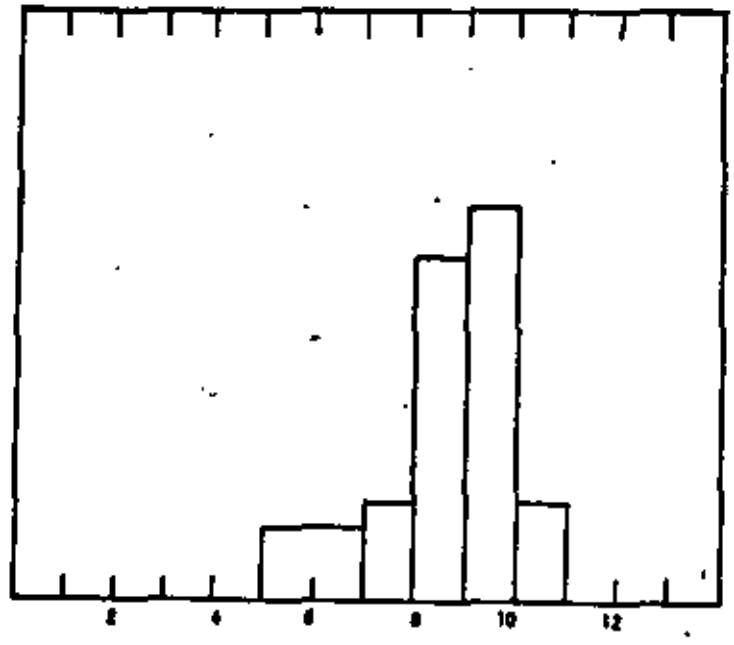
DIFFICULTIES WITH MONTE CARLO ANALYSES

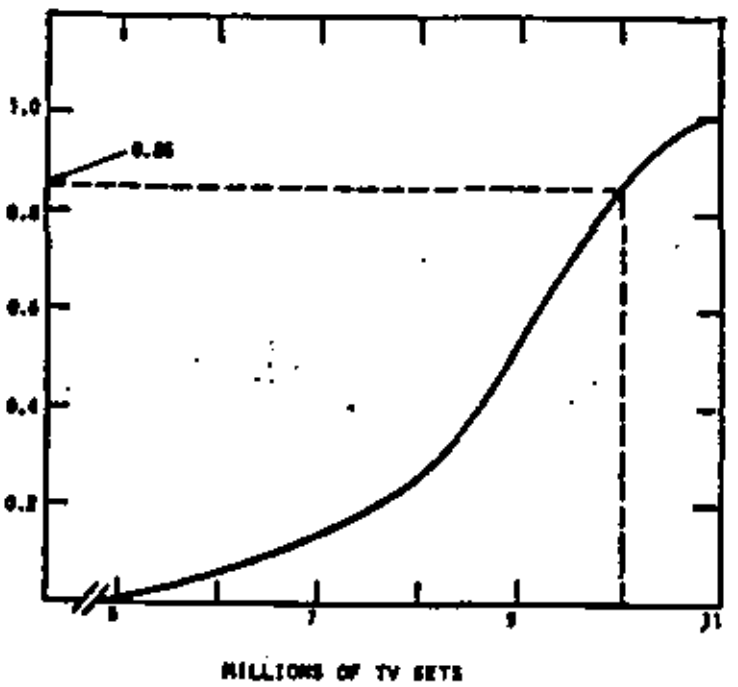
1. How Reliable are Inputs?
2. Management Unfamiliarity
3. Too Much Information
4. Risk Attitudes Not Considered.

U. S. MARKET FOR TV SETS

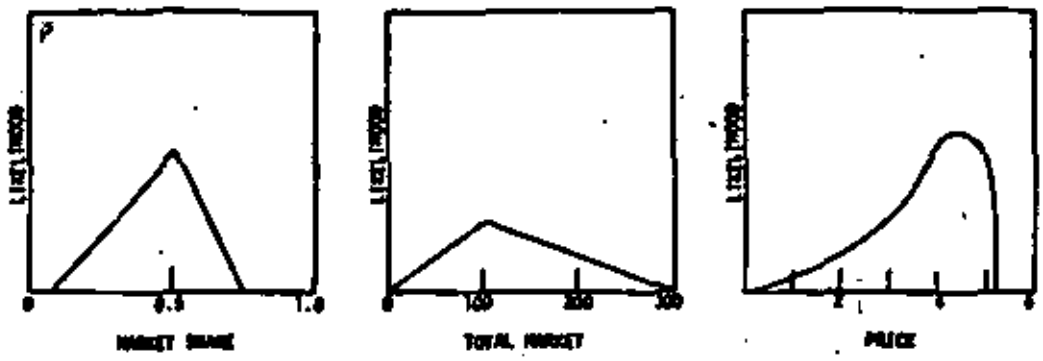
RANGE, MILLIONS OF CARS	PROBABILITY OF ACHIEVING MARKET IN THAT RANGE
5 - 7	15%
7 - 8	10%
8 - 9	30%
9 - 10	35%
10 - 11	10%
	100%

HISTOGRAM REPRESENTATION




CUMULATIVE DISTRIBUTION FUNCTION
1.0
0.8
0.6
0.4
0.2
0.85
9
11
MILLIONS OF TV SETS

SIMULATION - MONTE CARLO



MATHEMATICAL MODEL
(EXPECTED VALUES)

TRIAL	MARKET SHARE	TOTAL MARKET	PRICE	RESULTANT REVENUE
1	0.34	90,000	$ 2.90	$121,000
2	0.42	65,000	2.70	61,000
3	0.46	150,000	2.20	151,000
4	0.20	105,000	4.20	126,420
5	0.65	130,000	3.10	221,650
6	0.48	220,000	3.50	346,500
7	0.50	80,000	4.00	160,000
8	0.32	90,000	1.90	90,500
9	0.25	230,000	3.00	187,500
10	0.40	120,000	3.30	158,400

SUMMARY

($000 OMITTED)

REVENUE INTERVAL	TRIALS	ESTIMATED PROBABILITY
0-100	2	0.20
100-200	6	0.60
200-300	2	0.20
300-400	0	0.00
400-1000	0	0.00
		1.00

MONTE CARLO ANALYSIS - [illegible] CHEMICALS

	Situation 1 Skewed Distributions			Situation 2 Normal Distributions		
Variable	Pessimistic	Best Guess	Optimistic	Pessimistic	Best Guess	Optimistic
Plastic A - Purchased Knowhow						
(1) Annual Sales	-20%	Given	+60%	-50%	Given	+50%
(2) Price	-2¢/lb. and keep dropping to 1970	Given	+2¢/lb.	-2¢/lb.	Given	+2¢/lb.
(3) Fixed Capital	No Change	Given	-10%	+10%	Given	-10%
(4) Operating Expense	+30%	Given	-30%	+10%	Given	-10%
Plastic B - Develop Own Process						
(1) Annual Sales	-60%	Given	+20%	[illegible]	Given	+50%
(2) Price	-2¢/lb. and keep dropping to 1970	Given	+2¢/lb.	-2¢/lb.	Given	+2¢/lb.
(3) Years to develop	+3 years	Given	-1 year	+1 year	Given	-1 year
(4) Fixed Capital	+20%	Given	-10%	+30%	Given	-30%
(5) Operating Expense	+30%	Given	-6%	+20%	Given	-20%

MANAGEMENT ATTITUDES TOWARDS RISK

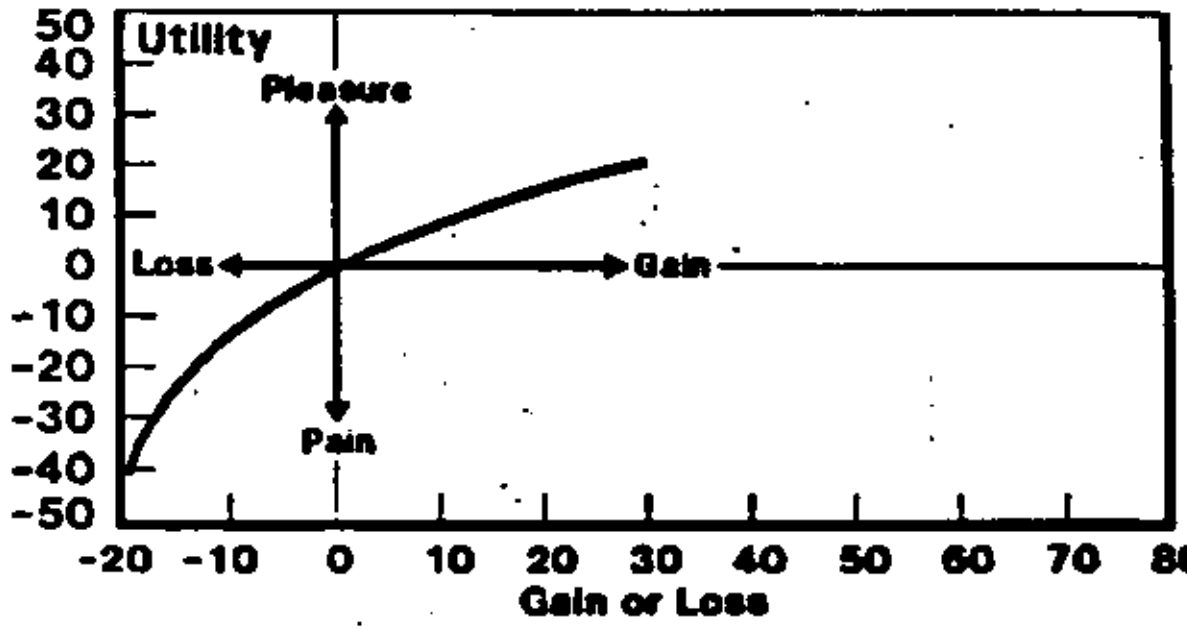
What is Risk?

1. Chance of Success
2. Probability of Loss
3. Worst Possible Outcome
4. Spread in Values
5. Discount From Expected Value

Death of a Rich But Eccentric Uncle

1. You are mentioned in Will
2. You can have either:
   a. $ 1MM tax-free
   b. 50/50 chance of $ 10MM (determined by single coin flip)
3. Which Choice would you take?

Conceptual Utility Function



Utility Function Equation

$$U(x) = \frac{1}{r}(1 - e^{-rx}), \text{ with } r > 0$$

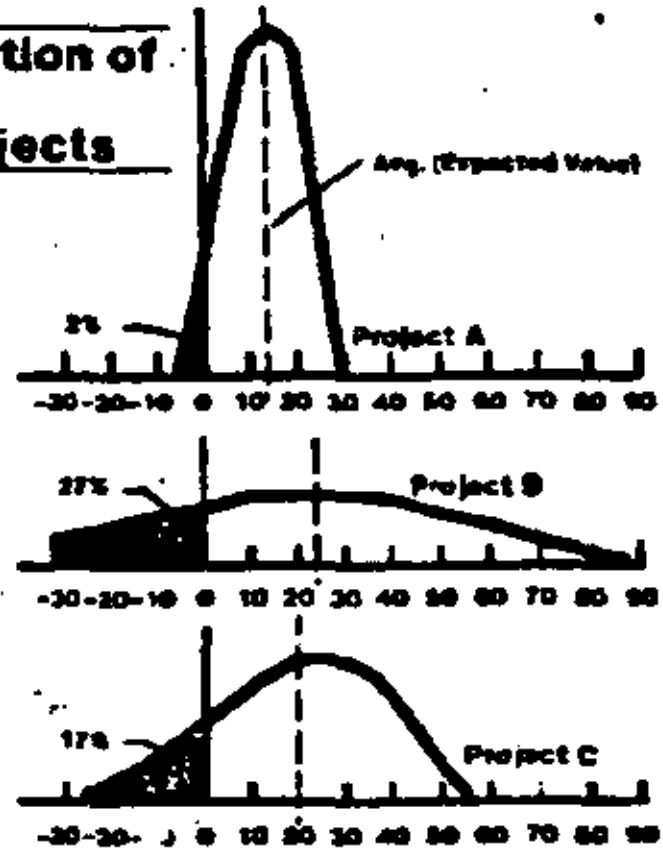
where

x = monetary gain or loss

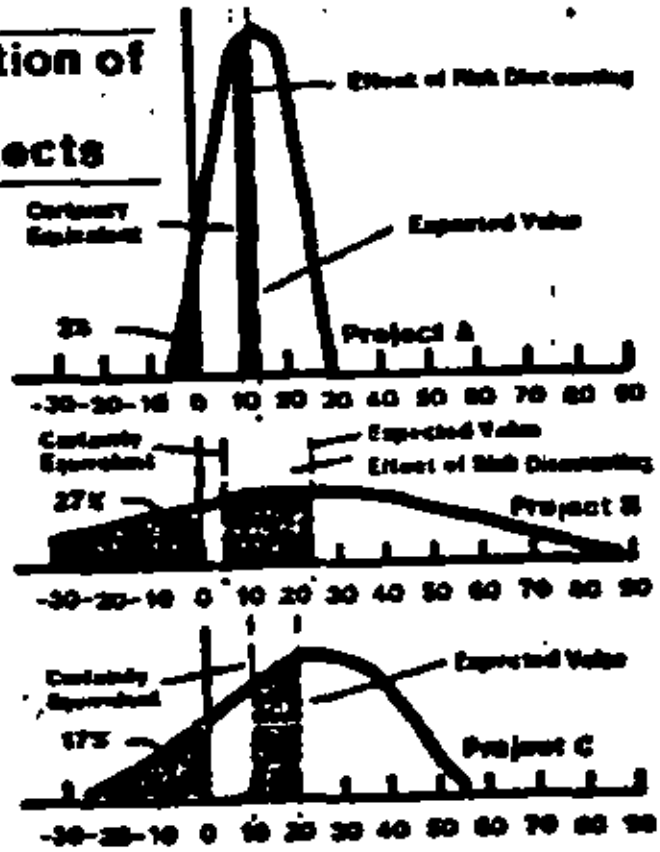
r = risk aversion coefficient

$u(x)$ = utility of x

Probability Distribution of Present Values for 3 Hypothetical Projects



Probability Distribution of Present Values for 3 Hypothetical Projects



Effect of Risk Analysis on Project Ranking

Ranking Criterion	Project Ranking
1. Expected Value	B, C, A
2. Minimum Chance of Negative PV	A, C, B
3. Certainty Equivalent Method	C, A, B

SESSION NO. 9 - HIGH-RISK EXAMPLES

Acquisitions, and projects in developing countries, are two high-risk investment areas. They are discussed in considerable detail in the written papers supporting this session, in order to illustrate the kinds of risks involved, and how they should be handled in an evaluation. Guidelines and checklists are included. Coverage in the lectures is varied to fit participant interest and experience in these areas.

Growth by acquisition can be profitable but is subject to risks that are not as likely to occur with internal growth projects. Evaluation difficulties frequently include limited information on the company to be acquired, and lack of time for thorough consideration of these often complex proposals. Economics are frequently overstated--partly because of evaluation errors--the acquiring firm over values the firm to be acquired; partly because of the human problems and disruptions associated with integrating the acquired company into the surviving firm.

In developing countries, the development of a realistic appraisal is usually very difficult. Data are scarce, forecasts are unreliable, environments are different, inflation is the rule, and the complicated laws for doing business change frequently. Also, there frequently are significant project delays because of governmental red tape. Normally uneconomic operations can be very attractive and vice-versa. Joint ventures are often required, and the development of viable joint venture is usually an order of magnitude more difficult than for a wholly owned venture.

Research projects represent another kind of high risk activity. Also, corporate research is expensive and any sizeable program requires a significant outlay of funds. Effective allocation of these funds is important but difficult, as the payoff normally comes many years in the future. Economic data at the research stage are generally limited and of uncertain reliability. Qualitative hunches can be extremely important. Management attitudes towards risk must also be considered. This session also describes a special type of sensitivity analysis to identify potential gain and project riskiness and rank research projects for budgeting and forecasting purposes.

Useful reference articles are appended.

Acquisitions - Some Evaluation Difficulties

1. Time and Data Problems
2. Tax Effects
3. Future Margins
4. Support Investment
5. What are the alternates?

Accounting Magic

Different applications of generally accepted accounting principles can more than double earnings per share (Arthur Anderson & Company example):

	Hypothetical Company Market Value at 10 Times Earnings, $/Share	
Basis A		$ 8.00
Adjustments:		
1. Value inventory on first-in-first-out basis rather than last-in-first-out.	$3.20	
2. Use straight line instead of accelerated depreciation for book and tax purposes.	$0.80	
3. Amortize R&D costs over five years instead of charging to current expense.	$0.60	
4. Fund only present value of pensions vested instead of current pension costs.	$1.20	
5. Grant stock options instead of paying cash bonuses to officers.	$1.60	
6. Include capital gains in income instead of crediting directly to earned surplus.	$2.50	
Basis B		$17.90

ACQUISITION CHECKLIST

I. Background Information on Existing Company

A. History of Business

B. Corporate Organization

1. Ownership

2. Management and Management Structure

3. Management Philosophy

4. Management control techniques used--budgets, control reports, long range planning, delegations of authority.

5. Fit with acquiring company; is timing right?

C. Financial

1. Audited detailed balance sheets and operating statements for past three to five years, with sufficient backup to restate as necessary to acquiring company practices and adequately analyze corporate solvency, profitability, and growth.

2. Details of property, plant and equipment showing date of purchase, original cost, and depreciated value.

3. Product line operating reports, detailing fixed and variable manufacturing, and major overhead costs.

4. Credit policy and practice.

5. Company policy on dividends and finances in general.

6. Unbooked capital expenditures, authorized or contemplated.

7. Contingent liabilities.

8. Projected sales, capital requirements and operating statements, for next two to five years (prepared by existing management of acquisition candidate, as they see the future).

D. Legal and Tax

1. Articles of incorporation and bylaws.

2. Copies of Contracts

   Leasing and Rental Agreements
   Licensing and Royalty Agreements
   Raw Materials
   Mortgages
   Loans
   Distributor Agreements
   Sales Agreements
   Union Agreements
   Management Contracts

3. Federal Tax Returns for pertinent years, and federal revenue agent reports.

4. Information on other taxes.

E. Marketing

1. Products
2. Markets
3. Distribution
4. Pricing
5. Customers
6. Competitive Position
7. Sales Organization
8. Product and Market Research
9. Advertising and Promotion

F. Manufacturing

1. Plant Location(s) and Sizes
2. Process Description
3. Raw Materials--price, availability, specifications
4. Key Variables, yields, hazards
5. Sources of Know-how
6. Organization
7. Development and Engineering Support

G. Personnel

1. Wage and Salary Data
2. Fringe Benefits
3. Appraisal of Quality

II. Industry Performance Data

1. Return on Investment, Margin on Sales, Turnover
2. Growth Rates
3. Other Significant Business Characteristics

III. Post-Acquisition Plans

1. In-depth Coverage of Relevant Areas Under I
2. Develop Restated Financial Forecasts

IV. Financial Forecast

1. Acquisition Basis and Tax Treatment
2. Investments

   a. Purchase Cost
   b. Facilities Improvements
   c. Growth Needs
   d. Replacement Investment

3. Profit and Loss

4. Profitability (Base Case Current Operations, Expansion Increment, Total and Sensitivities)

5. Grass Roots Alternates

Size of World Population and Gross National Product

	% of World Total in 1970	
	Population	Gross National Product
United States	6	33
Western Europe	10	23
Latin America	8	5
Africa and Middle East	12	4
Far East	32	12
Sino-Soviet Bloc	32	23
Total World	100	100

Typical Developing Country Project

Partnership Basis		Principal Incentives
Local Partner	Foreign Partner	
Local Marketing	Export Sales	Tax Holiday
Limited Capital	Available Capital	Duty Free Imports (Equipment and Raw Materials not available locally)
Government Contacts	Technical Knowhow	Duty barriers on imported competitive products
	Management	

Economics of Typical Developing Country Project

	Return on Investment, %		
	Joint Venture	Foreign Partner	Local Partner
A. Small Plant			
1. Original Estimate of Local Partner	15	N.A.	Unknown
2. Foreign Owner	11	15	but
B. Expand small Plant to Capacity	24	30	large
C. Large New Plant	20	24	
D. Combined Project	19	23	

CHECKLIST FOR EVALUATING PROJECTS IN DEVELOPING COUNTRIES

I. The Country

A. Size, geography, climate, principal cities, industries, and markets
B. Economic indices, real growth, future expectations
C. Government - type and stability

II. Attitude toward and rules for foreign investment

A. Per Cent Foreign Investment (allowed, desired)
B. Investment Incentives
C. Project financing
D. Tax Regulations and other legal requirements
E. Imports (Raw Material, Equipment, Competitive Products)
F. Government approvals required
G. Realistic investment timetable
H. Government forms and detailed submission requirements

III. Markets

A. Available data, reliability
B. Import Restrictions
C. Export Opportunities
D. Price Controls
E. Competitive Information
F. Supply-Demand and gross realization forecast
G. Marketing Expenses--Sales taxes, commission, freight, and other

IV. Plant Location

Effect on investment/operating costs/profits

V. Investment

A. Fixed Capital
   1. Land - cost, ownership restrictions
   2. Building--unit cost, size, materials, codes
   3. Equipment--local versus imports, new versus used
   4. Support--power generation, water sources, etc.
   5. Duties
   6. Cash Grants

B. Working Capital
   1. Requirement for local distributor?
   2. Adequate inventories
   3. Payment terms, (bad debt losses)

C. Startup

Labor quality, efficiency, training expense

VI. Operating Costs

A. Raw Material
   1. Local Sources--quality, reliability, price, terms
   2. Import possibilities

B. Processing
   1. Utilities--cost, reliability, self-generation need
   2. Labor--cost, efficiency, termination, use of contract labor
   3. Other

C. Tax Aspects
   1. Tax holidays
   2. Depreciation
   3. Investment Credit

VII. Special Fees to Foreign Owner

1. Licensing, royalties, technical assistance
2. Management
3. Export sales

VIII. Dividend and Capital Repatriation

IX. Project Termination

1. Legal requirements
2. Sale-transfer to nationals
3. Recoverable value

X. Cash Flow Forecast and Economics

A. 100 Per Cent Equity

B. Leverage
   1. Per Cent Debt
   2. Interest rate and possible subsidies
   3. Repayment terms
   4. Guarantees

XI. Risks and Sensitivities

1. Eliminate incentives
2. Short project life
3. Rapid wage escalation
4. Price and cost uncertainties
5. Investment uncertainties
6. Lower operating efficiencies
7. Volume effect

Research Project Ranking

Research projects as a group, although necessary, are risky. This is because of the very limited data normally available when the work is begun, the extensive commitment of time and resources before the work is completed, and the relatively small proportion of projects undertaken, which are ultimately commercialized. Many projects with little potential economic payoff are started, and continue too long.

Analysis and ranking of research projects is highly subjective and not a cut and dried affair. Approaches used by others are discussed along with a combination approach suggested by the lecturers.

Importance of Research

A. Trends in U.S. R&D, $ billion

1955	6
1960	14
1970	28
1980	55

B. Loss of Sales Without Research

1. Analysis of fifty established products on which research had been eliminated but marketing efforts stayed the same.

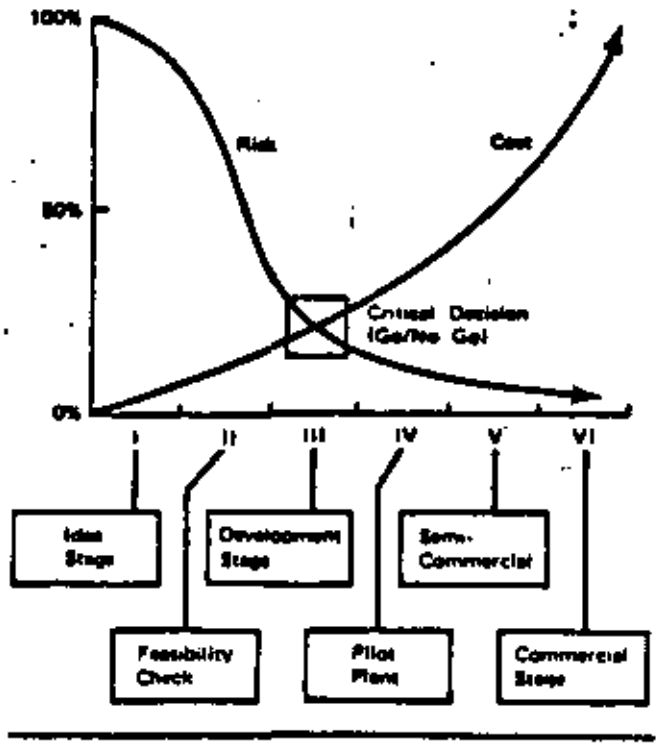
2. Typical result--10 per cent per year loss in sales volume.

3. Reference--Roche, A. F., "Measuring The Profits From Research," Research Management, Vol. 10, No. 3, 1967, p. 157.

Experience Results in R&D[1]
(20 major firms)

1. Poor projects continue too long.
2. Technical challenges vs. market needs.
3. Poor interchange between R&D and Marketing.
4. Inadequate use of findings.
5. Project selection systems very widely.

(1) Mansfield, E. and Wagner, S., "Organizational and Strategic Factors Associated with Probabilities of success on Industrial R&D," The Journal of Business, April, 1975, p. 1979.



