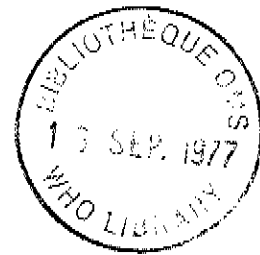


Administrative Management



*Costs & Cost Analysis*

BENEFIT/COST ANALYSIS

BENEFIT/COST ANALYSIS

1. INTRODUCTION

The purpose of this lecture is to explain and demonstrate a quantitative method for determining the most economic choice between alternative investment options.

This technique, which we term Benefit/Cost Analysis was originally developed for industry or other profit-making organizations. Here it is normally referred to as Return on Investment (ROI) analysis and has probably become the most trusted and widely used quantitative technique for economic evaluation and control.

It is however equally applicable for non-profit making institutions and is now being used extensively in government agencies and international organizations.

Basically the technique has to do with what we might call "the time value of money." This means in its simplest form that \$1 today is worth more to me than \$1 tomorrow, simply because my \$1 today can be invested in some venture and thereby generate income in excess of the \$1 invested.

The "time value of money" concept has therefore nothing to do with variations in monetary values over time, i.e. inflation/deflation, but is based on entirely stable monetary values.

The powerful effect of this time value concept can be amply demonstrated by the following somewhat theoretical example.

VISUAL 1

Now, it is highly unlikely that we will have cases where the time horizon is of the magnitude as in this case. However, the problem still remains that we often will have to select between projects having different projections of future benefit and costs and also where different time horizons may apply.

In these situations objective comparison between projects can be extremely difficult if not impossible without the aid of some quantitative technique, and this is where Benefit/Cost Analysis ought to be applied.

## 2. THE DISCOUNT FUNCTION

I have mentioned that it is what we called "the time value of money" which forms the basis for Benefit/Cost analysis, and further that according to this, \$1 today has a greater worth than \$1 tomorrow.

Benefit/Cost analysis therefore is concerned with discounting projected streams of future benefits and costs.

VISUAL 2

This shows an example of anticipated future money streams of some project with a time horizon of 6 years.

Supposing we have to take up a loan for the entire financing of this particular project.

- How can we then evaluate clearly whether the future benefits are sufficient to cover both the loan and the interest charged?
- And how can we evaluate the extent to which it is economical, in case we want to compare this project with an alternative with different characteristics?

We do this by discounting future streams to its present value at a pre-set rate

(say the interest-rate for the loan).

In other words, as this Visual shows, we evaluate the worth of the project in terms of benefits and costs received today.

The net present value of say the benefits is then that sum of money which if invested today at the particular interest rate would, in total, yield the sums as projected in years 4, 5 and 6.

Visual 2 also gives the general discount formula to be applied in these evaluations,

$$V_0 = \frac{V_n}{(1 + r)^n}$$

Where  $V_0$  = value at year 0, i.e. present value

$V_n$  = " " " n

$r$  = discount rate.

The discount rate  $r$  may vary widely from organization to organization.

VISUAL 3

A more fitting description of  $r$  is one which is commonly used in industry, which is to call it the cost of capital.

As such it more accurately reflects what  $r$  really should represent:

- For projects financed entirely from loans,  $r$  should be the interest rate charged.
- For profit oriented organizations,  $r$  would be the weighted average between the interest rate on debt capital, and the cost of raising equity capital.

Now fortunately, instead of having to apply the discount formula in time-consuming calculations every time we come across a problem, we can make use of the following discount tables

VISUAL 4

VISUAL 5

### 3. THE PROBLEM

Turning now from the more general aspects of this technique, I will try to illustrate its practical application through a health related case study.

You are requested to recommend which of 3 specified alternative projects to embark on. Resources are limited in such a way that one can only afford to undertake 1 of the 3 projects.

The alternatives are as follows:

- a. A smallpox eradication project (SX)
- b. A malaria eradication project employing spraying techniques (MS)
- c. A malaria eradication project employing genetic control techniques (MG)

VISUAL 6

This shows for each of the 3 projects the estimated benefits and costs and their distribution in time. (Note that all projects have the same total undiscounted cost of implementation, viz. \$200,000. The undiscounted benefits however vary between the 3 projects both in actual magnitude and in distribution over time).

It should be noted that this example has been developed purely to demonstrate the Benefit/Cost technique.

The example does, therefore, not pretend to reflect the expected benefit and cost streams of smallpox and malaria eradication projects in general.

We will use a 10 year time horizon for our evaluation of the 3 projects.  
(Although benefits are likely to accrue also beyond the 10th year in  
Projects MS and MG. it has been decided to disregard such benefits for  
reason of uncertainty as to their magnitude.)

We will further assume that the funding will be entirely through a World  
Bank loan at an interest rate of 8%.

Using Benefit/Cost analysis, which of the three projects do you recommend?

VISUAL 7

[Explanations on Visual as to  
discounting and evaluation of projects]

The actual ranking of the 3 projects in order of preference would then be  
as shown

VISUAL 8

This demonstrates to some extent the "time value of money" concept as  
discussed previously in this lecture.

The smallpox project, although having the lowest absolute benefit of the  
3 projects, still proves the most worthwhile when discounted. simply  
because the benefits occur at an earlier stage than the other 2.

The exact opposite is then true for the project MG.