Proposed Ranking Method

- Integrates Marketing and Technical Factors
- Combines qualitative and quantitative methods
- Simplified form
- Easy to Use
- Range of Estimates
- Flags critical uncertainties

Project Ranking Summary

1. Project Identification
2. R&D Expenses to Date
3. Project Goals
4. Project Advantages
5. Project Disadvantages
6. Comments and References
7. Ranking Summary
8. Recommended Action
9. Future R&D Expenditures

Quantitative Factors

1. Profitability at Capacity
2. Margin on Sales
3. Turnover
4. Breakeven Point
5. Cumulative Cash Proceeds
6. Years to Commercialize
7. Likely Sales Buildup
8. Remaining R&D Cost
9. Net Year's R&D Cost

Qualitative Factors

1. Stability
2. Growth
3. Marketability
4. Position
5. R&D
6. Engineering
7. Production

Completed Plastic B Ranking

Factors — Ranking Summary

	Pesso	Best Guess	Opt.
Economic	58	72	82
Qualitative	43	63	81
Total	50	68	82

Ranking of Six Projects

	B.G. Rating	Std. Dev.	Benefit Cost	Degree of Action	Next Year R&D, $M
Plastic B	68	8	N.A.	1	900
Product V	62	14	50	2	500
Product W	58	13	15	3	200
Product X	54	14	35	3	150
Product Y	43	15	10-40	4	30
Product Z	29	5	25	5	0
					1,780

SESSION NO. 10 - CURRENT INTEREST TOPICS

At the beginning of the seminar, each class is asked to provide the lecturers any special topics of interest that they would like covered in this seminar. This session will provide both students and instructors an opportunity to comment on these special topics.

In addition, the lecturers will add new material from time to time, and include it here. Data on the relative economics of alternate energy sources, are one such example.

SESSION NO. 11--MANAGERIAL AND FINANCIAL TOPICS

This session is intended to cover special topics that relate to the evaluation process such as capital budgeting and reporting results. Some of the topics highlighted earlier, such as cost of capital, and tax complications, will be discussed further, if of interest to the class. Comments on typical evaluation organizations are also given.

Particular emphasis will be given to the appropriation request, as the end-result of a successful project study. These reports provide management a concise summary of the basis and justification used for the funds being requested. The use of a typical form is illustrated in the Loco Chemicals Company case.

A reference article is appended describing the appropriation request form being used by one large company.

SUMMARY

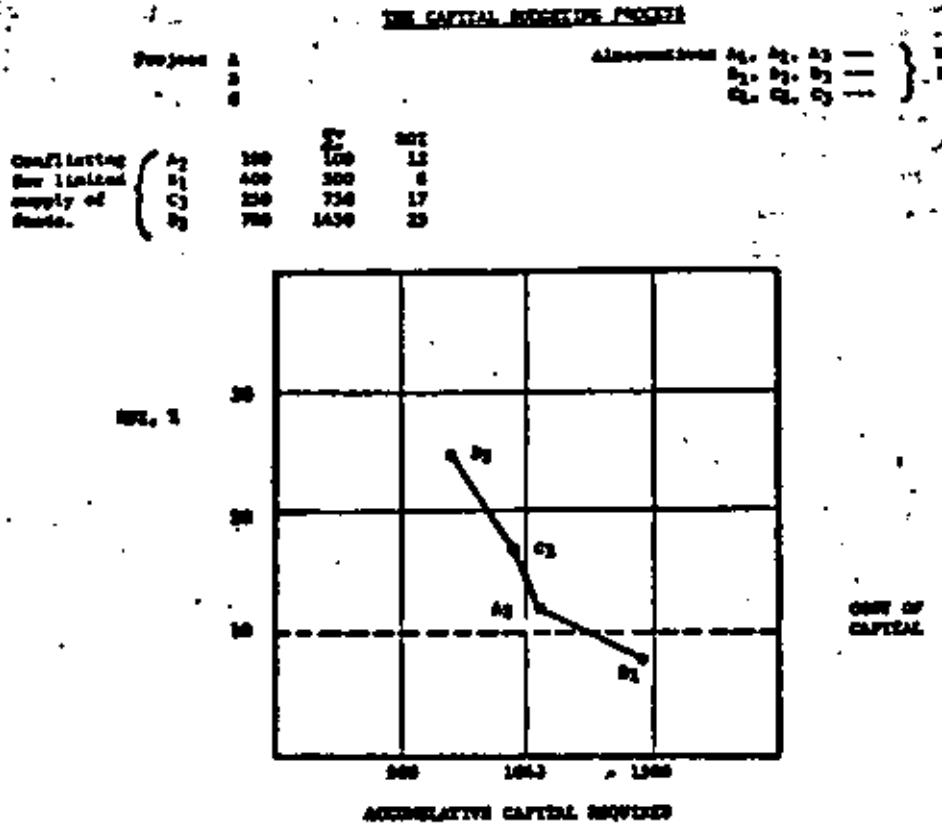
1. EFFECTIVE CAPITAL EXPENDITURE CONTROL STARTS WITH A LONG TERM PLAN.
2. THE FINANCIAL OFFICER IS THE KEY TO ANY CONTROL PROCESS.
3. PRINCIPAL STEPS FOR CONTROL OF CAPITAL:
   - A. ESTABLISH A BUDGET
   - B. PREPARE APPROPRIATION REQUESTS
   - C. FOLLOW UP ON PROJECTS IN PROCESS
   - D. POST-AUDIT
4. COMMUNICATE RESULTS EFFECTIVELY.

CAPITAL BUDGETING

THE PURPOSE OF ANY EVALUATION IS TO IDENTIFY THE IDENTIFY THE BEST ALTERNATIVE.

IN ANY COMPANY THERE ARE MANY REQUESTS FOR CAPITAL FUNDS.

SINCE MONEY IS A LIMITED RESOURCE, THERE HAS TO BE SOME MEANS TO RATION CAPITAL.



WHAT ARE SOME OF THE DIFFICULTIES THAT ARE INHERENT IN CAPITAL EXPENDITURE REQUESTS?

1. INCOMPLETE DOCUMENTATION OF WHY THE CAPITAL ITEM IS REQUIRED
2. LACK OF FORMAL JUSTIFICATION (e.g. DISCOUNTED CASH FLOW)
3. FAILURE TO CONSIDER ALL OF THE ALTERNATIVES
4. INADEQUATE OR NO ALLOWANCE FOR RISK
5. POORLY WRITTEN AND COMMUNICATED DOCUMENTS
6. BIAS TOWARDS ANY ONE OF THE ALTERNATIVES
7. ERRORS IN DATA AND CALCULATIONS

COMMUNICATING WITH BUSINESSMEN

UNDERSTAND THEIR PERSPECTIVE:

- CAPITAL RESOURCES ARE LIMITED, WHICH IS FURTHER AGGRAVATED WHEN MONEY IS TIGHT
- OBJECT THEREFORE IS TO MAXIMIZE BENEFITS FROM ITS CAPITAL INVESTMENTS
- CONCERN WITH THE IMPACT THAT THE PROPOSED INVESTMENT HAS ON THE OVERALL ECONOMIC PERFORMANCE OF THE ENTERPRISE
- FACTOR IN THE COMPETITIVE, POLITICAL, SOCIAL AND ECONOMIC ENVIRONMENT

EACH REPORT COMES UNDER CLOSE SCRUTINY

WHAT BASIS AND ASSUMPTIONS WERE USED IN ESTIMATING THE ECONOMIC DATA?

WHAT LEVEL OF CONFIDENCE DOES THE ENGINEER HAVE REGARDING THESE ESTIMATES?

HOW WOULD THE INVESTMENT OUTCOME BE AFFECTED BY VARIATIONS TO THESE ESTIMATED VALUES?

WHAT BUSINESSMEN LOOK FOR

CAPITAL REQUIREMENTS

PROFIT CONTRIBUTION, CASH FLOW

MEETING MINIMUM RETURN CRITERIA

SECURITY OF INVESTMENT (RISK)

ALTERNATE USES FOR AVAILABLE CAPITAL

PRESENTATION TIPS

KNOW YOUR MATERIAL THOROUGHLY

ENSURE SMOOTH HANDLING OF VISUAL AID MATERIAL

BE PREPARED TO BE INTERRUPTED WITH QUESTIONS

HAVE BACKUP MATERIAL AVAILABLE

BE PREPARED TO REDIRECT YOUR EMPHASIS

KNOW WHEN TO KEEP QUITE

W. R. BREWSTER, ANALYST
EXXON INTERNATIONAL

Requesting Dept.: P[ ] S[ ] Mktg.[ ] R&D[ ]

Approval Required: Board[ ] Gen. Off.[ ] Field Mgr.[ ] Other[ ]

Request for Appropriation

Capital Investments (6a,b,c) $_____
Loans (6d) $_____
Lease Commitments (6f) $_____

Date_____
Appn. No._____
Est. No._____
Requesting Location_____

1. Project Title and Location

2. Description of Proposal

3. Purpose of Expenditure — Increase Profits ___ By:
Maintain Profits ___
Other

4. Timing:
Construction Period _____ mos.
Estimated Start-up Date _____
Estimated Useful Life _____ yrs.
Term of Lease or Loan _____ yrs.

5. Effect of Delay in Approval:

6. Funds Appropriated:
a. Depreciable Capital $_____
b. Non-Depreciable Fixed Capital $_____
c. Costs Expensed $_____
d. Loans $_____
e. Total Initial Investment $_____
f. Lease Commitments (Disc. @ 5%) $_____

7. Associated Investments:
a. Change in Current Assets $_____
b. Change in Current Liabilities $_____
c. Change in Net Working Capital $_____
d. Other Commitments (Disc. @ 5%) $_____
e. Contingent Liabilities $_____
f. Possible Future Investments $_____

8. Present Facilities:
a. Approximate Age _____ yrs.
b. Approximate Original Cost $_____
c. Salvage Value $_____
d. Dismantling Cost $_____

9. Description of Base Case Against Which PI is Calculated:

10. Profitability Index: _____
a. Sensitivities

	Likely Variation in Value	Change in PI
Investment		
Price		
Volume		
Savings		
Project Life		

11. Effect on P&L and Rate of Return:
(M Dollars except as noted)

	Pre-Start	Project Year 1	2	3	4	5	6-10	11-15	16-20	21-
Profit After Taxes										
Cumulative Cash Position										
Average Investment										
Book Rate of Return - %										
R of R w/Disc. Commit. - %										

12. Related Appropriations Either Recently Authorized or to be Requested:

13. Budget Status:

14. Remarks:

Recommended By _____ Date _____ Approved _____ Date _____

SESSION NO. 12 - WORKSHOP NO. 3

Work on the Loco Chemicals Company case is completed. The sensitivity and post-audit calculations are discussed, and compared with the case writer solutions. Possible applications of Monte Carlo techniques and a research project evaluation and ranking technique are also discussed. Recommended actions are agreed upon and an appropriation request prepared.

The case writer solutions are provided as a supplementary handout.

HOW TO PREPARE AN APPRAISAL REPORT

Summary. Briefly describe the investment project and its objectives. Include a short table comparing original and current estimates for the following items on a consistent set of evaluation procedures: investment, physical output, net earnings and PI. Explain major differences in profitability, and summarize conclusions.

Project description. Describe the original project or program. Give a concise description of the type and size of facilities involved. Explain technological factors. When pertinent, include events leading to conception of the project. Discuss the objectives of the project in terms of output, costs, etc. If the investment is part of a larger program, describe it and how it fits.

State the original estimate of investment cost and PI. Then restate it, including adjustments for evaluation procedures or base case.

Appraisal objectives and evaluation basis. List objectives preset for the appraisal study. Explain the evaluation basis used. Explain key assumptions and base case used in the original pre-investment evaluation. Show any major changes in evaluation procedure or scope made for the post-installation evaluation.

To obtain a truer measure of profitability, alter the base case to reflect current thinking as to the optimum case without the investment. In any event, compare pre and post-evaluations with the same base case. Discuss planned future expansion or modifications related to the original proposal. State assumed relationships to other functional areas and the competitive environment. Describe any dependent relationships assumed for particular variables, either to other variables or outside influences.

Project performance. Discussion and supporting tables compare historical and currently projected results (where made) with the preinvestment estimates (where available), stated on a consistent set of evaluation procedures. Report the following information:

1. Amount and timing of investment.
2. Profit and loss statement and cash flow summaries as originally projected, actually experienced to date, and now projected for future years.
3. PI and/or present value at 10 PI.
4. Add explanatory discussion and tables needed to isolate the following factors where important:
   a. Units of production, throughput, yields and/or sales volumes.
   b. Unit consumption of materials and other operating expenses.
   c. Unit realizations and costs.
   d. Performance with respect to market position, productivity, product quality improvement, etc., where applicable.

Where a new forecast of future performance is made, but project profitability is still uncertain, include likely ranges for items estimated above.

Where profitability is well determinable, make a PI reconciliation to show reasons for big changes in profitability. This reconciliation is probably best done by beginning with the original PI and adjusting to the current PI forecast in steps. Make changes to the cash flows in the following order:

1. Up-date the original evaluation basis for changes in evaluation procedure, changes in handling of tax effects, (rates, depreciation schedules, investment credits, etc.), and other procedural changes not in the original evaluation.
2. Revise the original base case against which the project was evaluated if experience shows another base case to be more appropriate.
3. Revise for actual experience to date alone. Adjust all major elements, preferably in the order of investment first, expenses, volumes and finally prices.
4. Finally, adjust for changes expected in the current forecast of the future in the various elements.

Combine or supplement the above steps if needed for clarity.

Analyze significant variances and reasons for differences explained.

Conclusions and comments. State whether or not the investment is meeting or is expected to meet its objectives. Where performance is not meeting expectations, state any plans for enhancing profitability. Include any recommendations for improving performance, future investment proposals, and/or current evaluation methods. Schedule reappraisals on projects that involve operational changes, or where uncertainties cloud the future.

Review the basis for and logic behind the original investment decision, in light of appraisal results. Describe alternatives which might have better met the investment objectives. Identify variables which appear to be most critical. Describe and tabulate data expected to be useful for future investment planning and estimating. Specify further study areas which will improve results obtained from future appraisals of similar investments.

result is for return to be less than the estimate.

Program objectives. A PIA has five main objectives:

	Relative difficulty
1. Measure physical performance	Easy
2. Review original decision basis	Hard
3. Study ways to improve existing operations	Varies
4. Look for evaluation procedure inadequacies	Varies
5. Provide future decision guides	Varies

Findings commonly reported:

Measuring performance is relatively easy. Most operating data are available. Generally, investment, operating cost and yields have been better than originally forecast. Frequently there has been inadequate recognition of competitive effects and their impact on volumes, realizations, and marketing expenses. Companies need to note effect of the business cycle on investment cost and the probability of continuing operating improvements through learning and bottleneck removal.

Decision-basis review. This can be difficult. The analyst must try to put himself in the position of management at the time of project approval. From there, he would see if the cases selected and assumptions made still seem reasonable. This is a two-step procedure. Consider first the corporate environment and information available at the time of project approval. Second, note the effect of subsequent developments. Related to this has been the need for better documentation of the original decision basis. People originally involved often are either gone, or no longer recall details of something done five or more years ago.

In almost all of these studies some *ways to improve existing operations* are uncovered. Just focusing management attention on these projects helps. These become showcases on how your company runs its business. Frequently, improvement efforts start in line departments, prior to completion of a study.

Evaluation procedure deficiencies. These were com-

Continued on Page 209

TABLE 3—Effect of foreign competition

1. Project: Manufacture plastics intermediate
2. Description: The Canadian company resold a plastic intermediate import from Europe. Decided to build plant when competition threatened local production. Patent protection was available on know-how. Past growth, 20%/yr. One customer was taking 60% of sales, as premium grade, and expected continued rapid growth.

3. Summary economics	Original evaluation		PIA	
Physical output				
Capacity	1.2MM lb.		1.2MM lb.	
% of capacity, year 1	67%		44%	
Investment, $M				
Fixed capital	550		584	
Working capital	100		88	
	650		672	
First year results	$M	¢/lb.	$M	¢/lb.
Realization	1040	130	658	126
Manufacturing cost	735	92	537	103
SAR	115	14	95	18
	850	106	632	121
Before-tax profit	190	24	26	5
Income taxes	100	13	14	3
After tax profit	90	11	12	2
% return on capital	13.9		1.8	

4. Rate of return reconciliation

	Change in return	Rate of return
Original evaluation		13.9
Investment effects	−0.5	
Sales volume	−8.0	
Selling price	−2.5	
Expenses	−1.1	
Actual result		1.8

5. Comments: This project illustrates the need for market and cost research in depth. Volume to principal customer decreased markedly because Japanese imports were replacing his end products in Canada. This customer bought highest quality goods at an above-average price. Loss of this business was also responsible for a price decline. A modest business growth of 5 to 8%/yr. is now forecast. Second and third year returns on capital are estimated at 2 to 4%, respectively. With capacity sales, a 5 to 6% return is now forecast.

TABLE 4—Need to push new developments as quickly as possible

1. Project: Addition to an existing plant to provide a new plastic resin with greatly improved molding qualities.
2. Description: This is a new research development which a company discovered and pushed into production. As the product was much better than any competitive material on the market at that time, the company acted quickly, wasted little time in estimating and rushed the job to completion.

3. Summary economics	Original evaluation		PIA	
Physical output				
Capacity, MM lb	10		10	
% of capacity, year 1	46%		78%	
Investment, $M	1200		823	
First year results	$M	¢/lb.	$M	¢/lb.
Realization	921	20.0	1500	19.2
Direct costs	230	5.0	390	5.0
Overland & allocated charges	360	7.8	375	4.8
	590	12.8	765	9.8
Before-tax profit	331	7.2	735	9.4
Income taxes	175	3.8	375	4.8
After-tax profits	155	3.4	360	4.6
Return on investment	13%		44%	

4. Comments: The estimating for this project was done without full design information and in a few days, rather than several months. As you can imagine, actual results bear little relation to the estimate, with a 30% underrun over-all. However, nobody cared in the least. The product caught on and very high early sales and profits were recorded. It is likely that the plant will be paid for before competition brings out an equal product. This rather unusual example illustrates a case where the cost engineer is a relatively unimportant link in the project chain. When necessary, he must be able to do some of this estimating very quickly using shortcut techniques.

TABLE 5—Many companies in a limited market

1. Project: Expand existing chemical "X" plant to supply added customers and discourage competitive expansion.
2. Description: A low cost expansion made after one year of commercial operations, to improve present marginal returns. Difficulty was foreseen in providing service to all customers as plant neared capacity. There appeared a need to move quickly to discourage competition.

3. Summary economics	Original evaluation Expansion increment	PIA Expansion increment
Physical output		
Capacity, tons	9,000	9,000
% of capacity, year 1	18%	5%
Investment, $M		
Fixed capital	300	630
Working capital	20	45
	320	675
First year results	$M	$M
Realization	220	(5)
Variable costs	150	40
Fixed costs	80	105
	230	145
Before-tax profit	(10)	(150)
Income taxes	(5)	(80)
After-tax profit	(5)	(70)
Estimated return at capacity	24%	15%
Years to reach capacity	5	10

4. Comments: The original small (21,000 ton/yr.) plant operated at 92% of capacity in the first year, but yielded only a 0.5% return on investment.

This expansion project was hurried through in an attempt to discourage a competitor from building a plant and provide incremental profits.

The effort was unsuccessful. As a result, the expansion was not properly utilized and efforts to generate added sales caused the company to lower prices—a step it feels it would not have taken without the expansions. Fixed investment was under-estimated by 30% because of the short time available to prepare the project. Marketing costs and working capital were higher than anticipated because of the need to provide more service to customers—a result of intense competition.

The incremental expansion originally projected to yield a 24% return at capacity now shows a 15% return at capacity, and capacity is not reached for 10 years. As a result, the combined profitability on the expanded plant is now estimated at 4.5%, or well below a minimum acceptable return. Unfortunately, only a minimum salvage value is possible if the plant were shut down and no known alternate uses are seen for most of the equipment. The best choice for the company now is to make the best of a poor earlier decision and continue current operations.

Continued on Page 21

mon in projects approved in the late 1950s. However, this is less of a problem now. A big benefit of the program is to develop *guides for improving future decisions*. Some typical steps in this area are:

1. Place greater emphasis on analysis of project components, as well as the total proposal.
2. Where possible, develop economics for all outside participants in joint dealings, rather than just analyze your company's position (acquisitions, for example).
3. In some acquisitions, limited access to vital information about the company being acquired has hindered valuation of properties.
4. Pay more attention to capital expenditure timing and the problem of investment acceleration or deferral.
5. Management should accept low return economics if judgment and strategic considerations dictate project acceptance, rather than adjusting assumptions or incentives to assure that the project meets the minimum standard.
6. Place more emphasis on the effect of alternate forecasts and their probabilities (what flexibility do the facilities have, to operate economically in different environments?).

These are illustrated in the case histories in Tables 3, 4, and 5 (Page 209).

TYPICAL APPROACHES TO THE PIA

Project scheduling. Selecting projects for post-audit is one very important decision in an on-going PIA program. To do this well, all major investments should be covered. Choice of study depth employed should be flexible. Not only is there a big shortage of economics-oriented personnel to do these audits, but a detailed study is both time-consuming and expensive. One can cost $20,000.

The typical steps are:

1. Annual or semi-annual review of all approved appropriations above some level ($500,000, for example). Determine if audit should be made, when, and suggested depth. If only a review of critical factors is anticipated, list items to be reviewed.
2. Develop a separate list of special programs. These can represent either a logical combination of investments that otherwise would be audited separately, or a key activity composed of many small investments that would not otherwise call for detailed audit.
3. Submit list to company management for approval.

About the author

HENRY C. THORNE, JR., *is manager planning and commercial development, Patchogue Plymouth Co., Atlanta, Ga., a subsidiary of Amoco Chemicals Co. He has been with the Amoco organization since 1952—serving in Chicago, Tulsa, Okla.; Whiting, Ind., and Atlanta. He is a recognized expert in the field of investment evaluation, with 20 years diversified experience in the petroleum and petrochemical industries and has been responsible for providing company-wide standards and guidance for economic evaluations in several Amoco affiliates. Mr. Thorne has published other articles in HP (1-'65 and 1-'71). He holds a B.S. degree in chemical engineering from Cornell and M.B.A. from Northwestern.*

performing PIA, to the extent it is not readily available from the normal accounting records.

Report preparation. The Financial Department usually handles audits. But line departments should help. They know the operating problems and will have to implement recommendations. This line involvement includes direct field participation, as much as possible.

The audit study consists of five main steps: (1) review of original decision basis and possible alternates, (2) data gathering, (3) analysis, (4) report writing, (5) management review and approval.

Ideally, the line department participates in all phases.

Feedback of results up and down the chain of command is critical. Commendations, of course, are as important as requests for improvement.

Potential problem areas. There are four of these.

1. Data. Any project appraisal involves many factors. Often, data are either not determinable from accounting records or would cost too much to obtain. Since any appraisal involves the comparison of alternates, it is the changes in cash costs and revenues because of a (usually small) change in the total business which are important. Even if the variables for one of the alternates is known, the option not undertaken is usually subject to as much, or more uncertainty than when the original evaluation was made.

2. Timing. There is always a conflict between the desire to wait as long as possible to gain as much experience as possible, and the need for quick information. One benefit of performing a PIA early is to point out problem areas, so corrections can be made. The usual compromise is to do the post-audit two to three years after plant startup. Repeat the audit several years later in cases where initial performance is unsatisfactory, or management interest and information gained is great. It is best to perform PIA's of a product line prior to plant expansion.

3. Who does the work? Line and financial personnel should participate in these studies. Day-to-day pressures often keep line personnel from taking as active part as would be desirable.

4. Reporting format. The form and content of an appraisal report used by one large company is in the Box.[2] Some or all elements would be included depending on the depth of an appraisal. It should describe the investment and performance, including a reconciliation with original estimates. Usually, a new forecast and analysis of future expenditures is also shown.

Summary tables and charts help to tell the story clearly, concisely, and completely. A number of items frequently covered are discussed in the Box. A typical summary economics statement and rate of return reconciliation are shown in Tables 1 and 2.

ACKNOWLEDGMENT

Case histories in Tables 1, 4 and 5 are drawn from several given at an American Association of Cost Engineers convention in 1964. The examples are from real projects with the data changed to disguise each case. The paper was given by R. G. Surtees of Canadian Industries Ltd. Data were drawn from the investment experience reports of Canadian companies—mostly the Canadian subsidiaries of large American and British companies.

LITERATURE CITED

[1] Park, W. R., "Post-Installation Appraisals—What the Literature Tells Us," *Hydrocarbon Processing*, March 1971, page 111.
[2] Reporting form and format from Standard Oil (Indiana), reproduced by permission.

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Introduction

Applications of risk analysis to research and commercial projects are numerous.(1,2,3) In a typical analysis, economic inputs are expressed as random variables which are then combined by Monte Carlo techniques to give a distribution of present values for the project. Such inputs as plant investment and operating costs, sales volume, product prices and project life can be expressed as random variables. The variables can be specified in as much detail as desired, but frequently will be defined by a median, a high, and a low value. Such random values usually cannot be defined explicitly, but must be estimated by the analyst, the project team, management, or a combination.

The use of decision trees has been discussed in several articles in the literature.(4,5,6) Decision trees, like Monte Carlo risk analysis, permit the inclusion and specification of uncertain events. Generally this is done by expressing the probabilities that specific events will or will not occur, and what the present values of the outcome will be in either case. Various decision nodes are connected in series, with each decision leading to a course of action which has an uncertain outcome. Branching occurs at decision points where alternative courses of action can be followed.

In solving a decision tree problem, a roll-back of outcomes is employed starting with the final event. The possible outcomes of this event are multiplied by the probabilities of their occurrence, giving an expected value which can then be "rolled back" to the last previous point of uncertainty. This procedure is repeated until the expected value at the present moment is calculated. This expected value if a single number, not a distribution of values. The incorporation of Monte Carlo randomization in the roll-back procedure, a technique employed by the authors, provides the distribution of present values for the project.

What is Decision Tree Analysis?

Figure 1 is a decision tree for a hypothetical research project involving the consecutive steps of bench scale, pilot plant, market development, and commercialization. In practice, some of the steps can overlap or proceed simultaneously, but for illustration, we show only the controlling activity at each step. For this example, let us assume that all costs and returns are expressed as present values calculated at a fixed rate of return and computed relative to a point in time--in this

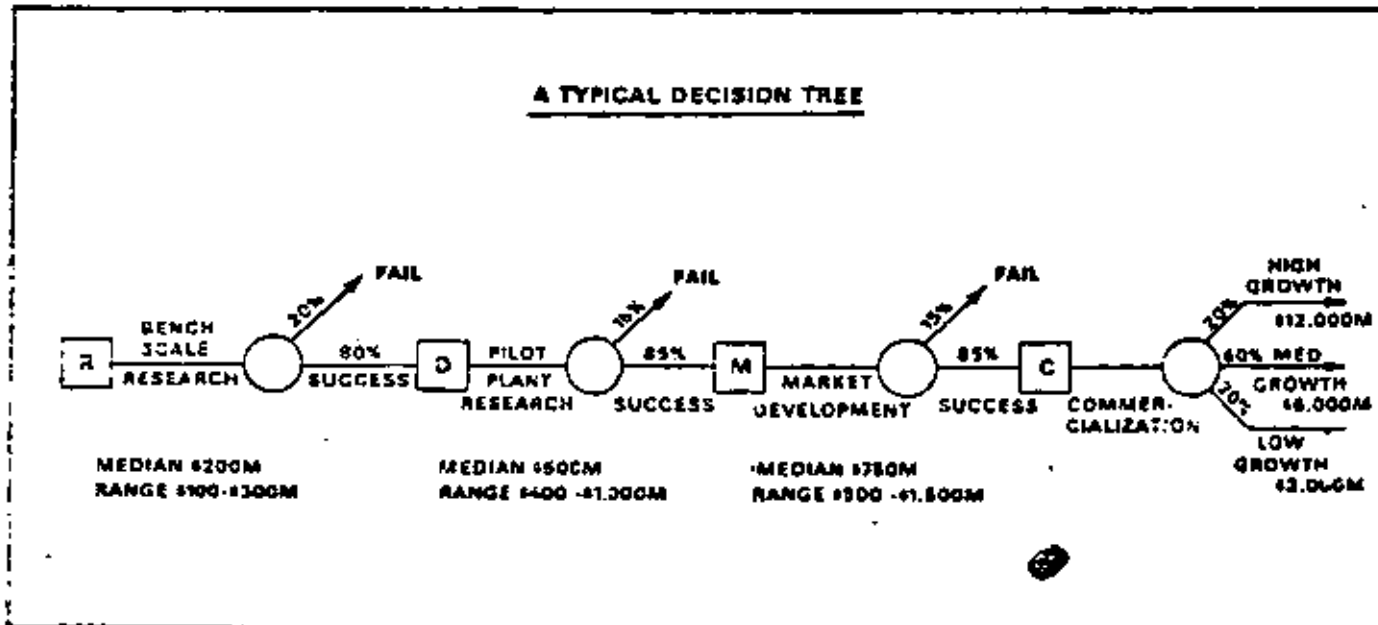

FIGURE 1

case, the present, either before-tax or after-tax present values can be used in stating and solving the problems. Decision A is the decision facing management now--should it spend money at the bench level on this particular research project? Cost is uncertain but is expected to fall between $100 M and $300 M with a median of $200 M. By deciding not to invest in this project, management can spend the money on another project. To continue our hypothesis, let us further suppose that management, in cooperation with the research planners, has reviewed the bench-scale research plan and long-range goals of the project and believes that there is an 80 percent chance that the research will be successful and will lead to consideration of the construction and operation of a pilot plant, Decision B. Pilot plant costs are projected to be between $400 M and $1,000 M. Management and the planners presently speculate that there is an 85 percent probability that the pilot plant stage will be successful. In assessing the probability at 85 percent, management has considered that the basic technology involved largely exists and that the major uncertainty lies in the process yields. If major new hardware had to be developed, the probability would have been assessed lower.

If the pilot scale development is successful, there is still another stage before commercialization, market development, and then final economic evaluation. Estimated median cost of this stage is $750 M. If the product or products being manufactured already exist in the market[illegible], then market development will be directed [illegible] location of suitable market areas and discussions with potential customers. If the product or products are new and have not previously been marketed, then market development will largely be directed toward testing and evaluation by potential purchasers, and the assessment of probable market size. In addition at this stage, detailed process designs would be prepared and would serve as a basis for final cost estimates and final economics for commercialization. The probabilities of success and failure of this step are extremely difficult to assess at the "idea" stage. However, commercialization represents one of the major uncertainties in the project, and an estimate of this uncertainty must be made, so that management can be made aware of the risks of the project. If the product is already widely sold, then the probability of success at this stage may be high, and if the product is new, it may be quite low. However, exceptions can occur--as, for example, the development of the new product for fulfilling a specific known need (e.g., biodegradable detergents).

In our example, we will assume that our particular product is already being marketed, and the market is growing rapidly. Therefore, management believes that the product will be accepted and that potential users will encourage another source of supply, and in some cases will sign advance sales contracts. Consequently, an 85 percent probability of success is assigned to this stage.

Once the market development and final economic justification are successfully completed, then a commercial plant will be built. At the time the plant is justified, it will be possible to estimate probable sales volumes based on the results of the marketing stage with reasonable accuracy. From the present point in time, however, there is considerable uncertainty in predicting how much product will be sold. Furthermore, the effect of an additional source of supply will result in some erosion in price. Based on possible variations in price and sales volumes, plants of three different sizes have been projected. Estimated present value for the small plant is $3,000 M, and for the large plant, $12,000 M. The intermediate size plant is estimated to have a present value of $6,000 M. After considerable discussion, management decides that it should weigh these cases at 20%, 20%, and 60%, respectively.

Having thus defined the decision tree, the roll-back calculation is a simple matter. We start at the most distant point in time and work back to the present. We see that there are three present values associated with commercialization, each having a separate probability of occurrence. By multiplying each present value by its probability and summing, we get an expected value for commercialization; and, in this case, it calculates at $6,600 M. As we roll back to the next node of uncertainty, we pass the Decision C, or commercialization decision.

Next, we will roll back through the marketing node of uncertainty. This is accomplished by multiplying the $6,600 M expected value for commercialization times the probability of commercialization after market development, or 85 percent. This gives an expected value of $5,610 M from which must be subtracted the cost of the market development step, or $750 M. Rolling back into the pilot plant step, we again multiply by the 85 percent probability of success, and subtract the cost for this research, $500 M, leaving an expected value at Decision D of $3,630 M. The roll-back is completed by multiplying by the probability of success of the bench-scale research, 80 percent, and subtracting the bench-scale research cost of $200 M. This leaves an expected value for the project of $2,700 M.

The expected value we calculated from the decision tree analysis, is useful in judging whether to proceed with the project, but does not display some of the information which is inherently provided in the statement of the problem. In setting up the problem, the evaluation team has in effect enumerated a large number of possible outcomes for the project--some which lead to commercialization and the generation of present value, and some which lead to project termination and, therefore, result in net costs. What would be even more useful than an expected value for the project is a distribution of present values of the many outcomes effectively projected by the decision tree analysis.

tree approach. At each node of uncertainty, outcomes must be randomly selected. Carrying out the roll-back in this fashion results in a distribution such as that of Figure 2, which is provided for the particular problem shown in Figure 1. This distribution shows that in 44% of the projected outcomes, the project has been terminated and a net cost results. In the other 56% of the outcomes, commercialization has resulted with the distribution of present values as shown. Quite obviously, the display of this information tells much more to the management responsible for approving the project than the single-valued expected value computed from straight roll-back of the tree. It clearly identifies the magnitude of the risk as assessed by the evaluating team. When management reviews the decision tree diagram, it can also see how the failures relate to the various necessary steps of the project. Finally, management can be informed as to the major uncertain steps in each of the phases.

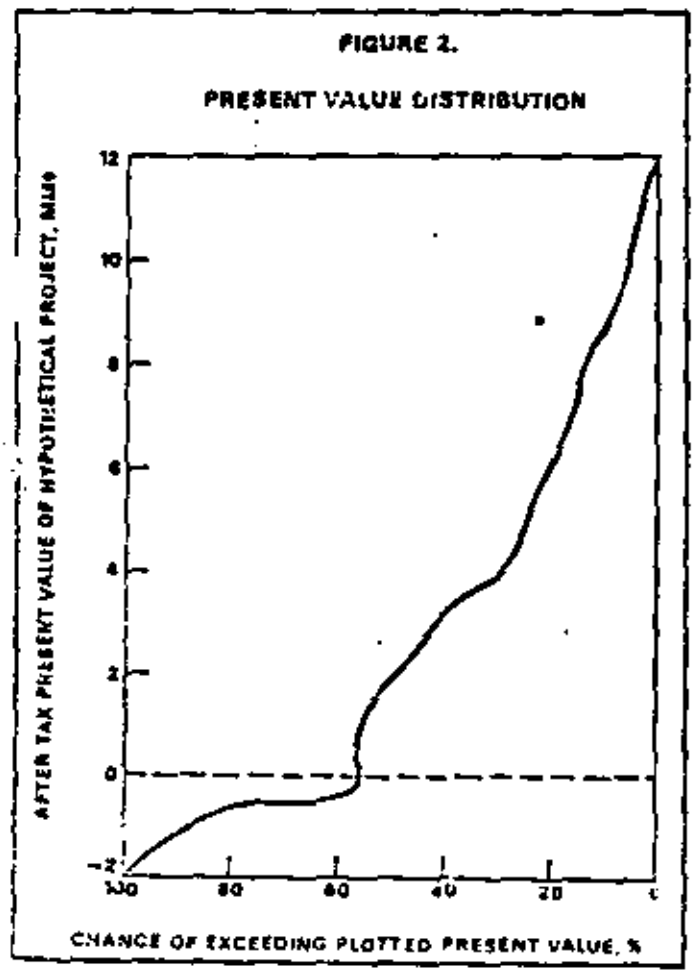

Figure 2

For example, in the pilot plant phase of the problem under discussion, the main uncertainty is believed to be in the process yield, or in the effect of scale-up on process yield. Management is thereby alerted to watch for the results from this step in the process, if they decide to proceed with the development. They also can see [illegible] are unsatisfactory.

At each decision node, one could consider the possibility that management would not make a favorable decision, even though all the inputs were favorable. For example, at the commercialization decision, management could reject commercialization even though the research, development and marketing steps were completed and the commercial prospects were favorable. Such rejections might arise because of unavailability of funds. In some problems it may be well to include probabilities to allow for such occurrences at some decision nodes. However, for most problems, the assumption that management will make a favorable decision if all the inputs and expected output are favorable, seems reasonable; this was the approach taken in this particular problem.

Additional detail (more uncertainty nodes and decisions) can be included than shown in Figure 1. However, caution is advised in over-elaborating details of the project. One reason for this is that in most projects there are relatively few real decision points. Decisions are not made on a daily, monthly, or quarterly basis; generally, they are made when funds must be appropriated for new pilot plant units, or when new programs are justified, or annually at budget time. Furthermore, the more decision points that are employed (with associated uncertain events), the more critical the estimation of probability at each node becomes. For example, if there are ten decision nodes in series and each has a 90 percent chance of success, the overall probability of success is $(.9)^{10}$ or only 35 percent.

It frequently is helpful to have a very detailed layout of research steps that are required in a particular project; for this, a PERT diagram can be used. This diagram helps the planners to visualize all of the steps that are needed to carry out a project, and the most critical steps in terms of time and cost can be identified.

Decision Tree Formats for R&D

Decision tree analysis of research projects within Standard Oil of Indiana, although not uniformly applied, has had a favorable reception. We are now using this analysis tool as an aid in selecting projects for exploratory or bench-scale research as well as the more obvious application to projects in the development or pilot plant research stage. The following paragraphs present five different decision tree formats and also speak to the interplay between marketing opportunities and technology innovations.

Marketing opportunities interface with chances for technological improvements in various ways and it is useful to organize our thinking along product lines. Under existing products, we will consider three separate cases: expand own product; be in marketing an existing product;

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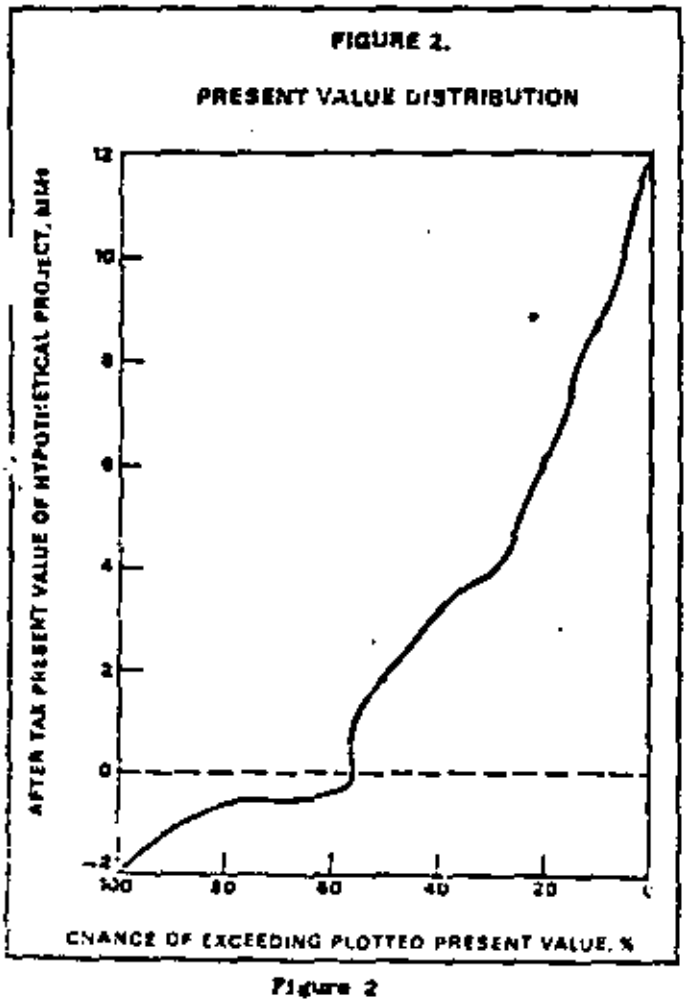

FIGURE 2.

Figure 2

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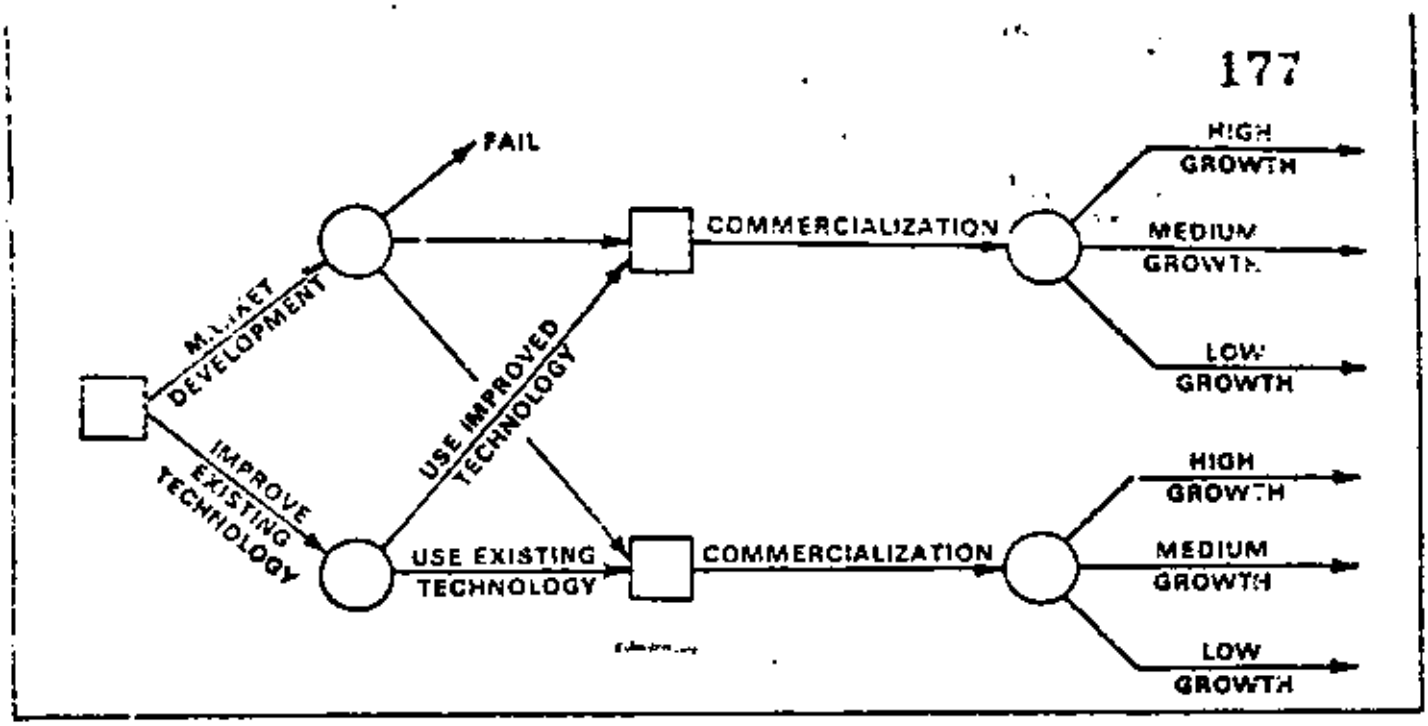

Figure 3

and thirdly, a study of new technology routes to an existing product. For new products, there are only the two cases to consider: using existing technology; and developing new technology to produce the new product.

Figure 3 is the decision tree for the case of expanding one's own product. The first decision management faces is "can we improve on existing technology to satisfy a growing market?". Parallel activities are projected for market development and for research work to improve the existing technology. Commercialization of the opportunity, assuming market development is successful and that the project is not stopped at that point, splits into two paths. The path of the highest potential value is the one using improved technology. Commercialization of this route will take longer because of the changes in the technology. The elements included in the calculations of the present values for the various growth rates include information on sales volumes, selling prices and plant investment information along with estimates of marketing and manufacturing costs. Present values are calculated using standard discounted cash flow techniques. Differences between the high and low growth cases might in some instances be merely larger plants for the high growth case or alternatively multiple plants. The medium growth rate is the most probable case with the high and low growth rates bracketing expected performance.

A company is faced with the decision of whether or not to begin marketing a product new to itself. The product already exists and the technology for its manufacture has been developed "in-house" or acquired from outside sources. The technology has developed to the point where pilot plant research is required to provide the necessary information needed for final plant design and project justification. Figure 4 is the decision tree which maps out this case. Here again, market development work will be conducted parallel with the pilot plant research. Successful completion of both the market development and the pilot plant research leads to commercialization in the three different cases of high, medium, and low growth rates. In this case, the company is embarking on a product and marketplace new to its experience and expertise. Here the company must rely on the best available information concerning the competitive technologies and an in-depth market research study. To evaluate the decision to proceed with development work, it is necessary to input best guesses on product prices for the various sales volumes along with investment and operating costs in order to develop the respective present values.

A project that has proceeded to the decision point of whether to conduct a market development program and to do pilot plant research could have had the advantage of earlier analysis of the form shown in Figure 5. Here we are comparing various new routes to produce an existing product. For Product X, the decision has been made to conduct a market research study, to review the technologies of existing routes to the product and to propose several new routes or new technologies for purposes of evaluating the technology alternatives. We are not interested in using the available competitive technology because this does not provide any technological advantage with which to enter

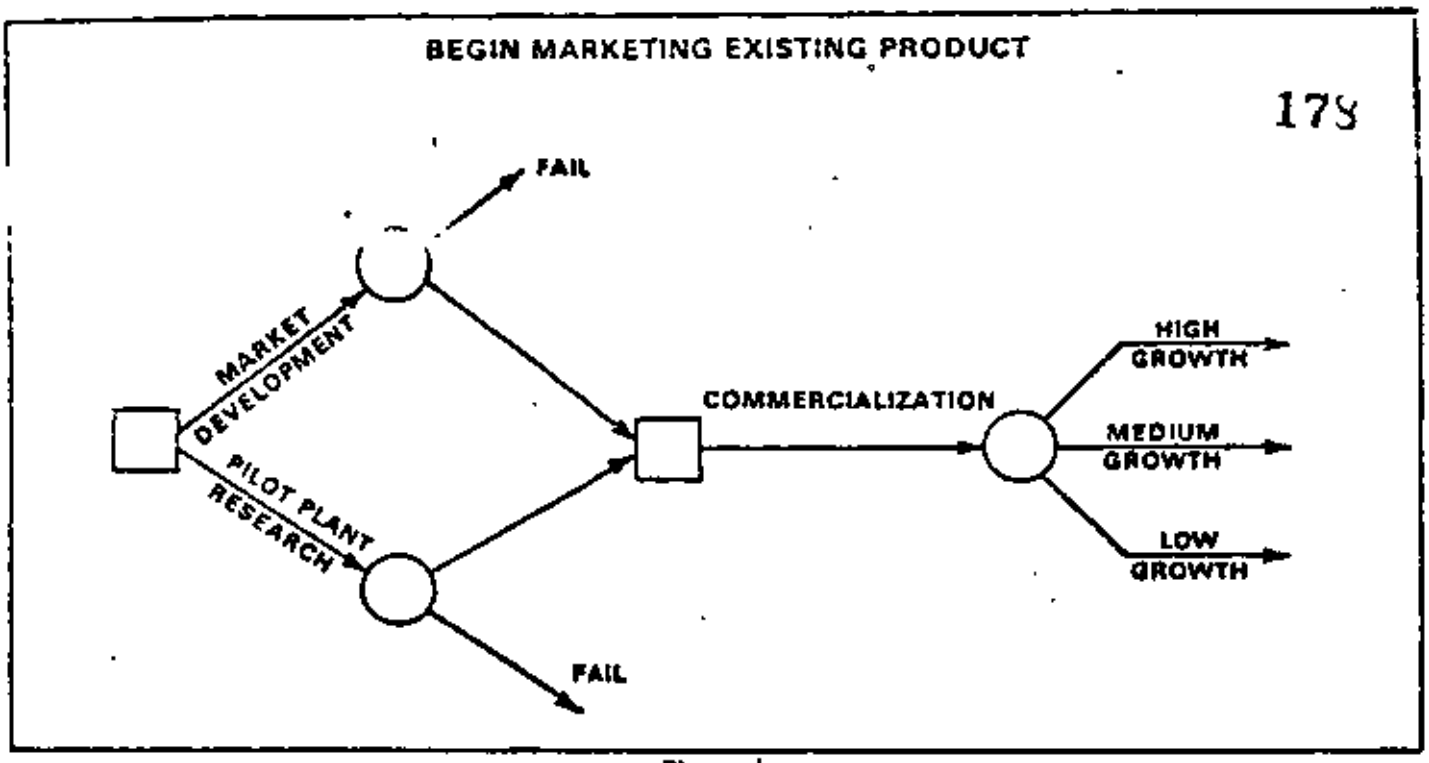

Figure 4

the marketplace. On the other hand, it is highly desirable that the competitive technology be thoroughly analyzed and well understood in order to provide the necessary frame of reference for evaluating the proposed technologies. In this case, commercialization of the technology does not entail estimating various market growth possibilities. Our goal is to bracket the technology in terms of yields, investment and/or operating costs. Thus, a best and a worst case along with the most probable case are developed in order to generate a present-value; probability distribution which spans the technology alternative. The best case, for example, could assume theoretical yields if this were reasonable or alternatively minimal capital investment. The worst case could be pessimistic with respect to either yields, investment or operating costs but still should be better than the competitive technology. Present values for the three cases are calculated using a floor price [7,8] predicted from the competitive technology and a sales volume indicated by the market research work. In all of the present value calculations, sales volume and selling price are the same for each case and each technology. In this way, roll-back on the decision trees provides a comparison of the technologies without perturbations of marketplace considerations.

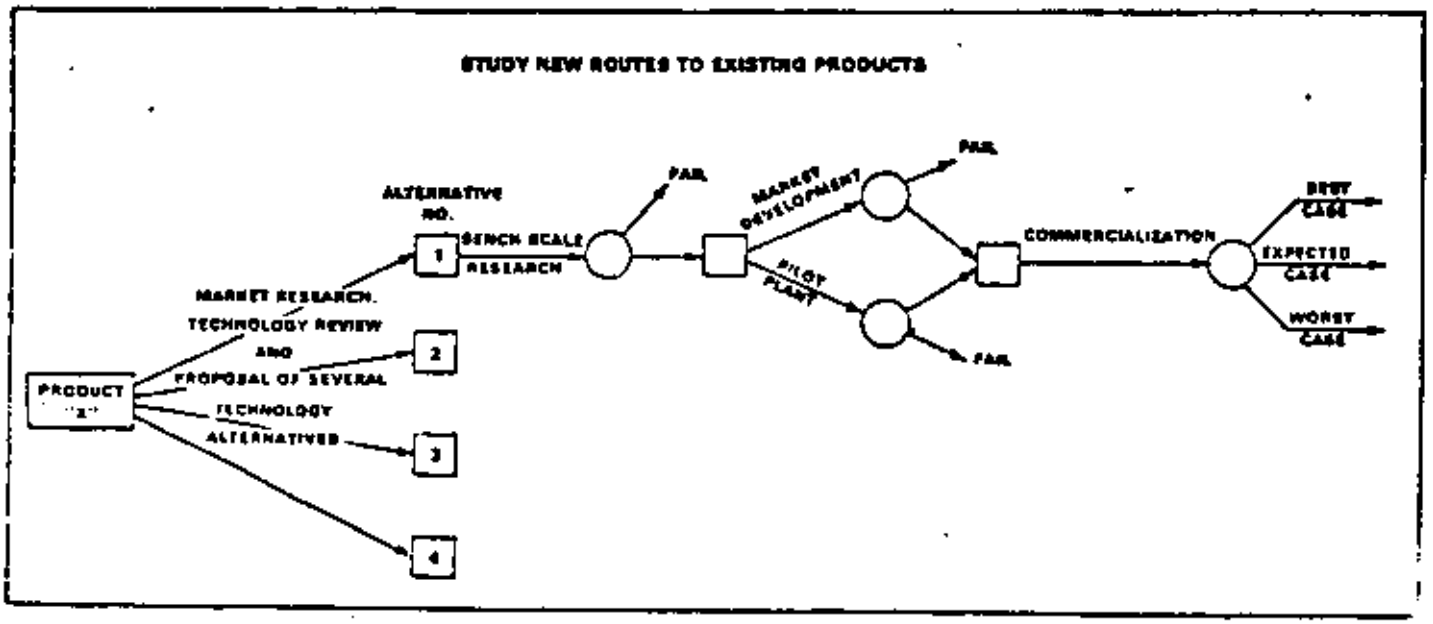

FIGURE 5

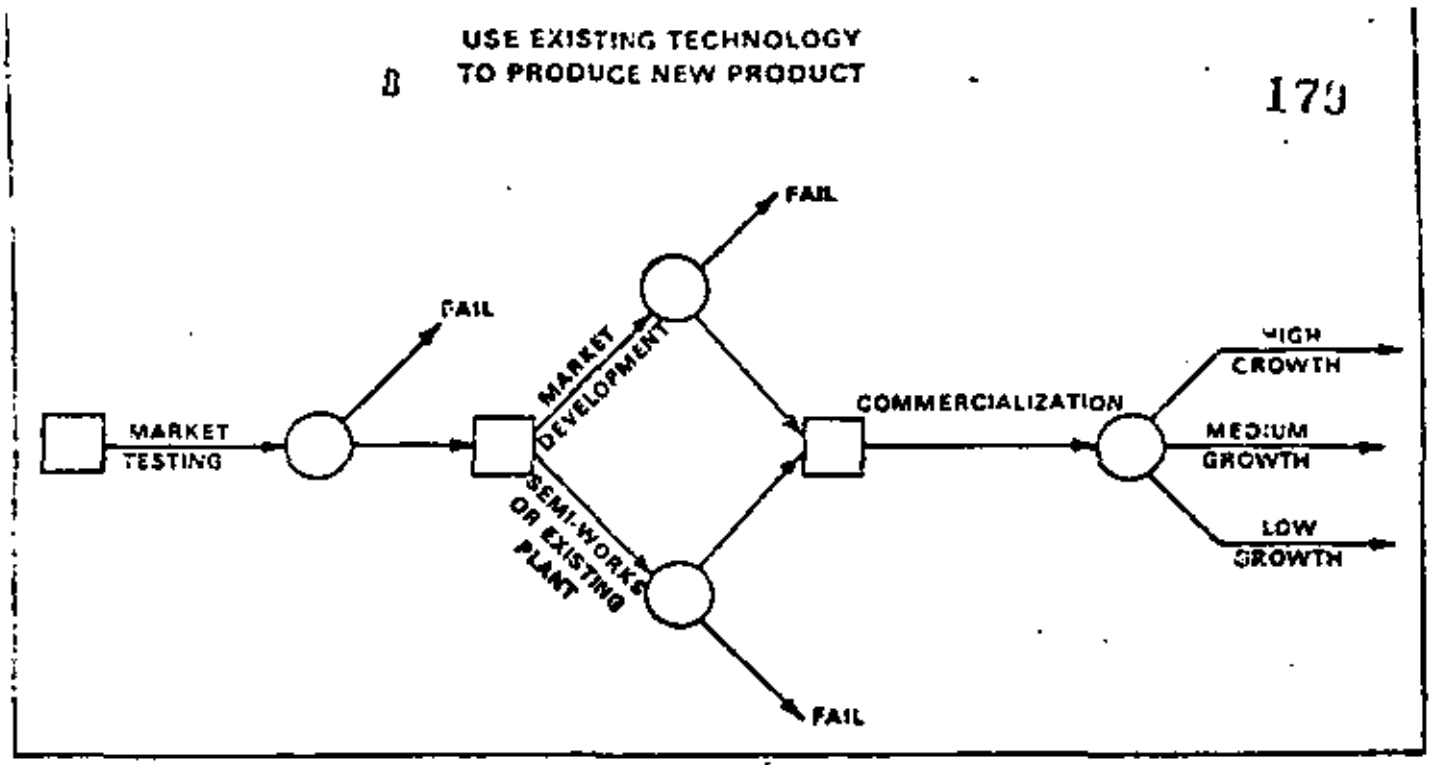

Figure 6

In the study of new routes to existing products, each of the research stages are encountered. Not only must pilot plant research be conducted in parallel with market development work, but both of these are preceded by bench scale research needed to show feasibility of the technology. The problem faced in studying new routes to existing products is one of which route is worthy of looking into, if

By developing decision trees for each of the nology alternatives and then comparing expected values and present value distributions, decisions can be made to allocate bench scale research to the most promising of the technology alternatives. Not only can we compare alternatives for one product, but it is possible to compare alternative technologies for different products. Research management, faced with an array of possible products to be worked on and technology alternatives to study, could allocate the bench-scale research funds to the project portfolio which optimizes the cumulative present-value distribution. In other words, within the constraint of a fixed budget for exploratory or bench-scale research, a portfolio of projects could be selected which minimized the negative and maximized the positive present values.

Decision trees for new products that include uncertainties associated both with market development prior to commercialization. In the case where existing technology is to be used to produce a new

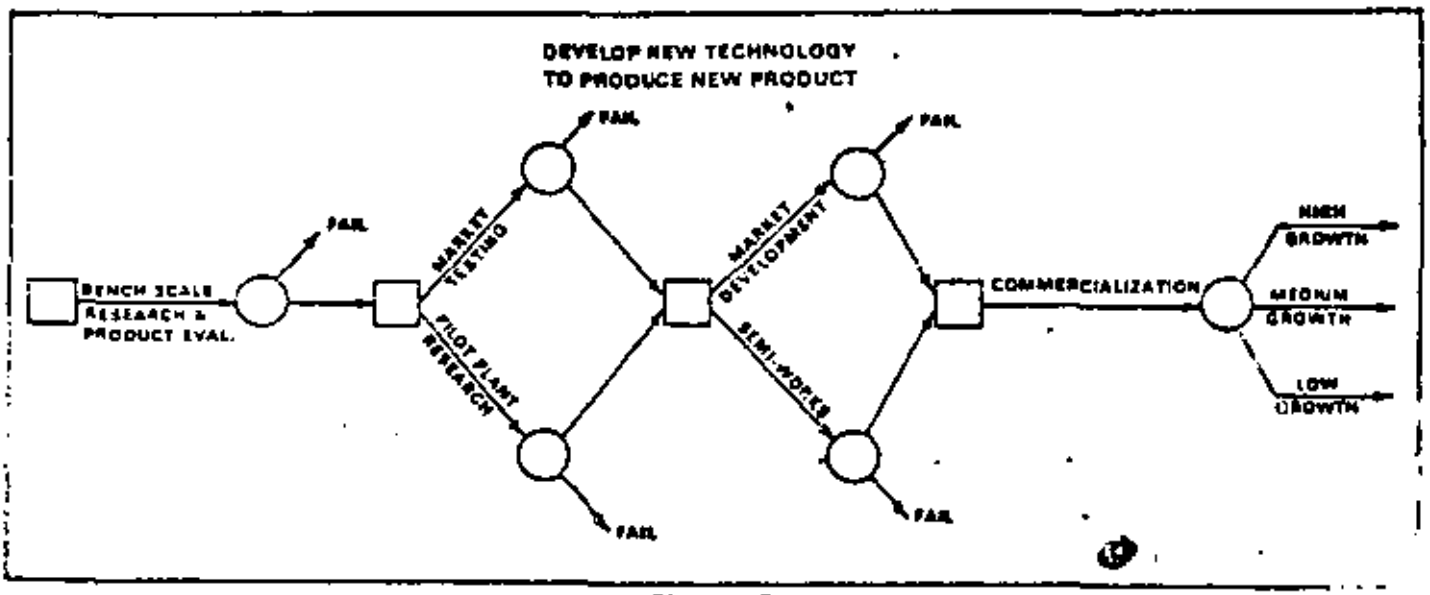

Figure 7

product (Figure 6), technology uncertainties are minor and quite likely existing facilities, blocked-out, or semi-works operations would be used to provide product for market development. In this case, marketplace uncertainties on selling price, sales volume and growth rates would be controlling since operating costs and investment requirements on existing technology could be fairly accurately quantified.

The decision tree shown in Figure 7 covers the more complicated situation where new technology must be developed to produce a new product. Bench scale research must be conducted to show feasibility of the technology prior to any pilot plant research and market testing. Successful completion of both these steps leads to the decision of market development and installation of a semi-works unit prior to final commercialization of the new product via the new technology. Here again, marketplace uncertainties are extremely important in developing the present-value distribution. This decision tree serves to emphasize the importance of serious market studies at the earliest possible time to aid in deciding whether to proceed with a new product project. It is exceedingly difficult not to become enamoured by the new product and new technology with the tendency to avoid the rigors of a marketing study and economic evaluation. Application of decision tree analysis at the conception or early stage of the project life provides the framework for systematic evaluation and review of the project.

A "Real-Life" Decision Tree

Figure 8 is an illustration of the application of decision tree analysis to an actual research project. The goal of this project is to develop a commercial process for the manufacture of a product "Q". This project had been under development for more than a year in exploratory research when the analysis was made. Also, a detailed process design based upon the exploratory results had just been completed permitting estimation of product costs. Results were encouraging at this point, and a decision tree analysis was constructed.

The decision at the present time is to continue bench-scale research, but one new dimension has been added to the project. This is a new physical form of "Q", identified as "R". The variation R paves the way to a much larger market than Product Q alone.

At the first node of uncertainty, three possibilities are considered. If the research with Q is unsuccessful, the entire project will be dropped because R must be made from Q. If Q can be made successfully, but R cannot, then the upper branch of the tree is followed. If both Q and R can be produced successfully, the lower branch pertains. Each branch includes a pilot plant stage, a final market testing-evaluation stage, and a commercialization stage. In the branch containing both Q and R, R can drop out after either the pilot plant or the final market testing stage, in which case only the upper branch of the tree applies. Also, in the lower branch, if operation on Q is unsuccessful, the project is always assumed to be terminated. Commercialization encompasses the construction of plants and the marketing of the commercial products. At the present point in time, however, the rate of growth of the market for either product Q or R is uncertain. Therefore, slow, intermediate and rapid growths are projected for each of the products, and probabilities are assigned to each of the cases. Because of the nature of the products, it is believed that growth rates for the

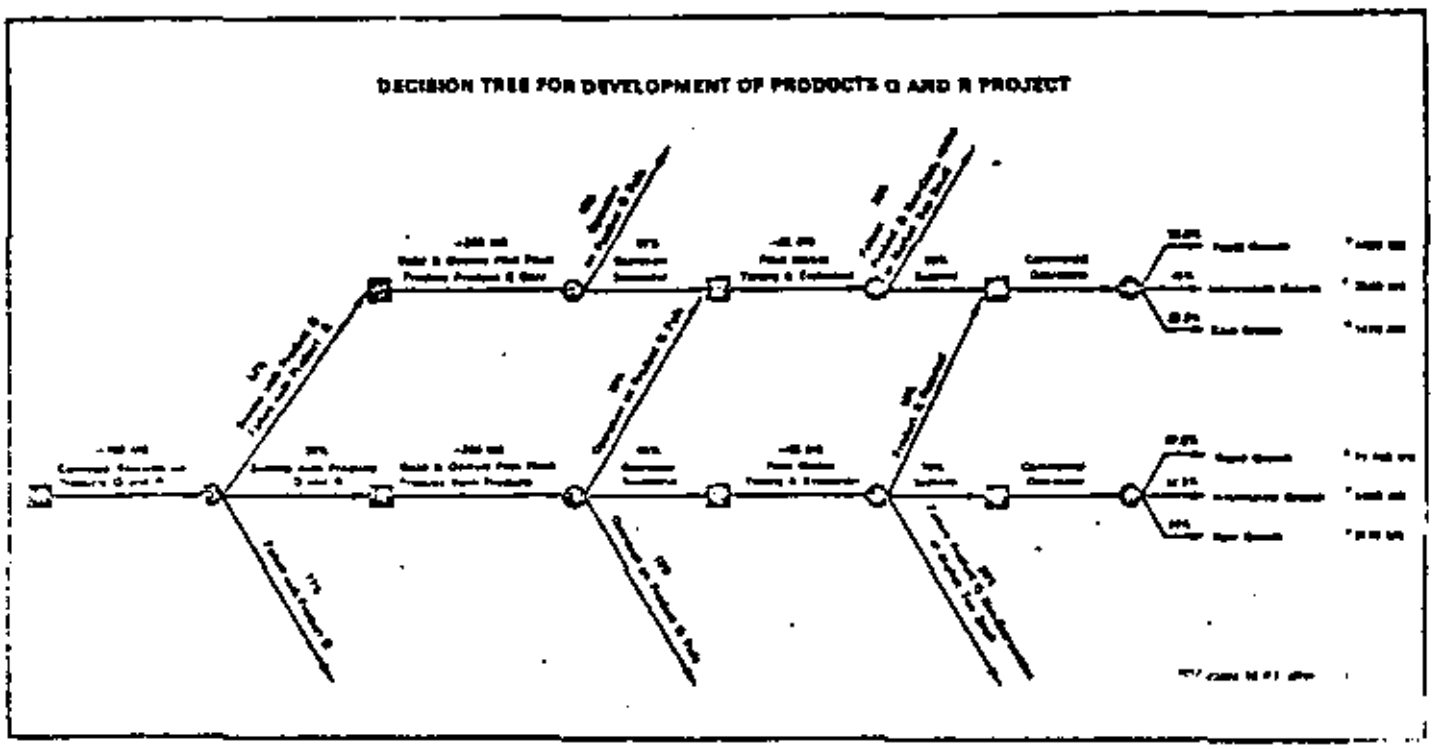

Figure 8

The probabilities shown in Figure 8 were obtained by a modified "Delphi" approach which included members of the research team and of management closely associated with the project. Each evaluating member was given a decision tree showing present values but omitting probabilities. Each made his own judgment of the probabilities without consultation with any other member of the group. The completed trees were collected, and the consensus probabilities were computed and used in the solution of the tree.

The expression of the present values of commercialization as three seperate cases for each branch leads to a discontinuous, stepped probability density function. In solving the problem, we converted this to a smooth probability function by drawing a curve through the midpoint of each of the steps.

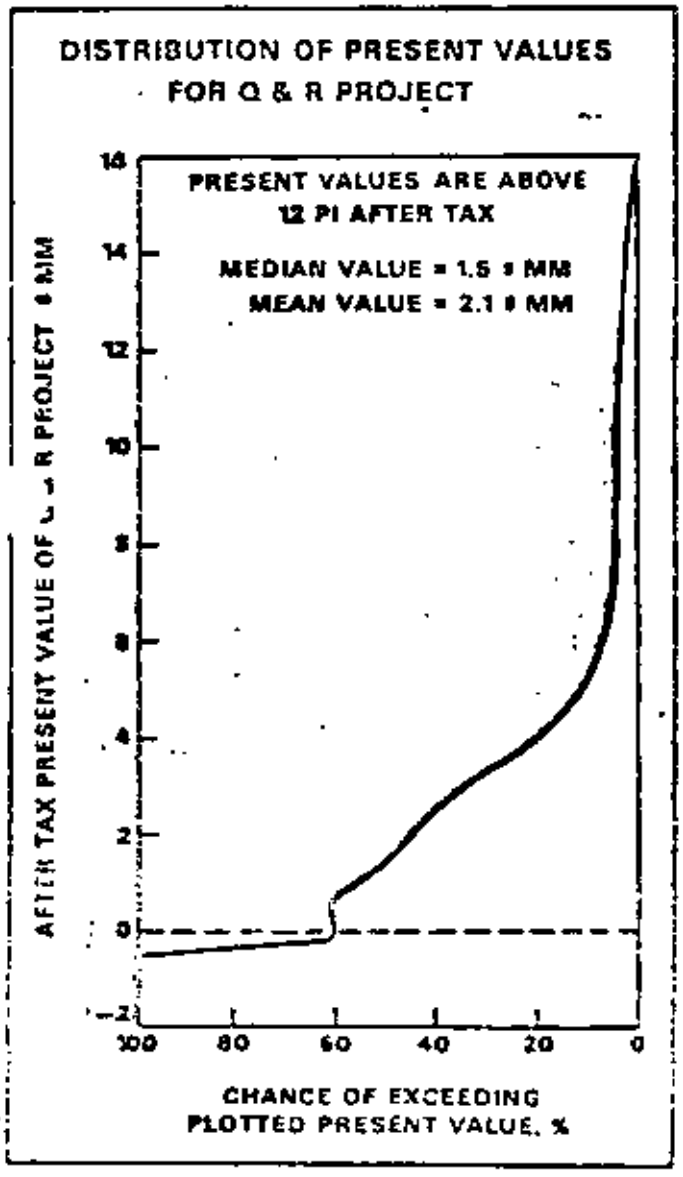

Figure 9

of the outcomes visualized represented failures or project termination at a present value cost of about $500 M. Sixty percent of the outcomes visualized represent research successes leading to commercialization with present values above the base discount rate ranging from about $1 MM up to $5 MM, with a slight possibility of failing in the $5 to $15 MM range.

The base discount rate for use in this type of problem needs to be determined with care. If the base rate is set higher than the rate of return obtained by most successful projects, then even good projects will have very low present values, even negative ones. If the discount rate is too low, then the present values for even relatively poor projects appear large. Probably the best rate to use is about five percentage points below the target rate of return. The calculation can also be done at the target discount rate to make certain that the expected value at least equals or exceeds zero (that is, that the target rate of return has been met).

Conclusions

Decision tree analysis should prove to be very useful in analyzing research projects, although each company will probably develop their own particular style or format. Application of decision tree analysis leads to speculative definition of the entire course of a project from its inception as an idea to final commercialization. Thinking-through the project helps to crystallize the rationale for undertaking the project, and helps to identify the major anticipated problems. It requires that prospects for commercialization be conceptualized and evaluated and emphasizes the importance of market studies at the outset of the project. A completed decision tree analysis can be compared with similar analyses of other projects to aid in project selection. During development of a project, the analysis can serve as a road map of problem areas, expected costs and anticipated profits and provide the framework for systematic evaluation and review of the project.

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F. .R Classic

Risk analysis in capital investment

David B. Hertz

How can business executives make the best investment decisions? Is there a method of risk analysis to help managers make wise acquisitions, launch new products, modernize the plant, or avoid overcapacity? "Risk Analysis in Capital Investment" takes a look at questions such as these and says "yes"—by measuring the multitude of risks involved in each situation. Mathematical formulas that predict a single rate of return or "best estimate" are not enough. The author's approach emphasizes the nature and processing of the data used and specific combinations of variables like cash flow, return on investment, and risk to estimate the odds for each potential outcome. Managers can examine the added information provided in this way to rate more accurately the chances of substantial gain in their ventures. The article, originally presented in 1964, continues to interest HBR readers: more than 153,000 reprints sold since then testify to the importance of this type of thinking on investment analysis. In a retrospective commentary, the author discusses the now routine use of risk analysis in business and government, emphasizing that the method can—and should—be used in any decision-requiring situations in our uncertain world.

When this article was first published, Mr. Hertz was a principal with McKinsey & Company, Inc., the management consulting firm. He is currently a senior director there as well as chairman of the board of a new magazine, *Prime Time*. He is the author of a follow-up article in HBR entitled "Investment Policies that Pay Off" (January-February 1968) in addition to several books, including *New Power for Management: Computer Systems and Management Science* (McGraw-Hill, 1969) and *The Theory and Practice of Industrial Research* (McGraw-Hill, 1949).

Of all the decisions that business executives must make, none is more challenging—and none has received more attention—than choosing among alternative capital investment opportunities. What makes this kind of decision so demanding, of course, is not the problem of projecting return on investment under any given set of assumptions. The difficulty is in the assumptions and in their impact. Each assumption involves its own degree—often a high degree—of uncertainty, and, taken together, these combined uncertainties can multiply into a total uncertainty of critical proportions. This is where the element of risk enters, and it is in the evaluation of risk that the executive has been able to get little help from currently available tools and techniques.

There is a way to help the executive sharpen key capital investment decisions by providing him or her with a realistic measurement of the risks involved. Armed with this gauge, which evaluates the risk at each possible level of return, he or she is then in a position to measure more knowledgeably alternative courses of action against corporate objectives.

Need for new concept

The evaluation of a capital investment project starts with the principle that the productivity of capital is measured by the rate of return we expect to receive over some future period. A dollar received next year is worth less to us than a dollar in hand today.

Expenditures three years hence are less costly than expenditures of equal magnitude two years from now. For this reason we cannot calculate the rate of return realistically unless we take into account (a) when the sums involved in an investment are spent and (b) when the returns are received.

Comparing alternative investments is thus complicated by the fact that they usually differ not only in size but also in the length of time over which expenditures will have to be made and benefits returned.

These facts of investment life long ago made apparent the shortcomings of approaches that simply averaged expenditures and benefits, or lumped them, as in the number-of-years-to-pay-out method. These shortcomings stimulated students of decision making to explore more precise methods for determining whether one investment would leave a company better off in the long run than would another course of action.

It is not surprising, then, that much effort has been applied to the development of ways to improve our ability to discriminate among investment alternatives. The focus of all of these investigations has been to sharpen the definition of the value of capital investments to the company. The controversy and furor that once came out in the business press over the most appropriate way of calculating these values have largely been resolved in favor of the discounted cash flow method as a reasonable means of measuring the rate of return that can be expected in the future from an investment made today.

Thus we have methods which are more or less elaborate mathematical formulas for comparing the outcomes of various investments and the combinations of the variables that will affect the investments. As these techniques have progressed, the mathematics involved has become more and more precise, so that we can now calculate discounted returns to a fraction of a percent.

But the sophisticated executive knows that behind these precise calculations are data which are not that precise. At best, the rate-of-return information he is provided with is based on an average of different opinions with varying reliabilities and different ranges of probability. When the expected returns on two investments are close, he is likely to be influenced by intangibles—a precarious pursuit at best. Even when the figures for two investments are quite far apart, and the choice seems clear, there lurk memories of the Edsel and other ill-fated ventures.

In short, the decision maker realizes that there is something more he ought to know, something in addition to the expected rate of return. What is missing has to do with the nature of the data on which the expected rate of return is calculated and with the way those data are processed. It involves uncertainty, with possibilities and probabilities extending across a wide range of rewards and risks. (For a summary of the new approach, see the ruled insert.)

The Achilles heel

The fatal weakness of past approaches thus has nothing to do with the mathematics of rate-of-return calculation. We have pushed along this path so far that the precision of our calculation is, if anything, somewhat illusory. The fact is that, no matter what mathematics is used, each of the variables entering into the calculation of rate of return is subject to a high level of uncertainty.

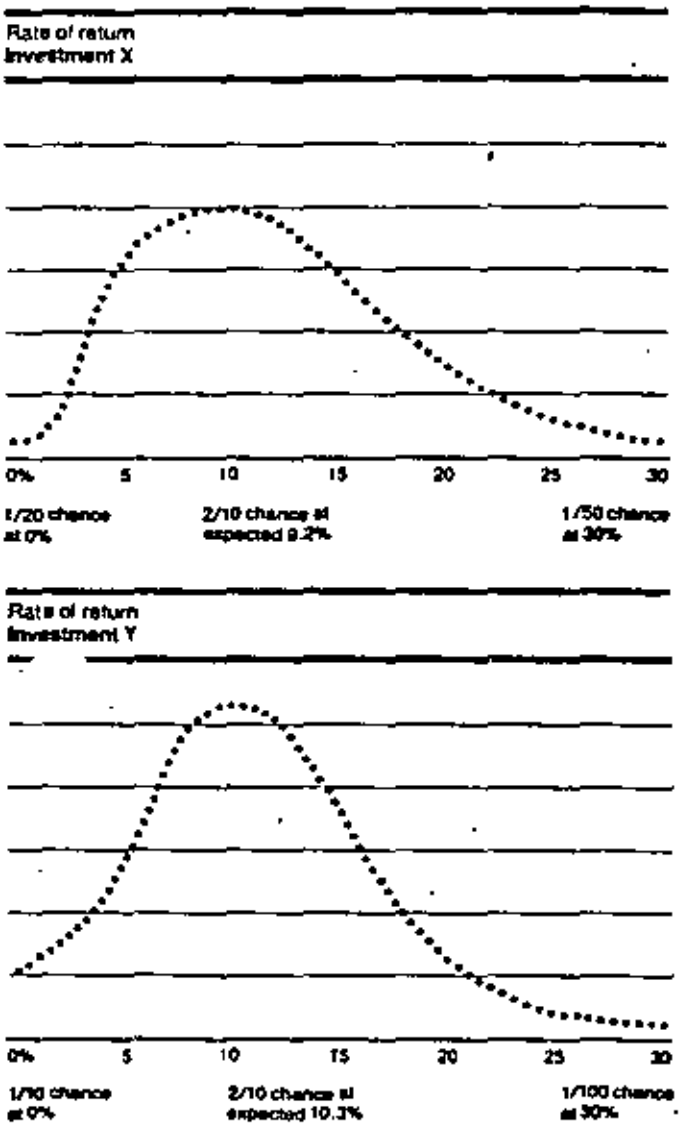
For example, the useful life of a new piece of capital equipment is rarely known in advance with any degree of certainty. It may be affected by variations in obsolescence or deterioration, and relatively small changes in use life can lead to large changes in return. Yet an expected value for the life of the equipment—based on a great deal of data from which a single best possible forecast has been developed—is entered into the rate-of-return calculation. The same is done for the other factors that have a significant bearing on the decision at hand.

Let us look at how this works out in a simple case—one in which the odds appear to be all in favor of a particular decision. The executives of a food company must decide whether to launch a new packaged cereal. They have come to the conclusion that five factors are the determining variables: advertising and promotion expense, total cereal market, share of market for this product, operating costs, and new capital investment.

On the basis of the "most likely" estimate for each of these variables, the picture looks very bright—a healthy 30% return. This future, however, depends on whether each of these estimates actually comes true. If each of these educated guesses has, for example, a 60% chance of being correct, there is only an 8% chance that all five will be correct ($.60 \times .60 \times .60 \times .60 \times .60$). So the "expected" return actually depends on a rather unlikely coincidence. The decision maker needs to know a great deal more about the other values used to make each of the five estimates and about what he stands to gain or lose from various combinations of these values.

This simple example illustrates that the rate of return actually depends on a specific combination of values of a great many different variables. But

Summary of new approach



After examining present methods of comparing alternative investments, the author reports on his firm's experience in applying a new approach to the problem. Using this approach, management takes the various levels of possible cash flows, return on investment, and other results of a proposed outlay and gets an estimate of the odds for each potential outcome.

Currently, many facilities decisions are based on discounted cash flow calculations. Management is told, for example, that investment X has an expected internal rate of return of 9.2%, while for investment Y a 10.3% return can be expected.

By contrast, the new approach would put in front of the executive a schedule that gives him the most likely return from X, but also tells him that X has 1 chance in 20 of being a total loss, 1 in 10 of earning from 4% to 5%, 2 in 10 of paying from 8% to 10%, and 1 chance in 50 of attaining a 30% rate of return.

From another schedule he learns what the most likely rate of return is from Y, but also that Y has 1 chance in 10 of resulting in a total loss, 1 in 10 of earning from 3% to 5% return, 2 in 10 of paying between 9% and 11%, and 1 chance in 100 of a 30% rate of return.

In this instance, the estimates of the rates of return provided by the two approaches would not be substantially different. However, to the decision maker with the added information, investment Y no longer looks like the clearly better choice, since with X the chances of substantial gain are higher and the risks of loss lower.

Two things have made this approach appealing to managers who have used it:

1. Certainly in every case it is a more descriptive statement of the two opportunities. And in some cases it might well reverse the decision, in line with particular corporate objectives.

2. This is not a difficult technique to use, since much of the information needed is already available—or readily accessible—and the validity of the principles involved has, for the most part, already been proved in other applications.

The enthusiasm with which managements exposed to this approach have received it suggests that it may have wide application. It has particular relevance, for example, in such knotty problems as investments relating to acquisitions or new products and in decisions that might involve excess capacity.

only the expected levels of ranges (worst, average, best; or pessimistic, most likely, optimistic) of these variables are used in formal mathematical ways to provide the figures given to management. Thus predicting a single most likely rate of return gives precise numbers that do not tell the whole story.

The expected rate of return represents only a few ...nts on a continuous curve of possible combina...ns of future happenings. It is a bit like trying to predict the outcome in a dice game by saying that the most likely outcome is a 7. The description is incomplete because it does not tell us about all the other things that could happen. In *Exhibit I*, for instance, we see the odds on throws of only two dice having 6 sides. Now suppose that each of eight dice has 100 sides. This is a situation more comparable to business investment, where the company's market share might become any 1 of 100 different sizes and where there are eight factors (pricing, promotion, and so on) that can affect the outcome.

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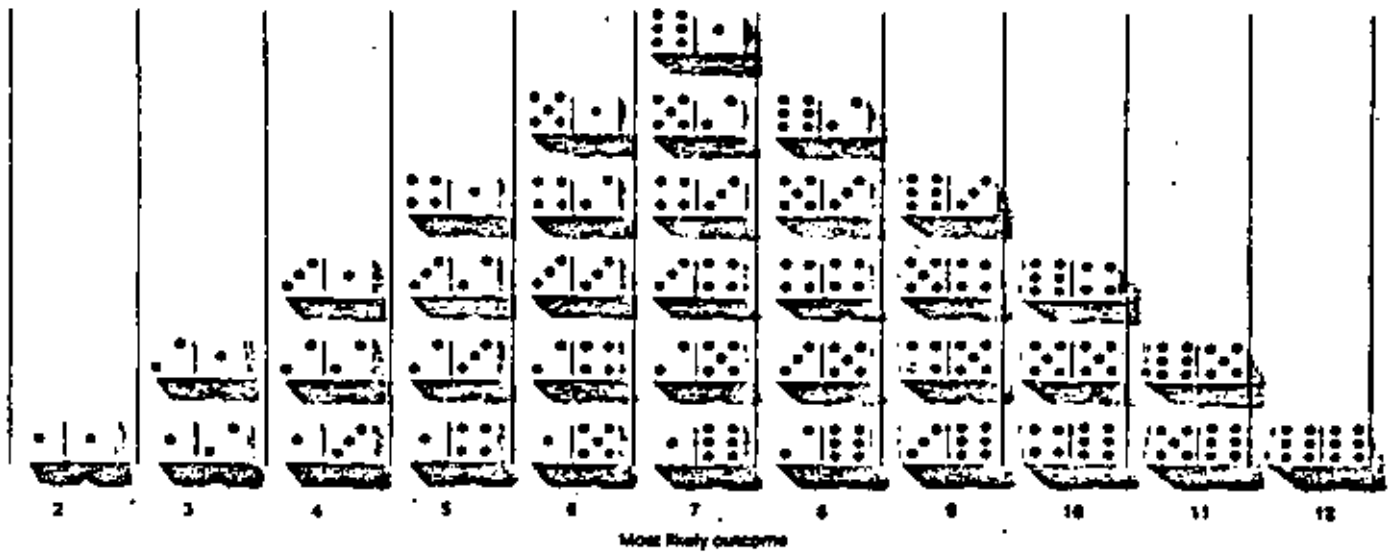


Nor is this the only trouble. Our willingness to bet on a roll of the dice depends not only on the odds but also on the stakes. Since the probability of rolling a 7 is 1 in 6, we might be quite willing to risk a few dollars on that outcome at suitable odds. But would we be equally willing to wager $10,000 or $100,000 at those same odds, or even at better odds? In short, risk is influenced both by the odds on various events occurring and by the magnitude of the rewards or penalties that are involved when they do occur.

To illustrate again, suppose that a company is considering an investment of $1 million. The best estimate of the probable return is $200,000 a year. It could well be that this estimate is the average of three possible returns—a 1-in-3 chance of getting no return at all, a 1-in-3 chance of getting $200,000 per year, a 1-in-3 chance of getting $400,000 per year. Suppose that getting no return at all would put the company out of business. Then, by accepting this proposal, management is taking a 1-in-3 chance of going bankrupt.

If only the best-estimate analysis is used, however, management might go ahead, unaware that it is taking a big chance. If all of the available information were examined, management might prefer an alternative proposal with a smaller, but more certain (that is, less variable) expectation.

Such considerations have led almost all advocates of the use of modern capital-investment-index calculations to plead for a recognition of the elements of uncertainty. Perhaps Ross G. Walker summed up current thinking when he spoke of "the almost impenetrable mists of any forecast."[1]

How can executives penetrate the mists of uncertainty surrounding the choices among alternatives?

Limited improvements

A number of efforts to cope with uncertainty have been successful up to a point, but all seem to fall short of the mark in one way or another:

1. *More accurate forecasts*—Reducing the error in estimates is a worthy objective. But no matter how many estimates of the future go into a capital investment decision, when all is said and done, the future is still the future. Therefore, however well we forecast, we are still left with the certain knowledge that we cannot eliminate all uncertainty.

2. *Empirical adjustments*—Adjusting the factors influencing the outcome of a decision is subject to serious difficulties. We would like to adjust them so as to cut down the likelihood that we will make a "bad" investment, but how can we do that without at the same time spoiling our chances to make a "good" one? And in any case, what is the basis for

1. "The Judgment Factor in Investment Decisions," HBR March-April 1961, p. 99.

2. "Measuring Capital Investments," *Financial Executive*, April 1963, p. 19.

3. "Capital Budgeting and Game Theory," HBR November-December 1956, p. 123.

adjustment? We adjust, not for uncertainty, but r bias.

For example, construction estimates are often exceeded. If a company's history of construction costs is that 90% of its estimates have been exceeded by 15%, then in a capital estimate there is every justification for increasing the value of this factor by 15%. This is a matter of improving the accuracy of the estimate.

But suppose that new-product sales estimates have been exceeded by more than 75% in one-fourth of all historical cases and have not reached 50% of the estimate in one-sixth of all such cases? Penalties for such overestimating are very real, and so management is apt to reduce the sales estimate to "cover" the one case in six—thereby reducing the calculated rate of return. In so doing, it is possibly missing some of its best opportunities.

3. *Revising cutoff rates*—Selecting higher cutoff rates for protecting against uncertainty is attempting much the same thing. Management would like to have a possibility of return in proportion to the risk it takes. Where there is much uncertainty involved in the various estimates of sales, costs, prices, and so on, a high calculated return from the investment provides some incentive for taking the risk. is is, in fact, a perfectly sound position. The able is that the decision maker still needs to know explicitly what risks he is taking—and what the odds are on achieving the expected return.

4. *Three-level estimates*—A start at spelling out risks is sometimes made by taking the high, medium, and low values of the estimated factors and calculating rates of return based on various combinations of the pessimistic, average, and optimistic estimates. These calculations give a picture of the range of possible results but do not tell the executive whether the pessimistic result is more likely than the optimistic one—or, in fact, whether the average result is much more likely to occur than either of the extremes. So, although this is a step in the right direction, it still does not give a clear enough picture for comparing alternatives.

5. *Selected probabilities*—Various methods have been used to include the probabilities of specific factors in the return calculation. L. C. Grant discussed a program for forecasting discounted cash flow rates of return where the service life is subject to obsolescence and deterioration. He calculated the odds that the investment will terminate at any time after it is made depending on the probability distribution of the service-life factor. After having calculated these rs for each year through maximum service life. etermined an overall expected rate of return.[4]

Edward G. Bennion suggested the use of game theory to take into account alternative market growth rates as they would determine rate of return for various options. He used the estimated probabilities that specific growth rates would occur to develop optimum strategies. Bennion pointed out:

"Forecasting can result in a negative contribution to capital budget decisions unless it goes further than merely providing a single most probable prediction. . . . [with] an estimated probability coefficient for the forecast, plus knowledge of the payoffs for the company's alternative investments and calculation of indifference probabilities . . . the margin of error may be substantially reduced, and the businessman can tell just how far off his forecast may be before it leads him to a wrong decision."[5]

Note that both of these methods yield an expected return, each based on only one uncertain input factor—service life in the first case, market growth in the second. Both are helpful, and both tend to improve the clarity with which the executive can view investment alternatives. But neither sharpens up the range of "risk taken" or "return hoped for" sufficiently to help very much in the complex decisions of capital planning.

Sharpening the picture

Since every one of the many factors that enter into the evaluation of a decision is subject to some uncertainty, the executive needs a helpful portrayal of the effects that the uncertainty surrounding each of the significant factors has on the returns he is likely to achieve. Therefore, I use a method combining the variabilities inherent in all the relevant factors under consideration. The objective is to give a clear picture of the relative risk and the probable odds of coming out ahead or behind in light of uncertain foreknowledge.

A simulation of the way these factors may combine as the future unfolds is the key to extracting the maximum information from the available forecasts. In fact, the approach is very simple, using a computer to do the necessary arithmetic. To carry out the analysis, a company must follow three steps:

1. Estimate the range of values for each of the factors [for example, range of selling price and sales growth rate] and within that range the likelihood of occurrence of each value.

2. Select at random one value from the distribution of values for each factor. Then combine the values for all of the factors and compute the rate of return (or present value) from that combination. For instance, the lowest in the range of prices might be combined with the highest in the range of growth rate and other factors. (The fact that the elements are dependent should be taken into account, as we shall see later.)

3. Do this over and over again to define and evaluate the odds of the occurrence of each possible rate of return. Since there are literally millions of possible combinations of values, we need to test the likelihood that various returns on the investment will occur. This is like finding out by recording the results of a great many throws what percent of 7s or other combinations we may expect in tossing dice. The result will be a listing of the rates of return we might achieve, ranging from a loss (if the factors go against us) to whatever maximum gain is possible with the estimates that have been made.

For each of these rates we can determine the chances that it may occur. (Note that a specific return can usually be achieved through more than one combination of events. The more combinations for a given rate, the higher the chances of achieving it—as with 7s in tossing dice.) The average expectation is the average of the values of all outcomes weighted by the chances of each occurring.

We can also determine the variability of outcome values from the average. This is important since, all other factors being equal, management would presumably prefer lower variability for the same return if given the choice. This concept has already been applied to investment portfolios.

When the expected return and variability of each of a series of investments have been determined, the same techniques may be used to examine the effectiveness of various combinations of them in meeting management objectives.

Practical test

To see how this new approach works in practice, let's take the experience of a management that has already analyzed a specific investment proposal by conventional techniques. Taking the same investment schedule and the same expected values actually used, we can find what results the new method would produce and compare them with the results obtained by conventional methods. As we shall see, the new picture of risks and returns is different from the old one. Yet the differences are attributable in no way to changes in the basic data—only to the increased sensitivity of the method to management's uncertainties about the key factors.

Investment proposal

In this case, a medium-size industrial chemical producer is considering a $10 million extension to its processing plant. The estimated service life of the facility is ten years; the engineers expect to use 250,000 tons of processed material worth $510 per ton at an average processing cost of $435 per ton. Is this investment a good bet? In fact, what is the return that the company may expect? What are the risks? We need to make the best and fullest use of all the market research and financial analyses that have been developed, so as to give management a clear picture of this project in an uncertain world.

The key input factors management has decided to use are market size, selling prices, market growth rate, share of market (which results in physical sales volume), investment required, residual value of investment, operating costs, fixed costs, and useful life of facilities. These factors are typical of those in many company projects that must be analyzed and combined to obtain a measure of the attractiveness of a proposed capital facilities investment.

Obtaining estimates

How do we make the recommended type of analysis of this proposal? Our aim is to develop for each of the nine factors listed a frequency distribution or probability curve. The information we need includes the possible range of values for each factor, the average, and some idea as to the likelihood that the various possible values will be reached.

It has been my experience that for major capital proposals managements usually make a significant investment in time and funds to pinpoint information about each of the relevant factors. An objective analysis of the values to be assigned to each can, with little additional effort, yield a subjective probability distribution.

Specifically, it is necessary to probe and question each of the experts involved—to find out, for example, whether the estimated cost of production

lly can be said to be exactly a certain value or whether, as is more likely, it should be estimated to lie within a certain range of values. Management usually ignores that range in its analysis. The range is relatively easy to determine; if a guess has to be made—as it often does—it is easier to guess with some accuracy a range rather than one specific value. I have found from experience that a series of meetings with management personnel to discuss such distributions are most helpful in getting at realistic answers to the a priori questions. (The term *realistic answers* implies all the information management does not have as well as all that it does have.)

The ranges are directly related to the degree of confidence that the estimator has in the estimate. Thus certain estimates may be known to be quite accurate. They would be represented by probability distributions stating, for instance, that there is only 1 chance in 10 that the actual value will be different from the best estimate by more than 10%. Others may have as much as 100% ranges above and below the best estimate.

Thus we treat the factor of selling price for the finished product by asking executives who are responsible for the original estimates these questions:

Given that $510 is the expected sales price, at is the probability that the price will exceed $550?

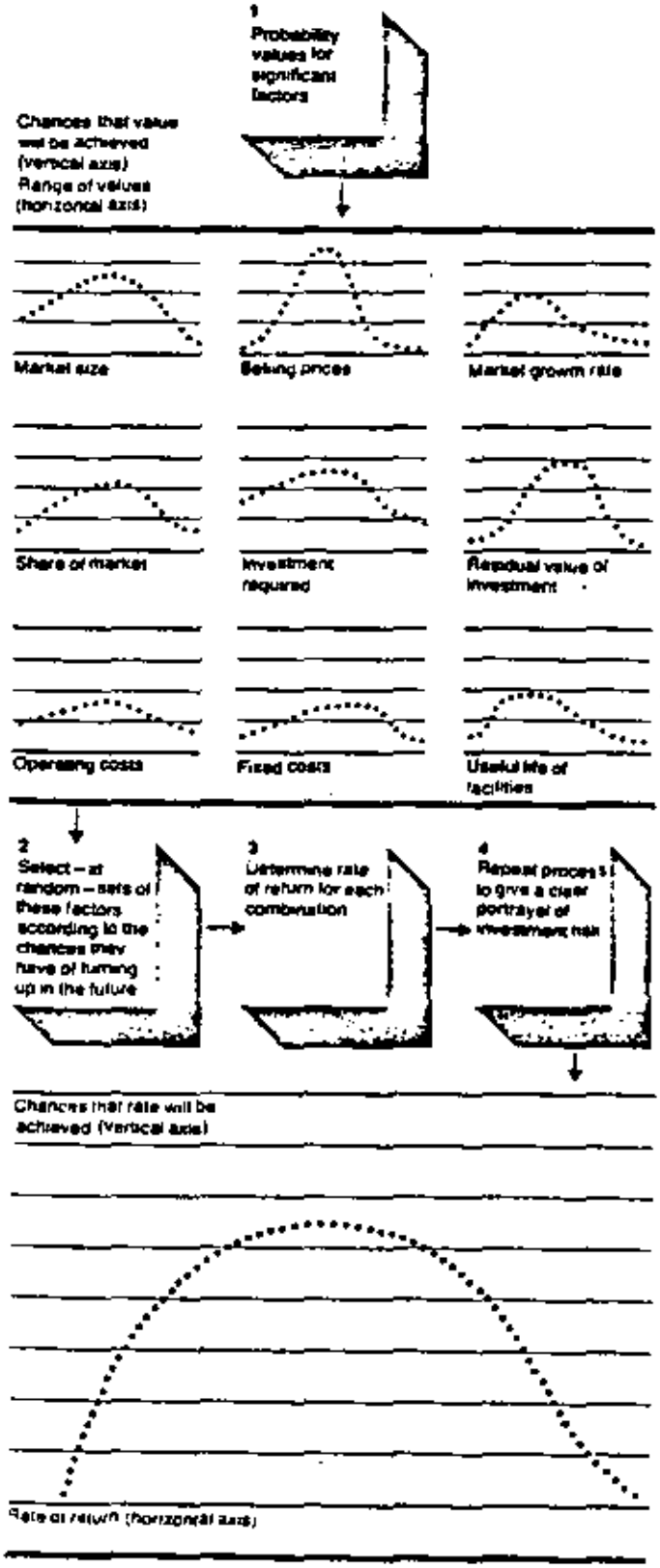
> Is there any chance that the price will exceed $650?

> How likely is it that the price will drop below $475?

Managements must ask similar questions for all of the other factors until they can construct a curve for each. Experience shows that this is not as difficult as it sounds. Often information on the degree of variation in factors is easy to obtain. For instance, historical information on variations in the price of a commodity is readily available. Similarly, managements can estimate the variability of sales from industry sales records. Even for factors that have no history, such as operating costs for a new product, those who make the average estimates must have some idea of the degree of confidence they have in their predictions, and therefore they are usually only too glad to express their feelings. Likewise, the less confidence they have in their estimates, the greater will be the range of possible values that the variable will assume.

This last point is likely to trouble businessmen. I it really make sense to seek estimates of variat[illegible]? It cannot be emphasized too strongly that the less certainty there is in an average estimate, the

Exhibit II
Simulation for investment planning



more important it is to consider the possible variation in that estimate.

Further, an estimate of the variation possible in a factor, no matter how judgmental it may be, is always better than a simple average estimate, since it includes more information about what is known and what is not known. This very lack of knowledge may distinguish one investment possibility from another, so that for rational decision making it must be taken into account.

This lack of knowledge is in itself important information about the proposed investment. To throw any information away simply because it is highly uncertain is a serious error in analysis that the new approach is designed to correct.

Computer runs

The next step in the proposed approach is to determine the returns that will result from random combinations of the factors involved. This requires realistic restrictions, such as not allowing the total market to vary more than some reasonable amount from year to year. Of course, any suitable method of rating the return may be used at this point. In the actual case, management preferred discounted cash flow for the reasons cited earlier, so that method is followed here.

A computer can be used to carry out the trials for the simulation method in very little time and at very little expense. Thus for one trial 3,600 discounted cash flow calculations, each based on a selection of the nine input factors, were run in two minutes at a cost of $15 for computer time. The resulting rate-of-return probabilities were read out immediately and graphed. The process is shown schematically in *Exhibit II*.

Data comparisons

The nine input factors described earlier fall into three categories:

1. *Market analyses*—Included are market size, market growth rate, the company's share of the market, and selling prices. For a given combination of these factors sales revenue may be determined for a particular business.

2. *Investment cost analyses*—Being tied to the kinds of service-life and operating-cost characteristics expected, these are subject to various kinds of error and uncertainty; for instance, automation progress makes service life uncertain.

3. *Operating and fixed costs*—These also are subject to uncertainty but are perhaps the easiest to estimate.

These categories are not independent, and for realistic results my approach allows the various factors to be tied together. Thus if price determines the total market, we first select from a probability distribution the price for the specific computer run and then use for the total market a probability distribution that is logically related to the price selected.

We are now ready to compare the values obtained under the new approach with those obtained by the old. This comparison is shown in *Exhibit III*.

Valuable results

How do the results under the new and old approaches compare? In this case, management had been informed, on the basis of the one-best-estimate approach, that the expected return was 15.2% before taxes. When we run the new set of data through the computer program, however, we get an expected return of only 14.6% before taxes. This surprising difference results not only from the range of values under the new approach but also from the weighing of each value in the range by the chances of its occurrence.

Our new analysis thus may help management to avoid an unwise investment. In fact, the general result of carefully weighing the information and lack of information in the manner I have suggested is to indicate the true nature of seemingly satisfactory investment proposals. If this practice were followed, managements might avoid much overcapacity.

The computer program developed to carry out the simulation allows for easy insertion of new variables. But most programs do not allow for dependence relationships among the various input factors. Further, the program used here permits the choice of a value for price from one distribution, which value determines a particular probability distribution (from among several) that will be used to determine the values for sales volume. The following scenario shows how this important technique works:

Suppose we have a wheel, as in roulette, with the numbers from 0 to 15 representing one price for the product or material, the numbers 16 to 30 representing a second price, the numbers 31 to 45 a third price, and so on. For each of these segments we would have a different range of expected market

times—for example, $150,000-$200,000 for the first, $100,000-$150,000 for the second, $75,000-$100,000 for the third. Now suppose we spin the wheel and the ball falls in 37. This means that we pick a sales volume in the $75,000-$100,000 range. If the ball goes in 11, we have a different price, and we turn to the $150,000-$100,000 range for a sales volume.

Most significant, perhaps, is the fact that the program allows management to ascertain the sensitivity of the results to each or all of the input factors. Simply by running the program with changes in the distribution of an input factor, it is possible to determine the effect of added or changed information (or lack of information). It may turn out that fairly large changes in some factors do not significantly affect the outcomes. In this case, as a matter of fact, management was particularly concerned about the difficulty in estimating market growth. Running the program with variations in this factor quickly demonstrated that for average annual growth rates from 3% to 5% there was no significant difference in the expected outcome.

In addition, let us see what the implications are of the detailed knowledge the simulation method gives us. Under the method using single expected values, management arrives only at a hoped-for expectation of 25.2% after taxes (which, as we have seen, is wrong unless there is no variability in the many input factors—a highly unlikely event).

With the proposed method, however, the uncertainties are clearly portrayed, as shown in *Exhibit IV*. Note the contrast with the profile obtained under the conventional approach. This concept has been used also for evaluation of product introductions, acquisition of businesses, and plant modernization.

Exhibit III
Comparison of expected values under old and new approaches

	Conventional "best estimate" approach	New approach
Market analyses		
1. Market size		
Expected value (in tons)	250,000	250,000
Range	–	100,000-340,000
2. Selling prices		
Expected value (in dollars/ton)	$510	$510
Range	–	$385-$575
3. Market growth rate		
Expected value	3%	3%
Range	–	0-6%
4. Eventual share of market		
Expected value	12%	12%
Range	–	9%-17%
Investment cost analyses		
5. Total investment required		
Expected value (in $ millions)	$9.5	$8.5
Range	–	$7.0-$10.5
6. Useful life of facilities		
Expected value (in years)	10	10
Range	–	5-15
7. Residual value (at 10 years)		
Expected value (in $ millions)	$4.5	$4.5
Range	–	$3.5-$5.0
Other costs		
8. Operating costs		
Expected value (in dollars/ton)	$435	$435
Range	–	$370-$545
9. Fixed costs		
Expected value (in $ thousands)	$300	$300
Range	–	$250-$375

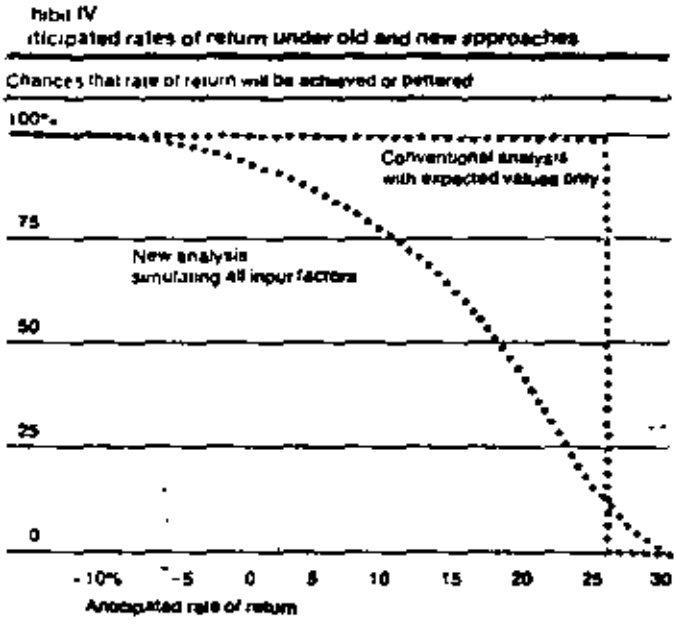
Note: Range figures in right-hand column represent approximately 1% to 99% probabilities. That is, there is only a 1-in-100 chance that the value actually achieved will be respectively greater or less than the range.

Comparing opportunities

From a decision-making point of view one of the most significant advantages of the new method of determining rate of return is that it allows management to discriminate among measures of (1) expected return based on weighted probabilities of all possible returns, (2) variability of return, and (3) risks.

To visualize this advantage, let us take an example based on another actual case but simplified for purposes of explanation. The example involves two investments under consideration, A and B. With the investment analysis, we obtain the tabulated and plotted data in *Exhibit V*. We see that:

- Investment B has a higher expected return than Investment A.
- Investment B also has substantially more variability than Investment A. There is a good chance that Investment B will earn a return quite different



Percent return	Probability of achieving at least the return shown
0%	96.5%
5	80.6
	75.2
	53.8
20	43.0
25	12.8
30	0

from the expected return of 6.8%—possibly as high as 15% or as low as a loss of 5%. Investment A is not likely to vary greatly from the anticipated 5% return.

☐ Investment B involves far more risk than does Investment A. There is virtually no chance of incurring a loss on Investment A. However, there is 1 chance in 10 of losing money on Investment B. If such a loss occurs, its expected size is approximately $200,000.

Clearly, the new method of evaluating investments provides management with far more information on which to base a decision. Investment decisions made only on the basis of maximum expected return are not unequivocally the best decisions.

Concluding note

The question management faces in selecting capital investments is first and foremost: What information is needed to clarify the key differences among various alternatives? There is agreement as to the basic factors that should be considered—markets, prices, costs, and so on. And the way the future return on the investment should be calculated, if not agreed on, is at least limited to a few methods, any of which can be consistently used in a given company. If the input variables turn out as estimated, any of the methods customarily used to rate investments should provide satisfactory (if not necessarily maximum) returns.

In actual practice, however, the conventional methods do not work out satisfactorily. Why? The reason, as we have seen earlier in this article and as every executive and economist knows, is that the estimates used in making the advance calculations are just that—estimates. More accurate estimates would be helpful, but at best the residual uncertainty can easily make a mockery of corporate hopes. Nevertheless, there is a solution. To collect realistic estimates for the key factors means to find out a great deal about them. Hence the kind of uncertainty that is involved in each estimate can be evaluated ahead of time. Using this knowledge of uncertainty, executives can maximize the value of the information for decision making.

The value of computer programs in developing clear portrayals of the uncertainty and risk surrounding alternative investments has been proved. Such programs can produce valuable information about the sensitivity of the possible outcomes to the variability of input factors and to the likelihood of achieving various possible rates of return. This information can be extremely important as a backup to management judgment. To have calculations of the odds on all possible outcomes lends some assurance to the decision makers that the available information has been used with maximum efficiency.

This simulation approach has the inherent advantage of simplicity. It requires only an extension of the input estimates (to the best of our ability) in terms of probabilities. No projection should be pinpointed unless we are certain of it.

The discipline of thinking through the uncertainties of the problem will in itself help to ensure improvement in making investment choices. For to understand uncertainty and risk is to understand

the key business problem—and the key business opportunity. Since the new approach can be applied on a continuing basis to each capital alternative as it comes up for consideration and progresses toward fruition, gradual progress may be expected in improving the estimation of the probabilities of variation.

Lastly, the courage to act boldly in the face of apparent uncertainty can be greatly bolstered by the clarity of portrayal of the risks and possible rewards. To achieve these lasting results requires only a slight effort beyond what most companies already exert in studying capital investments.

Retrospective commentary

When this article was published 15 years ago, there were two recurrent themes in the responses of the management community to it: (1) how the uncertainties surrounding each key element of an investment decision were to be determined, and (2) what criteria were to be used to decide to proceed with an investment once the uncertainties were quantified and displayed.

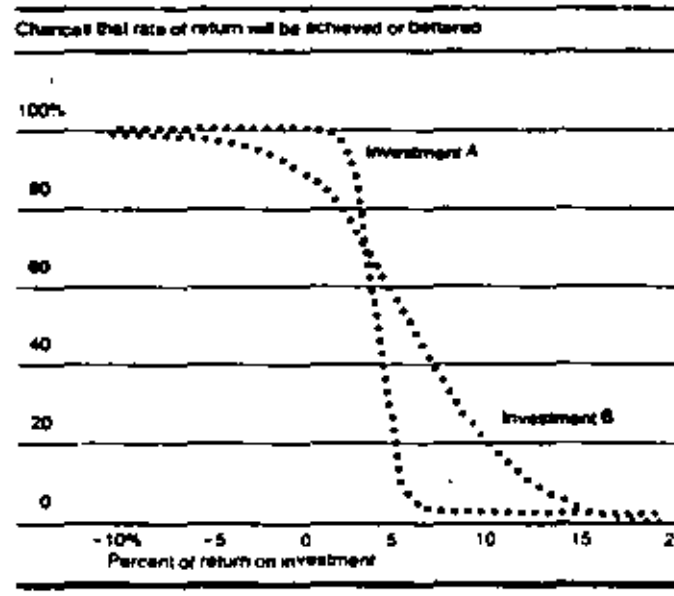
I answered the latter question in an HBR sequel, "Investment Policies That Pay Off," describing the relationships of risks and stakes to longer term investment criteria. This article, published in 1968, showed how risk analyses can provide bases for developing policies to choose among a variety of investment alternatives. Similar approaches were subsequently developed for investment fund portfolio management.

The analysis of uncertainty in describing complex decision-making situations is now an integral part of business and government. The elements of an investment decision—private or public—are subject to all the uncertainties of an unknown future. As the 1964 article showed, an estimated probability distribution paints the clearest picture of all possible outcomes. Such a description contains considerably more information than simplistic combinations of subjective best estimates of input factors. Best estimates are point estimates (there may be more than one—high, medium, low) of the value of an element of the investment analysis used for determining an outcome decision criterion, such as internal rate of return or present value of the investment.

Exhibit V
Comparison of two investment opportunities

Selected statistics	Investment A	Investment B
Amount of investment	$10,000,000	$10,000,000
Life of investment (in years)	10	10
Expected annual net cash inflow	$ 1,300,000	$ 1,400,000
Variability of cash inflow		
1 chance in 50 of being greater than	$ 1,700,000	$ 3,400,000
1 chance in 50 of being less than*	$ 900,000	($ 800,000)
Expected return on investment	5.0%	6.8%
Variability of return on investment		
1 chance in 50 of being greater than	7.0%	15.5%
1 chance in 50 of being less than*	3.0%	(4.0%)
Risk of investment		
Chances of a loss	Negligible	1 in 10
Expected size of loss	Negligible	$200,000

*In the case of negative figures (indicated by parentheses), less than means more than.



Thus even where the conventional approach was used for the best estimate in a single-point determination for the statistically estimated expected values from a distribution of an element, the single-point approach was shown to be exceedingly misleading. In *Exhibit III*, a single-point best-estimate analysis gave an internal rate of return of 25.2%. And a risk analysis employing estimated frequency distributions of the elements showed that an average of possible outcomes, weighted by the relative frequency of their occurrences at 14.6%, was more realistic as well as significantly different. It presented a truer picture of the actual average expectation of

the result of this investment (if it could be repeated over and over again).

The case was thus made, and the point of this result—that risk and uncertainty were more accurately defined by a simulation of input variables—was little questioned thereafter. Managements began to adopt some form of this procedure to examine some, if not all, significant investments where doubt existed about the risk levels involved. My sequel article attempted to demonstrate that if enough investments were chosen consistently on the basis of criteria related to these kinds of risk portrayals, the overall outcomes would stabilize around the desired expected value or best estimate of the criterion.

All this now seems simple and straightforward. Earlier it was falsely thought that risk analysis was aimed at *eliminating* uncertainty, which was not worth doing at all since the future is so desperately uncertain. Thus in 1970 the *Financial Times* (of London) published an article intended to show the futility of risk analysis. It concerned a baker of geriatric biscuits who made an investment only to go bankrupt when his nursing home market precipitately disappeared with the death of its founder. The author cited as a moral, "Don't put all your dough in one biscuit."

It took a while for the points to diffuse through executive circles that (1) exactly such an analysis would have been just as bad, or worse, done via single-point subjective estimates, and (2) no one analytical technique could control future events, even with sensitive inputs and requirements for follow-up control to improve the odds as projected by the original risk analyses. But in the end, judgment would be required in both input estimation and decision.

I did not intend the article to be an argument in methodology but rather a cautionary note to examine the data surrounding an investment proposal in light of all the pervasive uncertainties in the world, of which business is simply one part. The years since 1964 have made it clear to me that this message should have been amplified and more emphatically insisted on in the article.

Had this point been clearer, the issue whether to take the risk and proceed with an investment might have been less troublesome. Had I been able to look with more prescience, I might have seen that the area of risk analysis would become routine in business and virtually universally adopted in public cost-benefit issues.

Cost-benefit analysis for public decisions is, of course, only a special form of investment analysis. Government issues that require decisions involving significant uncertainty are too numerous to catalog fully—energy, from both fossil and nuclear sources; chemical, drug, and food carcinogen hazards; DNA manipulation and its progeny of gene splicing.

The Three Mile Island nuclear accident brought home the fallibility of stating a risk analysis conclusion in simplistic terms. The well-known Rasmussen report on nuclear reactor safety, commissioned by the Nuclear Regulatory Commission, undertook what amounted to a risk analysis that was intended to provide a basis for investment decisions relating to future nuclear energy production. The Nuclear Regulatory Commission, in January 1979, disclaimed the risk estimates of that report; new studies to estimate risk are now underway. But there is also a school of thought saying we face too many risks each day to worry about one more.

A commonly stated estimate of the risk of a major nuclear power plant accident is 1 chance in 1,000,000 years. In the 1964 article, I portrayed the image of risk with a chart of the throws of two dice that would be required to give various outcomes—from two 1s to two 6s, each of these having a 1-in-36 chance of occurring. There should be no problem in visualizing or testing the meaning and the chances of any of the events pictured by these dice. And, although 1 in 1,000,000 is somehow presented as "mind boggling" compared with 1 in 36, and so unlikely to occur as to be beyond our ken, I suggest that it is just as simply visualized.

We simply need to use eight dice at once. If we chart all the possible outcomes for eight dice, as we did for the two, we find that the sum of 8 (or 48) can occur just one way—via all 1s (or all 6s). The odds of this occurring are roughly 1 in 1,680,000. Thus the visualization of such odds, and more important, the lesson we must learn about risk—which incidents like Three Mile Island should teach us—is that *what can happen will happen if we just keep at it long enough*. Any of us can simulate a statistical picture of the estimated risks or even the complexities of the Rasmussen analysis with enough patience and enough dice (or a computer).

Incidentally, to make the eight dice act more like the odds of 1 in 1,000,000, simply mark any two "non-1" sides with a felt pen and count them as 1s if they turn up; the odds of getting all 1s become a little less than 1 in 1,100,000. And the chances of human error can be included by similarly marking other dice in the set. The difficulty is not in constructing such a simulation to portray the odds but in determining events that may lead to these odds and estimating the frequencies of their occurrence.

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Risk analysis has become one with public policy. Without it, any important choice that leads to uncertain outcomes is uninformed; with it, properly applied and understood, the decision maker—business executive, government administrator, scientist, legislator—is better able to decide why one course of action might be more desirable than another.

The fear of risk-taking

To try to eliminate risk in business enterprise is futile. Risk is inherent in the commitment of present resources to future expectations. Indeed, economic progress can be defined as the ability to take greater risks. The attempt to eliminate risks, even the attempt to minimize them, can only make them irrational and unbearable. It can only result in that greatest risk of all: rigidity.

The main goal of a management science must be to enable business to take the right risk. Indeed, it must be to enable business to take *greater* risks—by providing knowledge and understanding of alternative risks and alternative expectations; by identifying the resources and efforts needed for desired results; by mobilizing energies for contribution; and by measuring results against expectations, thereby providing means for early correction of wrong or inadequate decisions.

All this may sound like more quibbling over terms. The terminology of risk minimization does induce a decided animus against risk-taking and risk-making—that is, against business enterprise—in the literature of the management sciences. Much of it echoes the tone of the technocrats of a generation ago. For it wants to subordinate business to technique, and it seems to see economic activity as a sphere of physical determination rather than as an affirmation and exercise of responsible freedom and decision.

This is worse than being wrong. This is lack of respect for one's subject matter—the one thing no science can afford and no scientist can survive. Even the best and most serious work of good and serious people—and there is no lack of them in the management sciences—is bound to be vitiated by it.

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MANAGEMENT ATTITUDES TOWARD RISK

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Management Attitudes Towards Risk

Summary

Good management requires risk management. If managements are overly conservative, many potentially acceptable projects will be turned down. If the judgments are overly optimistic, corporate profitability will suffer.

There are two steps in project risk management: (1) measuring risk, (2) interpreting risk in terms of a consistent strategy towards risk taking. Measuring risk involves such techniques as sensitivity analyses, decision trees, and Monte Carlo analyses. Interpreting risk requires a knowledge of management attitudes towards risk. Usually these attitudes have been subjective and inconsistent. A consistent interpretation of risk requires a quantitative statement of management risk attitudes.

Development of a corporate risk attitude or utility function is fairly time consuming and still is not widely accepted. Experimental work has been undertaken by a number of organizations in the past ten years. One of the early studies is described in this paper. Further experimentation with this risk analysis tool is recommended in order to provide a sound basis for utilization by industry. Once generally accepted, the evaluator will have a method of discounting for risk and the expected value of any risky project will have as its complement, a certainty equivalent.

Introduction

The first priority in any capital expenditure program is to select good ventures. A very important second priority, is to manage risk.

We live in a complex and uncertain world and risk is always with us. Probably the most certain thing is that the future will be different from what we expect--and this difference is often very significant.

This has been clearly demonstrated for capital investments by post-installation appraisals of performance results. A recent AACE publication[5] reported a standard deviation of ± 7 units from originally estimated profitability, for a variety of investments. Thus, if a new investment had an estimated return of 17 per cent when approved, there would be a 68 per cent chance (one standard deviation) that the actual return would be between 10 per cent and 24 per cent--and a 32 per cent chance the profitability would fall outside these limits.

Although risk cannot be avoided, efforts are commonly undertaken to minimize its impact. One common method is for managements to be conservative in their decision-making. The degree of conservatism depends on many things--including the magnitude and type of investment, the general size and prosperty of the enterprise, and the background, personalities, and authority level of the individuals who make up the decision-making team.

As might be expected, studies to quantify management's conservatism--or risk attitude--show considerable scatter, and are not yet widely utilized.

They nevertheless have considerable potential value in risk analysis and in establishing an overall strategy towards risk-taking in a corporation.

The use of such risk attitude correlations is part of a growing management science field called decision analysis. It is being used in government and scientific applications, as well as corporate project studies. Examples where the technique has been tested include[3] space project planning, siting and licensing of nuclear power facilities, airport location, pollution control, oil and mineral exploration, etc.

Measuring Project Risk

There are a number of different ways of measuring project risk--of varying sophistication and usefulness.

Project sensitivities are commonly used to identify the important variables affecting a project appraisal. In their simplest form they show the change in a variable necessary to cause a given change in profitability--a one unit or one per cent change, for example. This simplified approach is often used in the early stages of a new project development, when the likely uncertainty in most variables is unknown. When a project is sufficiently defined for a capital appropriation, the sensitivities should show the likely uncertainty in the major variables, and the impact of this uncertainty on expected profitability. This type of approach is commonly used in presentations to management, and is easily understood by management.

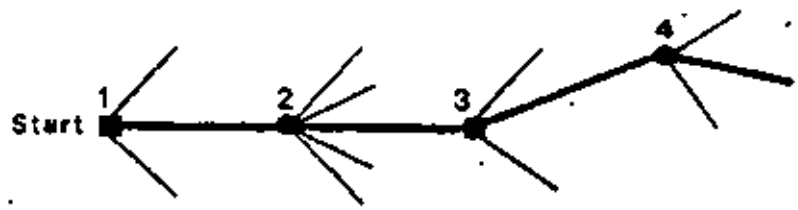
The hard part of such a sensitivity analysis is the determination of the likely uncertainty in each variable. The appropriate experts must be consulted and a consensus obtained. Usually, these estimates are based on what are called subjective probabilities, as they are derived from individual opinions and past experience, and are not subject to repetitive testing and measuring under real world conditions. Another problem is to assure that "likely uncertainty" means the same to everyone. The exact value doesn't matter as long as everyone uses it. For example, a typical uncertainty might be defined as the high and low values a variable has one chance in ten of exceeding.

More sophisticated methods of measuring project risk include decision tree and Monte Carlo analyses.

Briefly, decision tree analysis is a method of orderly structuring of a problem. The schematic form of a decision tree is shown in Figure 1. The tree has modes that are under the control of the decision maker (the square modes) and modes that are not under his full control (the circled or chance modes). For example, in a commercial development program, successive square modes could be bench scale research, pilot plant research, market development and commercial plant construction, and the circular modes showed possible results and their probability of occurrence.

Figure 1

Schematic Decision Tree



Nodes 1 and 3 are decision nodes
Nodes 2 and 4 are chance nodes

In preparing a decision tree, the analyst must answer a number of questions. For example, what choices can he make now? What choices can or must he defer? How can he make choices that are based on information learned along the way? What information can he gather purposefully and what can he learn during the normal course of events without intentional intervention? What experiments can he perform? What are the likely technical, marketing, and economic results?

After drawing the decision tree, the analyst must assign probabilities to the branches leaving the chance nodes. This is based on subjective estimates, usually by a number of different people. This is the hardest part, but except for a possible increased number of choices is no more difficult than determining likely uncertainties in the more common sensitivity analysis.

The next step is to establish the cost and benefit of each effect. This is often done by using net present values. The optimal strategy is then calculated, i.e., the strategy that maximizes expected values. This is fine as far as it goes, but usually it isn't far enough, as the implicit assumption of risk neutrality by management, often doesn't apply. Thus if the path with the highest expected value also had the greatest risk, it might well be turned down, and a less risky approach taken.

A more detailed discussion of decision tree analysis was given at an earlier AACE convention[1].

A Monte Carlo analysis[2] (Figure 2) replaces the probability of selected outcomes at the chance modes of a decision tree by a probability distribution of all possible outcomes. Again, the hardest part is the development of the subjective probability estimates. They can be developed at all chance modes, but are usually done only at the time of final decision when inputs are better defined and a sophisticated risk analysis is more meaningful. The uncertainties in the costs and revenues of a project proposal are usually converted into a probability distribution of net present values for the total project, without any quantitative adjustments for management risk attitude. Because of the number of calculations required, this technique is almost always done on a computer.

Figure 2 - Steps in Monte Carlo Analysis

1. Obtain probability values for significant factors.
2. Randomly select sets of these factors based on chance of occurrence.
3. Determine profitability for each combination.
4. Repeat many times to get probability distribution of profitability results.

Both decision tree and Monte Carlo analyses are useful tools in project studies but are less commonly used in presentations to management. One reason for this is that they contain too much information for easy understanding. Also, their use in decision-making has normally been based on maximizing present values without regard to the relative riskiness of the projects being compared. Unfortunately, these sophisticated and relatively complex analyses are generally developed only in studies of major investments, and these investments, because of their magnitude, are just where management is not risk-neutral. Thus, these tools will not be fully usable in terms of selecting the truly preferred alternate until they can be corrected for managements attitude to risk--something that generally is still not available in quantitative form.

Is Decision Analysis Next?

The management science technique known as decision analysis, is slowly emerging from theory to practice, although much further work is required. It is the logical next step in analyzing risk. Features of the discipline are the treatment of uncertainty through subjective probability and of attitudes towards risk through utility theory. The concept of subjective probabilities is well known and has already been briefly discussed. Utility theory, a method for quantifying managements attitude to risk, will be highlighted in the remainder of this paper.

Examples where formal decision analyses have been tested, include areas of multiple conflicting objectives, such as in business, public policy, engineering design, resource management, public health and medicine, educational management, etc. Decision analysis is more likely to be used on large projects than small projects, as the decision maker tends to be

risk-neutral on small projects (they deal with so many). In the future, this tool should see increasing application.

Utility Theory Example--Death of a Rich Uncle

Utility theory applies to individuals as well as firms and government bodies. It is only a fancy name for everyday behavior. Although a common concept, it has only recently been used in formal risk analysis.

To illustrate the concept, suppose you had a rich but eccentric uncle who died and mentioned you in his will. Instead of a simple bequest, he gave you two choices:

1. One million dollars tax-free (his estate would cover any taxes you incurred).

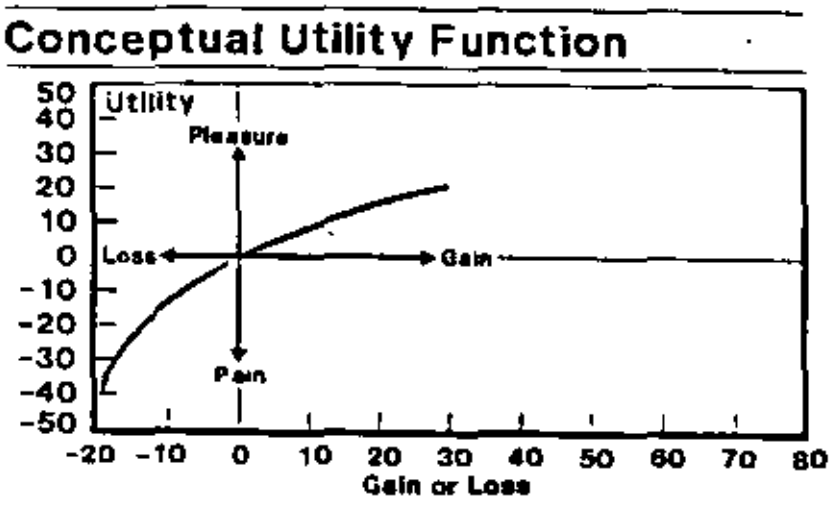
2. A 50/50 chance of $10 million, tax-free, to be determined by a single flip of an honest coin. If you won, you would have $10 million. If you lost, you would have nothing.

Which choice would you take?

This question has been asked of several groups of students and almost everyone took the $1 million. Yet with a 50/50 chance of $10 million, the expected value of the second choice is $5 million or 5 times that of the first choice. Why choose the lower expected value? Basically, it is a question of risk aversion. The pain of not receiving a sure $1 million (if we loose the coin flip) is usually greater than the extra pleasure of the added $9 million (if we win the coin flip). Of course, there are exceptions to this attitude since it is subjective, and depends on the individual and his present circumstances. Both the chronic gambler (risk lover), and anyone who is already wealthy (so his circumstances would be little altered by loosing one million dollars) would be likely to accept the second choice.

A conceptual utility function is shown in Figure 3. The abscissa is in dollars. The ordinate is an arbitrary index of pleasure and pain, or "utility." The decreasing slope is typical for investment situations and indicates a nonneutral risk attitude. Risk neutrally would be represented by a straight line, and would be more likely to apply to small investments, or when comparing high gain alternatives for larger investments.

Figure 3



The "best fit" curve must be experimentally determined by appropriate questioning of the subject. The utility scale is personal and subjective, and there is no reason to expect one man's utility function to agree with anothers.

A similar concept can be applied to business entities. The utility function concept is important from a project standpoint, as it provides a method of discounting for risk. As might be expected from the "rich uncle" example, utility is not a property of individual projects but of overall wealth level. It has also been shown that in order for the utility of a number of independent ventures to be additive, the utility function must be exponential.[3][6] Many other forms of utility functions[5] are possible, and are used in various studies. However, the additive property is considered important in the one-at-a-time analysis of independent investments opportunities. A typical form of the exponential equation is:

$$U(x) = \frac{1}{r}\left(1 - e^{-rx}\right), \text{ with } r > 0, \text{ for risk aversion,}$$

where x = monetary gain or loss,
r = experimentally determined risk aversion coefficient,
$U(x)$ = utility of x.

The Certainty Equivalent in Project Evaluation

Another term for the utility of a given monetary gain or loss is its certainty equivalent. To illustrate its potential usefulness, lets assume that a corporate utility function has been developed for and accepted by a company's management in order to provide a consistent policy towards risk-taking.

Suppose the company now has three large mutually exclusive investment chocies. The expected values of these projects when discounted at the minimum acceptable return are:

Project	Expected Value, $MM
A	13
B	23
C	20

Ignoring risk, Project B would be accepted as it has the highest expected value. Unfortunately, management also feels it is the riskiest project.

Because of the magnitude and importance of the investments, a risk analysis using certainty equivalents is desired. This method requires two steps:

1. Measuring Risk
   This is done by developing of a probability distribution of project profitability, using Monte Carlo analysis based on subjective probability estimates of the uncertainty in the major variables.

2. Interpreting Risk
   This is done by the certainty equivalent method which converts each probability distribution obtained in the first step to a single value which properly recognizes management's actual risk attitude.

The Monte Carlo results for Project A, B, and C are shown in attached Figure 4, in terms of project present values. The total area under each curve represents a probability of 100 per cent, indicating that there is no chance of project performance falling outside the range of the curves. Present value distributions are used since rate of return distributions become meaningless in the negative ranges.

Much information can be drawn from these profitability distributions, but unless management's attitude towards risk is known, it is still difficult to reach a decision. For example:

Project A — Least risk. There is no chance of loosing more than $4 million present value and only a 2 per cent change of a negative present value. The expected value is $13 million and the maximum that can be received is $29 million.

Project B — Most risk. The project has a 27 per cent chance of a negative present value, but also has the greatest possible gain. The present values range from ($32) million to $83 million with an expected value of $23 million.

Project C — Intermediate risk. There is a 17 per cent chance of a negative present value. The expected values range from ($25) million to $58 million with an expected value of $20 million.

This information is a great improvement over a single present value based on "best guess" forecasts for each project. From a decision-making viewpoint, however, there still are difficulties:

1. Not all management is familiar with probability distributions,

2. Even after fully understanding the meaning of the probability distributions, individuals are generally not able to adequately weigh all the information in the distributions,

3. The information tabulated does not indicate a clearly preferred alternate.

4. Risk attitudes still need to be considered.

A formalized risk attitude as in the certainty equivalent (CE) method can overcome these problems by making it possible to convert the probability distribution of a project's profitability into a single number. The CE can be viewed as the risk-adjusted average value of the present value distribution. When the CE is greater than zero, the project is a good investment. Where several mutually exclusive alternates are being considered, the one with the highest CE should be accepted. Where several independent projects are being analyzed, all with CE's greater than zero should be accepted.

Figure 5, attached, illustrates the use of the CE method for the three projects shown in Figure 4. The effect of risk discounting, i.e., the difference between the certainty equivalent, and the expected value is shown for each project. The difference becomes increasingly significant as risk increases. These curves also show that failure to take advantage of all available information could give different project rankings from that obtained by the certainty equivalent method. The rankings by three criteria are given in Figure 6.

Figure 6

Effect of Risk Analysis on Project Ranking

Ranking Criterion	Project Ranking
1. Expected Value	B, C, A
2. Minimum Chance of Negative PV	A, C, B
3. CE Method	C, A, B

The CE method not only makes risk analysis more understandable, but also improves project selection by giving proper weight to all information in the probability distribution.

Obtaining a Corporate Utility Function

If the CE method is as good as it sounds, why isn't everyone using it?

The answer is simple--as far as the writer knows, no firm has established a generally accepted corporated utility function so that certainty equivalents can be calculated. However, experimental work in this field has been undertaken by a number of firms.

I was involved in a serious effort to obtain such a function several years ago, when with a different company. Parts of this work have already been published[4]. Unfortunately it is in a fairly obscure and out of print source. I would like to review the study again as it deserves more attention in industry.

First, 36 corporate executives were interviewed and their risk attitudes quantified. This quantification was done by two series of 20 questions, somewhat similar to the rich uncle example. The first series was for $3 MM investments; the second series, for $50 MM investments. In each case the project had two possible outcomes--success or failure. Success was a positive present value; failure, a negative present value. The manager was told the size of the initial investment, the net present values for the two possible outcomes, the rate of return of the gain case and the required probability of success for the project to just meet the minimum acceptable return, when the expected gains and losses were weighted by the likelyhood of their occurrence (the risk-neutral situation). The manager was then asked what chance of success he would require to accept the project.

Figure 7 shows a few typical results.

Figure 7

Sample Questionnaire Results

	Data Given					
	Net Present Value, $MM		Rate of Return	Breakeven	Average Response	Required Risk
	Loss	Gain	of Gain Case	Probability, % (1)	Probability (2)	Margin (2)-(1)
$3 MM Investment						
1	- 1	+ 2	18	33	42	9
2	- 5	+14	68	26	42	16
3	-17	+48	200	26	44	18
4	- 3	+ 2	18	60	76	16
5	-19	+14	70	56	72	16
$50 MM Investment						
1	-25	+30	15	45	62	17
2	-90	+100	33	47	72	25
3	-150	+230	68	40	74	34
4	-170	+450	120	27	62	35
5	-200	+950	195	17	52	35

For the company being studied, a $3 MM investment was common and the managers did not allow too great a margin for adversity, expecting the successes and failures to more or less average out. At the $50 MM level, everyone became more conservative, and the required risk margin roughly doubled.

The minimum chance of success that the interviewees required for each hypothetical investment has been tabulated in histogram form for both

investment levels (Figures 8 and 9). The presentation of the histograms is ordered according to increasing magnitude of outcomes, with the largest values at the top of the sheets. The actual dollar magnitudes of the present values that were associated with each investment are shown to the left of each histogram.

There is considerable scatter, as the degree of conservatism varies from individual to individual. There are also inconsistences in individual responses. The average of all responses is shown by the vertical line. These average response probabilities are also listed in Figure 7, for the samples shown. Of course, there can be good reasons for not using averages. For example, the president's utility function may dominate over those of others.

The next step was to convert this information to a utility function of the general form shown earlier. By trial and error, the best fit was found to be a modified logarithmic equation. The final results for two of those interviewed is plotted in Figure 10 for $50 MM investments and shows very little difference between the subjects. However, as shown by the histograms, there was significant variation among other respondents. The work was not carried to the point of obtaining a consensus curve for the corporation.

Figure 11 compares the utility functions of one subject at the $3 MM and $50 MM levels. The significantly greater conservatism at the $50 MM level is clearly evident, and was generally observed with all respondents.

This work was done by Dr. Spetzler as part of his PhD thesis and the participating company unfortunately has not followed up on these studies since then. At the time this tool was developed, it was used on some trial projects that were presented to top management, but it was never used to develop an official statement of corporate risk attitudes.

This type of experimentation is typical of any new development, and should continue. Dr. Spetzler's study, if nothing else, showed that it is reasonably easy to develop a quantitative statement of corporate risk attitudes of individual members of top management, and with a little discussion with management, easy to understand by management.

The certainty equivalent concept is sound, and until it is in more general use, even the most sophisticated risk analysis will be incomplete. It is the writer's present feeling that certainty equivalent calculations will not be sensitive to small changes in a utility function's shape or equation. Once a particular management risk attitude is roughly defined trial calculation of certainty equivalents for a number of real projects will permit management to gain confidence that the calculated utility function and certainty equivalents do properly represent their risk attitudes, and can ultimately authorize their use as an official statement of corporate risk attitude.

Conclusions

Competition for high returns tends to drive all of us into high risk areas. If projects are selected by ranking methods which are blind to risk, then the firm tends to select a "diet" of high risk activities, and

the business becomes highly risky. Business can be less risky if methods of measuring and controlling risk are better understood and systematically utilized. The certainty equivalent concept discussed in this paper is one such method. Not the least benefit is that firms with a sound risk strategy, should be able to attract more capital, and at more favorable rates. Further experimentation with this risk-analysis tool is recommended.

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Figure 4

Probability Distribution of Present Values for 3 Hypothetical Projects

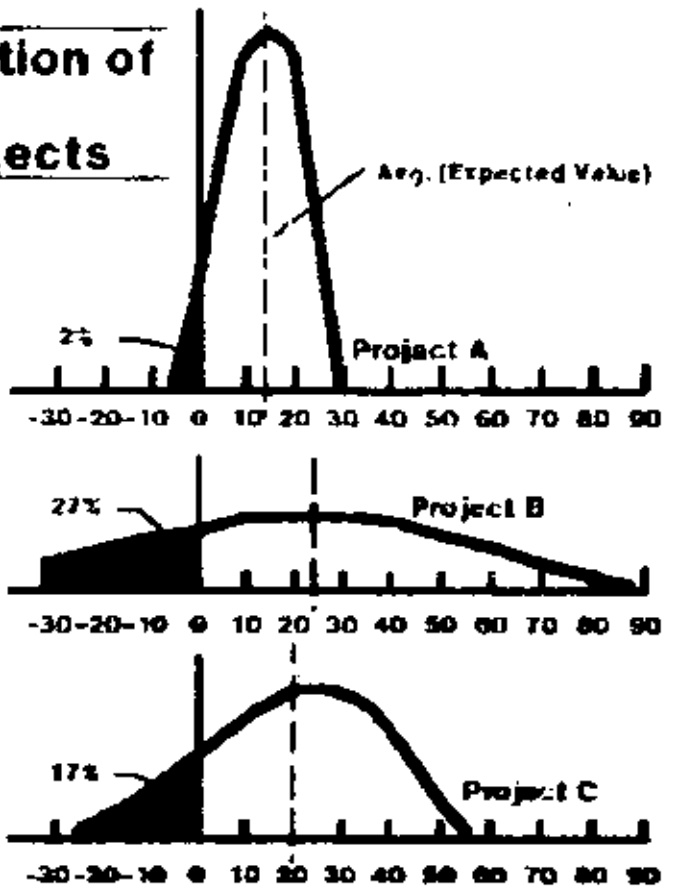
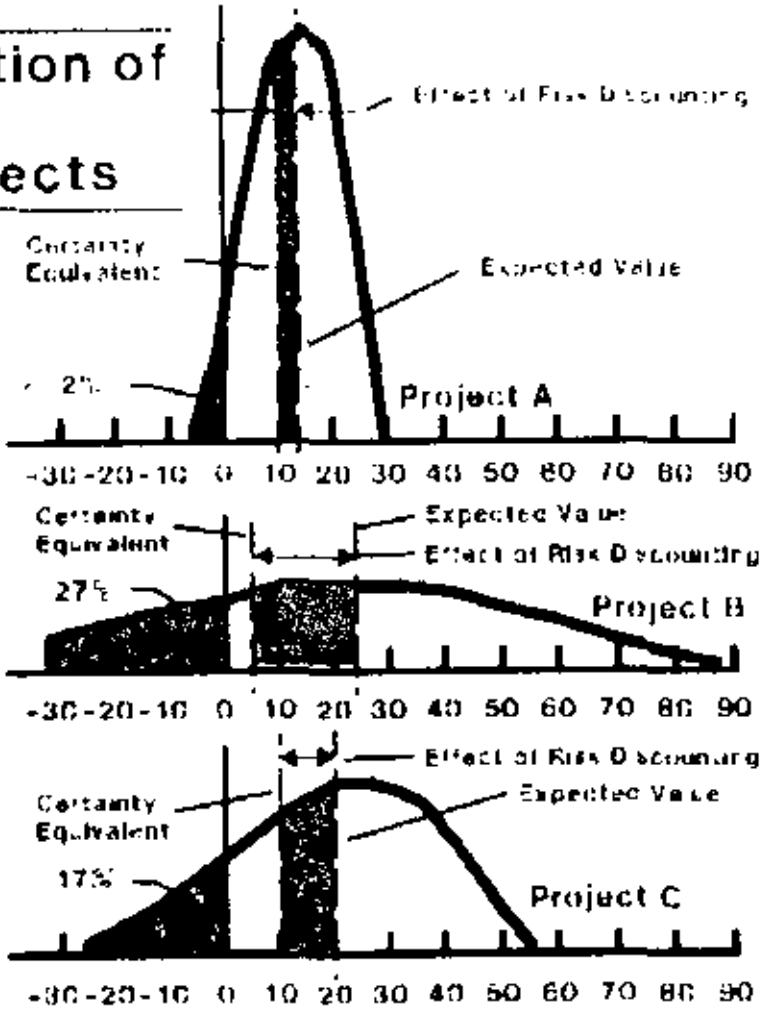


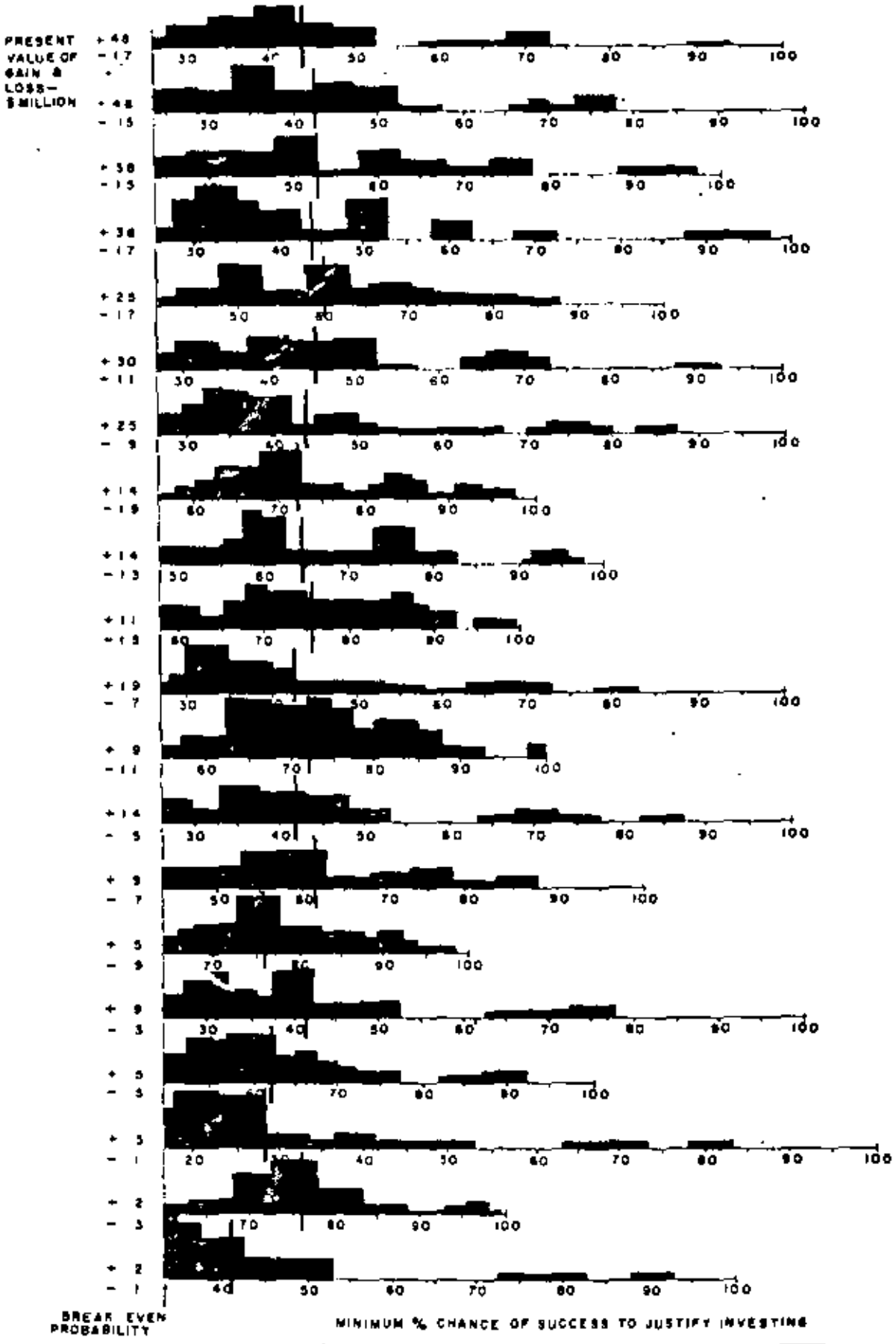
Figure 5

Probability Distribution of Present Values for 3 Hypothetical Projects



MANAGEMENT RISK ATTITUDE SURVEY

$3 MM INVESTMENT — ALL RESPONSES



MANAGEMENT RISK ATTITUDE SURVEY

- $50 MM INVESTMENT — ALL RESPONSES

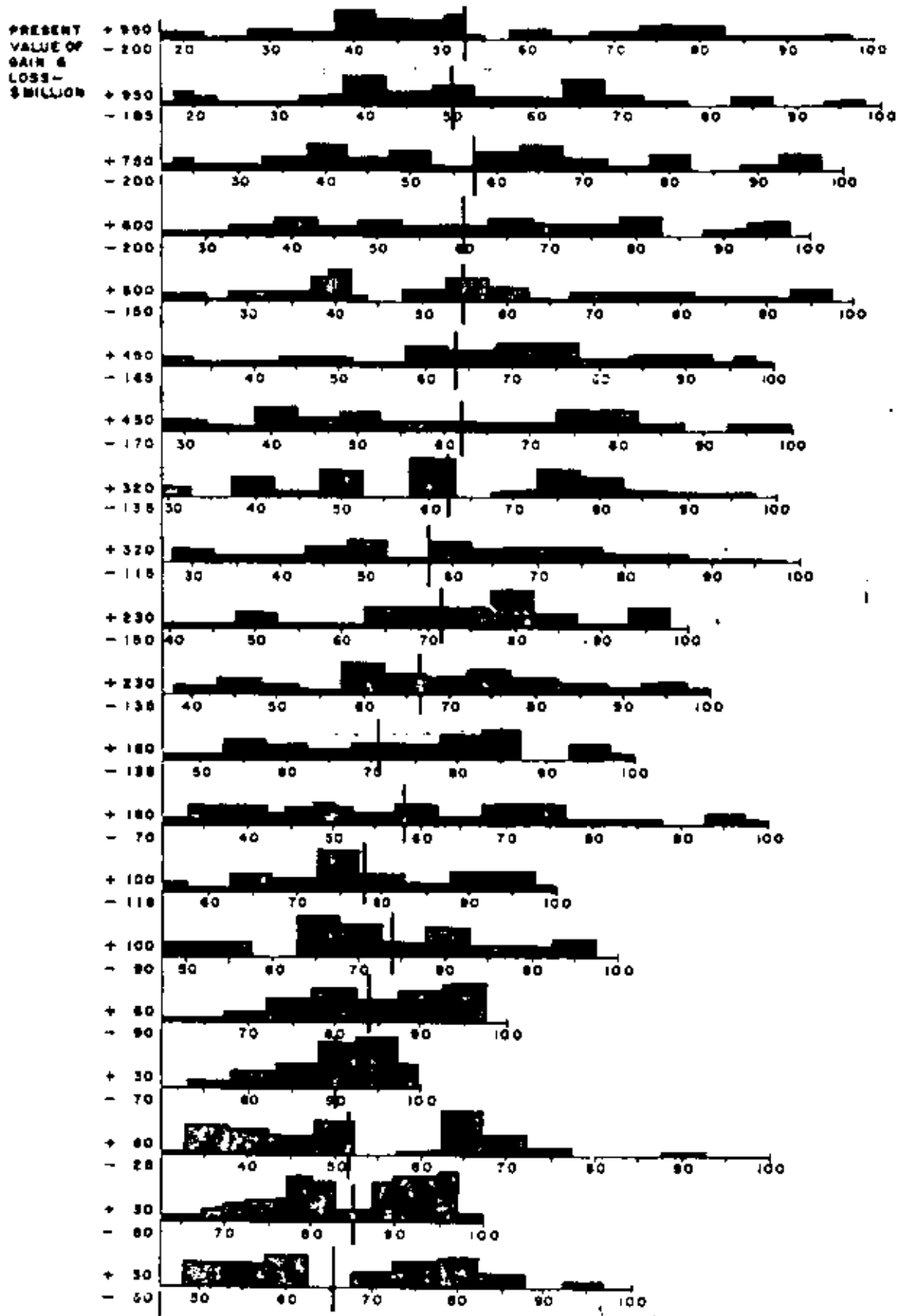
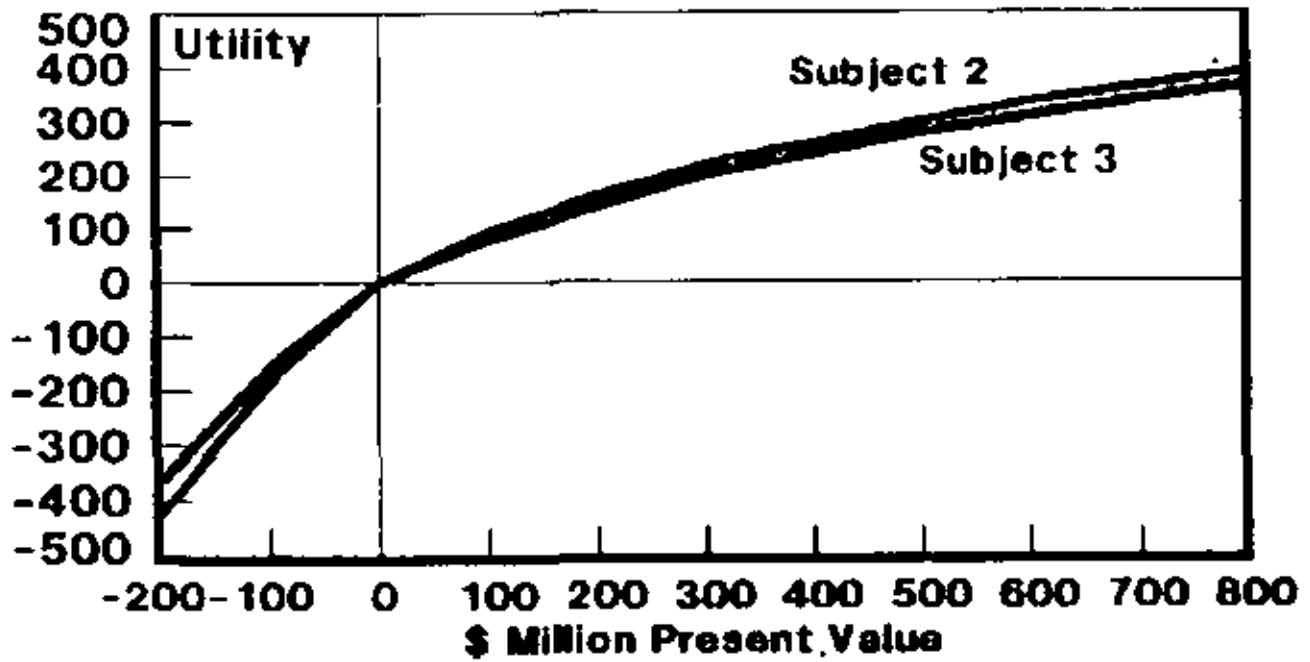
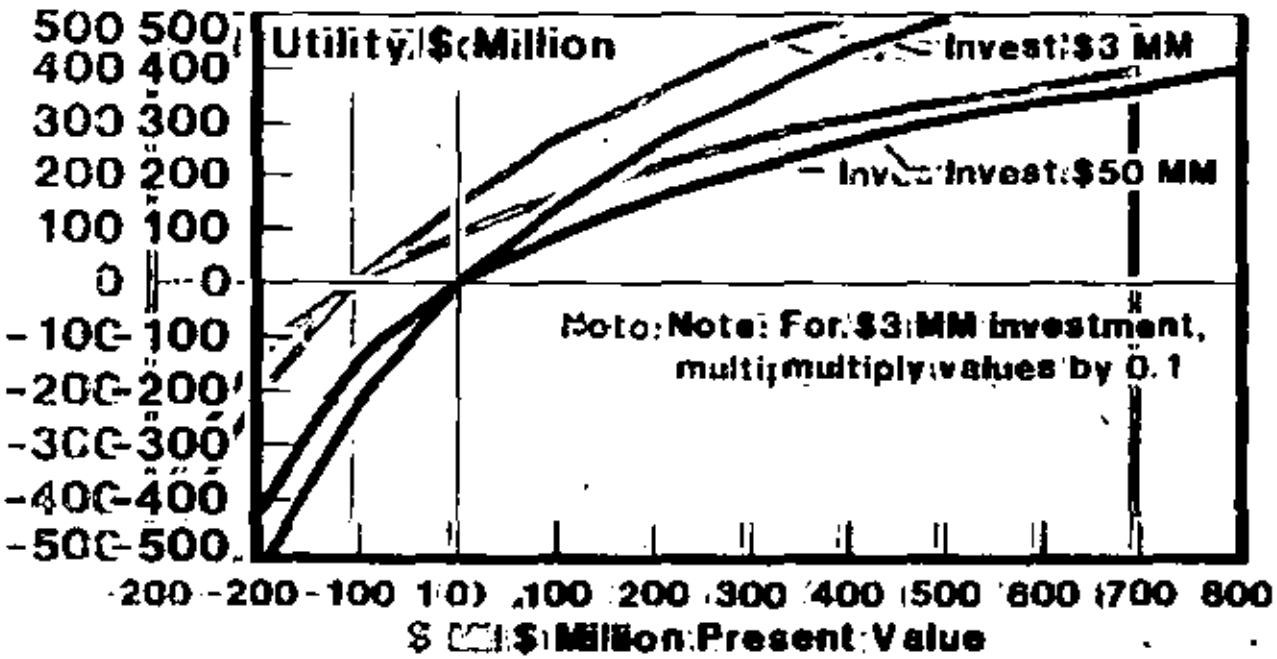


Figure 10

Utility Functions for 2 Subjects ($50 MM Investments)




Utility Function (Subject 2)
Utility $ Million
Invest $3 MM
Invest $50 MM
Note: For $3 MM investment, multiply values by 0.1
500 500
400 400
300 300
200 200
100 100
0 0
-100 -100
-200 -200
-300 -300
-400 -400
-500 -500
-200 -200 -100 100 200 300 400 500 600 700 800
$ Million Present Value

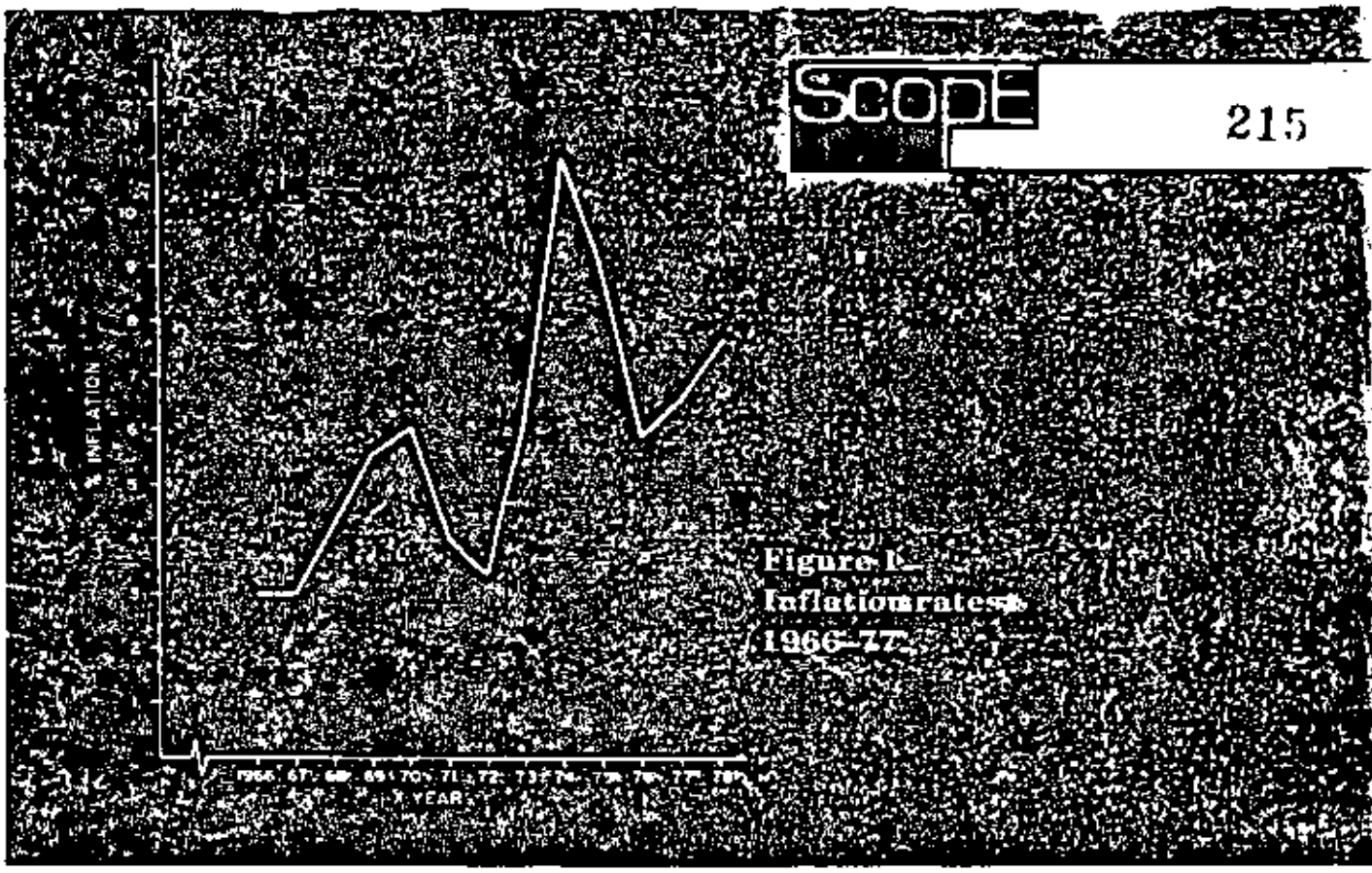


Figure 1. Inflation rates, 1966–77.

Making Decisions In an Inflationary Environment

Using too high an inflation rate can kill potentially good projects; too low a rate may lead to the acceptance of poor ones.

Wishard H. Grisst, Jr., Getty Refining & Marketing Co., Delaware City, Del.

By comparison with Brazil, Argentina, and Chile the inflation rates the U.S. has experienced during the last several years have been relatively low, although they seem quite high when tacked up against the 1.5 and 2% inflation rates of the 1950s and mid 60s, a very stable period in our economic history.

As shown in Figure 1, inflation rates from 1965 through 1971 averaged 4.3%. A lower rate, 3.3%, was registered in 1972, which rose to 6.2% in 1973, peaked at 11% in 1974, and coasted to 9.1 and 5.8% in 1975 and 1976, respectively. An inflation rate of 6.5% was posted for 1977, and last year it increased again, this time to 7.4%.

Obviously, inflation rates go up and down like a roller coaster. At best, in a capital evaluation it will only be possible to reflect a long term inflation rate trend, not year by year data. Because the future with respect to inflation is uncertain is no excuse to exclude it entirely when evaluating capital expenditures. The section on "Fundamentals of Investment Evaluation" in the "Chemical Engineers' Handbook"

Table 1. Three alternatives compared.

Alternative	Investment at Time Zero, thousand $	Profit Before Tax And Depreciation in Constant Dollars Referenced to Time Zero, thousand $/yr	Lease Payments in Constant Dollars Referenced to Time Zero, thousand $/yr
A	1,000	368.6	—
B	500	199.7	—
C	—	368.6	364.8

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Table 2. Alternative A, 0% inflation, all dollars are constant.

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Time	Profit Before Tax and Depreciation, thousand $	Depreciation, thousand $	Profit After Tax, thousand $	Cash Flow, thousand $	10% Discount Factor	Present Worth, thousand $
0					1	−1000
End 1st yr	368.6	333	17.8	350.8	0.9091	318.9
End 2nd yr	368.6	267	50.8	317.8	0.8264	262.6
End 3rd yr	368.6	200	84.3	284.3	0.7513	212.6
End 4th yr	368.6	133	117.8	250.8	0.6830	171.3
End 5th yr	368.6	67	150.8	117.8	0.6209	135.2
					Present Worth =	101.6

Table 3. Alternative A, 5% inflation.

	Current Dollars							
Time	PBT &D, thousand $	Depreciation, thousand $	Profit After Tax, thousand $	Cash Flow, thousand $	5% Deflator	Cash Flow, thousand $, Constant Dollars	10% Discount Factor	Present Worth, thousand $, Constant Dollars
0								−1000
End 1st yr	387.0	333	27	360	0.9524	342.9	0.9091	311.7
End 2nd yr	406.4	267	69.7	336.7	0.9070	305.9	0.8264	252.4
End 3rd yr	426.7	200	113.4	313.4	0.8638	270.7	0.7513	203.4
End 4th yr	448	133	157.5	290.5	0.8227	239.0	0.6830	163.2
End 5th yr	470.4	67	201.7	268.7	0.7835	210.5	0.6209	130.7
							Present Worth =	61.4

indicates that the usual effect of inflation on a project's profitability is major, and the accuracy of predicting inflation is poor.

The purpose of this article is to take a look at how inflation affects a project's profitability and to examine how inflation can be included in the evaluation of a project. Before we begin, it is necessary to define certain terms (inflation, escalation, current dollars, and constant dollars).

1. Inflation is a rise in the average level of all prices.

The price rise of a single commodity does not necessarily denote inflation since lower prices of other goods may offset that increase. Admittedly, the term "average level of all prices" is a bit abstract. For example, the Consumer Price Index (CPI) is based on retail prices of approximately 400 goods and services (certainly not all) chosen to represent the prices of all final goods and services purchased by urban residents.

2. Escalation is the rise in the price of a single commodity or service.

The combined effect of inflation and supply and demand changes is reflected in escalated prices. Escalated prices and costs should be used to develop future cash flows when evaluating a project. Of course, the various costs and sales prices will not all escalate in the same manner. Operating labor may be increasing at 6%/yr, maintenance labor at 9%/yr, and the raw material used by the project at 5%/yr.

3. "Current Dollars" refers to dollars realized in a specific year—the current dollars for any two years

Table 4. Alternative A, company's viewpoint.

Component of Present Worth, thousand$, Constant Dollars	Inflation, %/yr: 0	5	
PBT&D	698.6	6	698.
Depreciation	403	8	362.
Investment	−1000	−1000	
Net Present Worth	101.6	4	61.
Δ From 0% Inflation	—		−40.2

Table 5. Alternative A, government's viewpoint.

	Inflation, %/yr: 0	5	Δ
Taxes Received by Government, thousand$			
Current Dollars	421.5	569.3*	147.8*
Constant Dollars	421.5	474.5	53
Constant Dollars Discounted at 10%	295.6	335.8	40.2

*Meaningful only as an arithmetic check since dollars of different buying power are being compared.

may or may not have the same buying power.

Current dollars may be "rubber dollars." For example, a dollar in 1980 may only buy 80% of what a dollar in 1978 will buy. For this reason, accumulating current dollars over, say a 10-year period, is meaningless, except to check arithmetic. To evaluate a project, it is necessary to use escalated sales prices and costs to develop the project's cash flow in terms of current dollars.

4. "Constant Dollars" references the buying power of current dollars to some base year.

If a current dollar in 1980 can only purchase 80% of the goods and services that a dollar in 1978 can, then a current dollar in 1980 is only worth 80¢ in constant dollars using 1978 as the base year. Since the purpose of a company should be the maximization of long-term wealth, it is essential that an evaluation method to accomplish this end be based on constant dollars. In project evaluation, it is necessary to estimate the various elements of a project using escalated costs and prices, combine the elements into a cash flow pattern which is in current dollars, and then deflate the current dollar cash flow to a constant dollar cash flow before discounting at the cost of capital or real rate of return desired by the company. Keep in mind that the real world deals in current dollars. When we go to the bank for a loan we talk current dollars. The interest rate quoted has already been adjusted for inflation by the lending market. Constant dollars is an abstract concept used only to demonstrate what is happening to the buying power of a dollar in an inflationary economy.

Three mutually exclusive alternatives

Now that we have established these definitions, let us examine the effect of inflation on a hypothetical project. A company is faced with the opportunity to make an investment or lease equipment to produce a certain product that has a five-year economic life. There are three mutually exclusive alternatives by which the company can enter the field, Table 1.

Alternative A requires an investment of $1 million at time zero and is projected to yield a profit before tax and depreciation, in constant dollars referenced to time zero, of $368,600/yr for five years.

Alternative B requires an investment of only half a million dollars and results in profits before tax and depreciation of $199,700/yr in constant time zero dollars.

Alternative C requires no capital investment but instead obligates the company to a five-year fixed lease payment of $354,800/yr, which is in terms of time zero constant dollars. The profit before tax and depreciation for this case is the same as Alternative A ($368,600/yr).

For evaluation purposes, the following premises will be used:

- Tax Rate – 50%
- Economic Life – Depreciable Life – 5 Years
- Year End Discounting
- Sum of the Years Depreciation Method
- Cost of Capital (excluding inflation) – 10%
- Three Scenarios of Inflation: 0%/yr, 5%/yr, 10%/yr

Next, we will calculate the present worth of the

Table 6. Alternative C, 0% inflation, all dollars are constant.

Time	PBT&D, thousand $	Lease, thousand $	Cash Flow – Profit After Taxes, thousand $	10% Discount Factor	Present Worth, thousand $
0		354.8	−177.4	1	−177.4
End 1st yr	368.6	354.8	+6.9	0.9091	+6.3
End 2nd yr	368.6	354.8		0.8264	+5.7
End 3rd yr	368.6	354.8		0.7513	+6.2
End 4th yr	368.6	354.8		0.6830	+4.7
End 5th yr	368.6		+184.3	0.6209	114.4
					−41.1

Table 7. Alternative C, 5% inflation.

Time	PBT&D, thousand $	Lease Payment, thousand $	Cash Flow – Profit After Taxes, thousand $	5% Deflator	Cash Flow, thousand $, Constant Dollars	10% Discount Factor	Present Worth, thousand $, Constant Dollars
0		354.8	−177.4		−177.4	1	−177.4
End 1st yr	387.0	354.8	+16.1	0.9524	+15.3	0.9091	+13.9
End 2nd yr	406.4	354.8	+25.8	0.9070	+23.4	0.8264	+19.3
End 3rd yr	426.7	354.8	+36.0	0.8638	+31.1	0.7513	+23.4
End 4th yr	448	354.8	+46.6	0.8227	+38.3	0.6830	+26.2
End 5th yr	470.4		+235.2	0.7835	+184.3	0.6209	+114.4
							+19.5

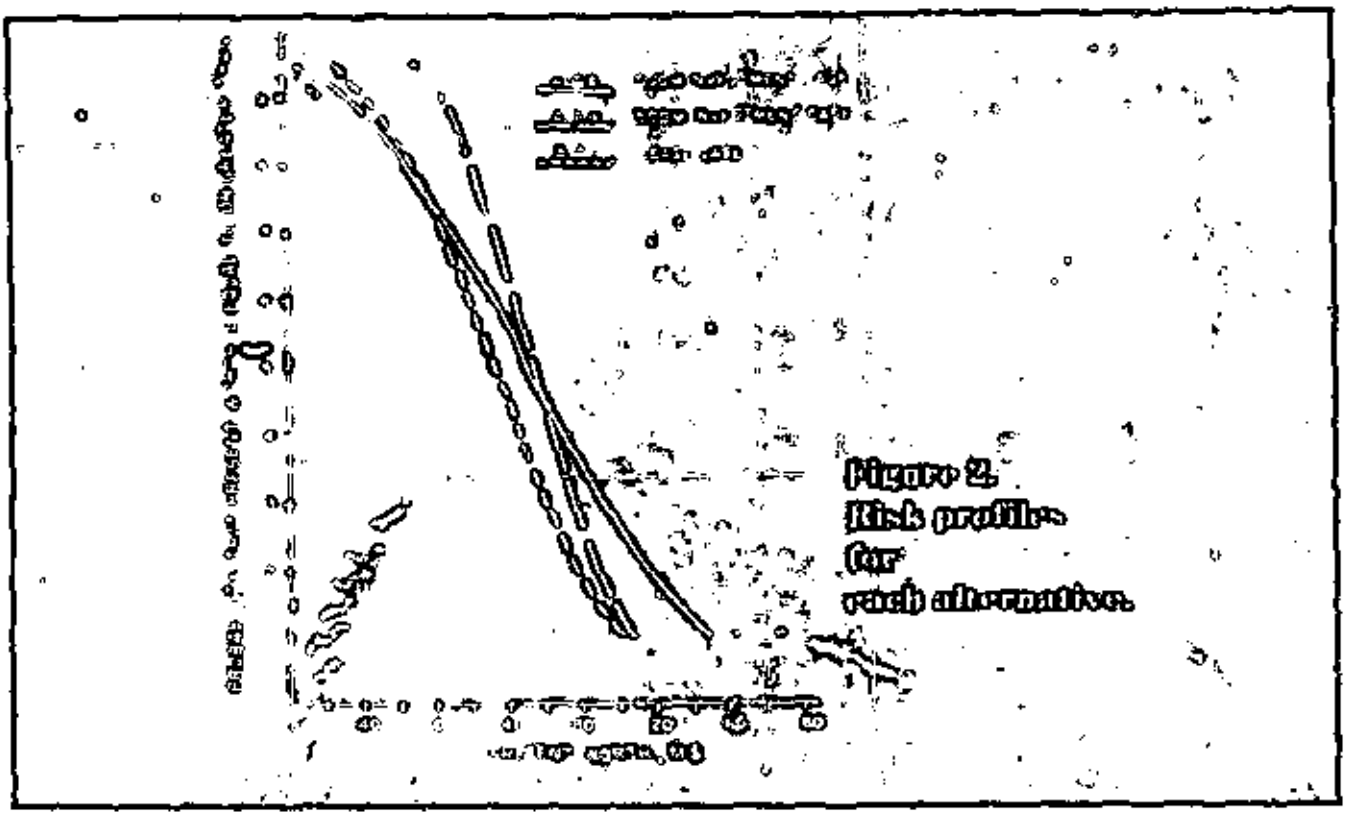

Figure 2. Risk profiles for each alternative.

three alternatives under the three scenarios of inflation (nine present worths in all). As shown on Table 2, the present worth of Alternative A is $101,600 when a zero inflation rate is assumed. Since there is no inflation, all dollars are in terms of constant dollars referenced to time zero. Since the profit before tax and depreciation stays the same for each of the five years, it can either be assumed that there is no escalation or that the combined effect of the various revenues and costs are escalating in such a manner as to result in a constant profit before tax and depreciation.

Now look at this alternative with a 5%/yr inflation scenario (see Table 3). For this purpose, the profit before tax and depreciation is increased in terms of current dollars by 5%/yr over that shown in Table 2.

A simplifying assumption was used in Table 3 that implies that if we have a 5%/yr inflation rate, that profit before tax and depreciation will rise at 5%/yr. This does not have to be the case. It could have just as easily been assumed that profit before tax was increasing at 6%/yr in a 5% inflationary economy. In a real world, it is unlikely that profit before tax and depreciation would be increasing at exactly the same rate as inflation. The simplification does not, however, detract from the concept we are going to investigate.

Depreciation on Table 3, since it is fixed by the government, is kept in the same pattern as on Table 2, but is now in terms of current dollars. As shown, the cash flows are calculated in terms of current dollars. Next, this cash flow is converted to constant dollars by using a 5% deflator. The constant constant cash flow is then discounted by a factor of 10% to obtain the present worth of the project in constant dollars. A present worth of current dollars discounted at 10% is meaningless since it is a mixture of apples and oranges in terms of buying power.

As shown on Table 3, the constant dollar present worth of Alternative A has dropped from $101,600 with a 0% inflation rate to $61,400 with a 5% inflation rate. As an aside, if we had discounted the current dollar cash flow of this case with a 10% discounting factor, the present worth would have been $208,200 of unknown buying power. You must either convert current dollar cash flow to a constant dollar cash flow before discounting at the cost of capital or use a discounting rate that combines cost of capital and inflation. In this case, a 15.5% discounting factor could have been applied to the current dollar cash flows to give the $61,400 present worth. The inflation rate and cost of capital are approximately additive. To be exact, the cost of capital and inflation rates are multiplied (e.g. $1.10 \times 1.05 = 1.155$, therefore, 15.5% gives the combined effect).

Uncle Sam took the dollars

Where did the constant dollars go? Due to the fixed pattern of depreciation, based on historical investment rather than replacement cost, Uncle Sam took the dollars. This can be shown by breaking the present worth down into its components as is done in Table 4. On a constant dollar basis, the profit before tax and depreciation and investment contribution to present worth with zero and 5% inflation is the same. The depreciation contribution to net present worth, however, is lower by $40,200 with 5% inflation than with no inflation.

Looking at the taxes received by the government,

Table 5, it is apparent that the loss in present worth of the project flowed to the government. As shown, the government received taxes worth $53,000 more in buying power with 5% inflation. If this is discounted at 10%, it accounts for the present worth lost by the project, $40,200.

Without going into the detail, Alternative B is developed in the same manner as that shown for Alternative A. The present worth of Alternatives A and B decreases as the inflation rate is increased.

Unlike Alternatives A and B, Alternative C shows an improvement in present worth in constant dollars when inflation sets in. As shown on Table 6, a negative $41,100 present worth is realized for Alternative C with no inflation. With 5% inflation, the present worth of Alternative C increases to $19,800 in constant dollars, Table 7.

Using the same approach as demonstrated, the present worth of the three alternatives are estimated to be as shown on Table 8. Clearly, if there is no inflation, Alternative A is favored. With 5% inflation, Alternatives A and B are a standoff and are definitely favored over Alternative C. With a 10% inflation rate, Alternative C becomes the best course of action.

Other uncertainties

To further cloud the problem, let us assume that there are other uncertainties besides inflation. The profit before tax and depreciation benefit has only a 10% chance of being 10% higher than the numbers used and has only a 10% chance of being 10% lower than those used. This defines the 80% confidence interval. Similarly:

- It is an 80% certainty that the investment is ±10% of that used. The lease payment is risk free.
- In regard to inflation, management feels there is a 10% chance of no inflation, a 50% chance of 5% inflation, and a 40% chance of 10% inflation.

Using the parameter method of risk analysis described by L. B. Davidson and D. O. Cooper in the September, 1976, issue of the *Journal of Petroleum Technology*, risk profiles can be developed for each of the alternatives under the combined risk scenario specified. These are shown in Figure 2.

Alternatives A and C have about a 25% chance of resulting in a negative present worth. There is a very little risk related to Alternative B (about 8% chance of a negative present worth). The means of Alternatives A and B are about equal, $52,000 and $55,000, respectively. Although there is a possibility that big dollars can be made by Alternative A, the relatively high risk of Alternative A makes Alternative B favored. Alternative C is poorer than B on all counts. Alternative B, the best alternative, has a present worth 80% confidence interval of $5,000 to $105,000 with a most likely of $55,000. The approach used to include the uncertainty of inflation shows that if management is uneasy about inflation it can be included in a risk analysis to guide management in making decisions.

In an attempt not to bog down in more detail than necessary, the examples were kept simple. The concepts hold regardless of how complex a case is being evaluated and can be used to show that:

1. *Inflation does affect the profitability of a project.* Although not shown in this article, similar examples to those presented can be used to demonstrate that a longer depreciation life increases the unfavorable effect of inflation on present worth as well as the use of straight line depreciation.

2. *Inflation can change the ranking of mutually exclusive projects or can change the order of preference of projects in a capital budgeting decision.*

3. *Inflation may be, and usually is, built into the discount rate.* Instead of deflating and discounting (two steps), the result can be accomplished by using a combined discount factor applied to the current dollar cash flow. For example, if 5% inflation is expected and the real rate of return is 10%, use a discount rate of 15.5%. In the same manner, for 10% inflation and 10% real rate of return, use a 21% factor. Inflation is roughly additive to the real rate of return.

4. *If inflation is felt to be a variable, it can be handled statistically in a risk analysis.*

5. *High rates of inflation can improve the attractiveness of a lease alternative relative to capital investment.*

6. *High rates of inflation tend to favor lower capital projects.*

Although it is not the intent of this article to get into the setting of premises to be used in an evaluation, some comment is necessary. Ideally, premises of costs and prices are developed by one group within a company and are developed in a consistent manner. The analyst must be sure the inflation factor applied to all premises is the same and is consistant with the inflation rate built into the discounting factor used to evaluate a project's present worth. When premises are obtained from various sources (marketing, operations, engineering, etc.) be sure to determine that they are consistent. In addition to consistency, use of too high an inflation rate (high discount rate) may kill potentially good projects, and use of too low a rate could lead to accepting poor ones.

Table 8. Estimation of the current worth of the alternatives.

Inflation Rate, %/yr	Present Worth, thousand $, Constant Dollars: Alternative A	Alternative B	Alternative C
0	101.6	80.1	−41.1
5	61.4	59.9	19.8
10	27.8	43.1	70.5

Griest