In order to demonstrate how to evaluate the absolute worth of a project in  
more detail, we could consider any one of the proposed projects again as shown

VISUAL 9

VISUAL 10

This shows that the absolute return of this project is 23,3%. in other words: this project would be profitable for all interest rates of loans for funding lower than 23,3% (The "Break-Even" point).

4. FINAL NOTE

Finally a word of caution related to the strict application of Benefit/Cost analysis as sole criterion for decisions.

In the compilation of projections on future monetary streams, one should not forget that:

VISUAL 11

It should also be stressed that any decision about investments must in the last analysis be based on as complete a consideration of all the relevant factors as it is possible to provide, and that the calculated present value of a project proposal is only one of two equally important factors which must be considered in arriving at a final decision.

The other factor is the effect of risk and uncertainty, which will be dealt with in some detail in the following lecture.

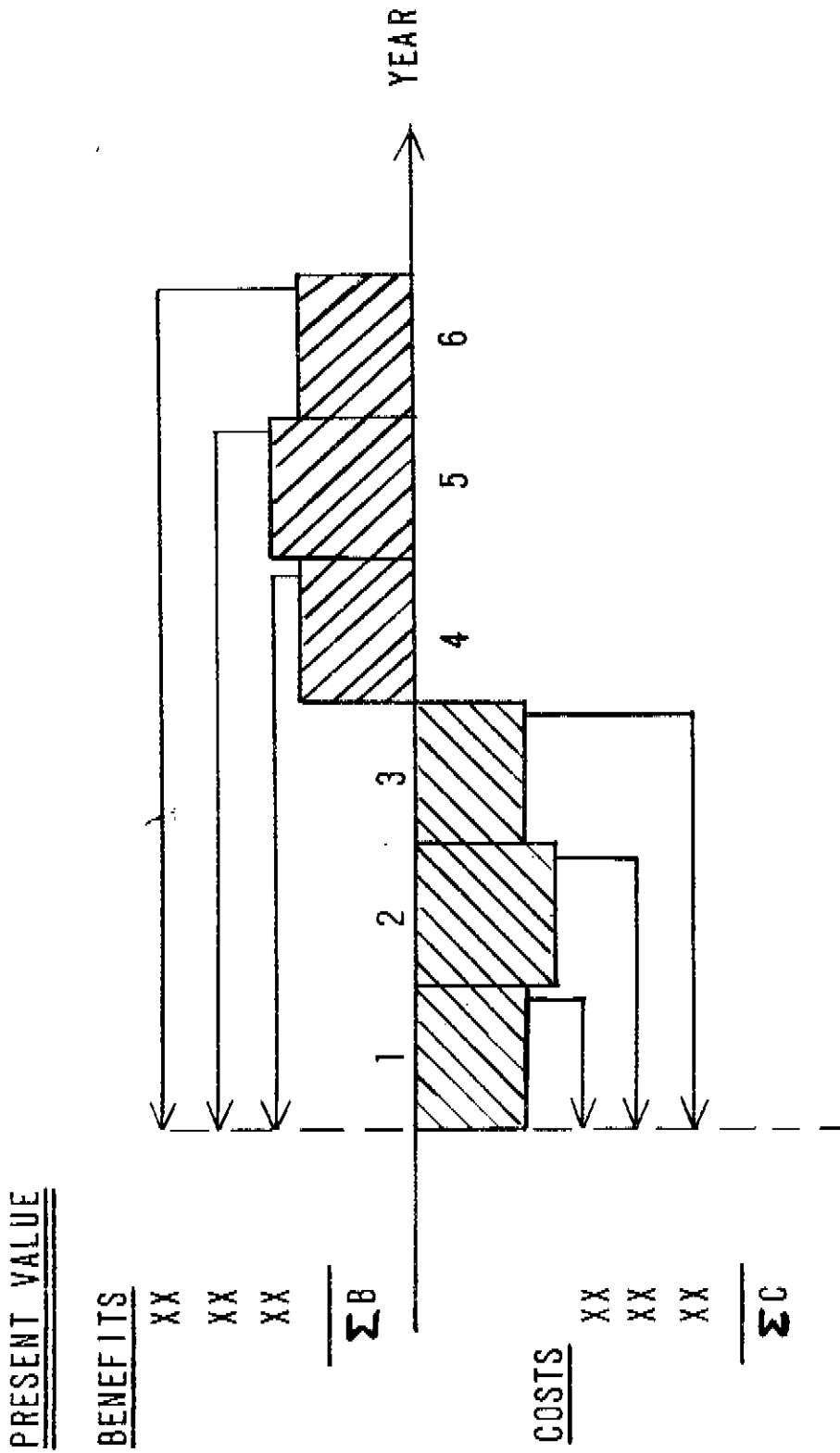
Sirs:

The Indian who sold Manhattan for \$24.00 was a sharp salesman. If he had put his \$24.00 away at 6% compounded semiannually, it would now be \$9.5 billion and could buy most of the now-improved land back.

S. BRANCH WALKER

Stamford, Conn.

- (Life, Aug.31 1959)



Step 1: The present values of the benefit and cost streams are discounted to time zero

$$(V_0 = \frac{V_n}{(1+r)^n})$$

Step 2: The net present value is calculated ( $\Sigma B - \Sigma C$ )

THE INTERNAL DISCOUNT RATES OF SOME AGENCIES

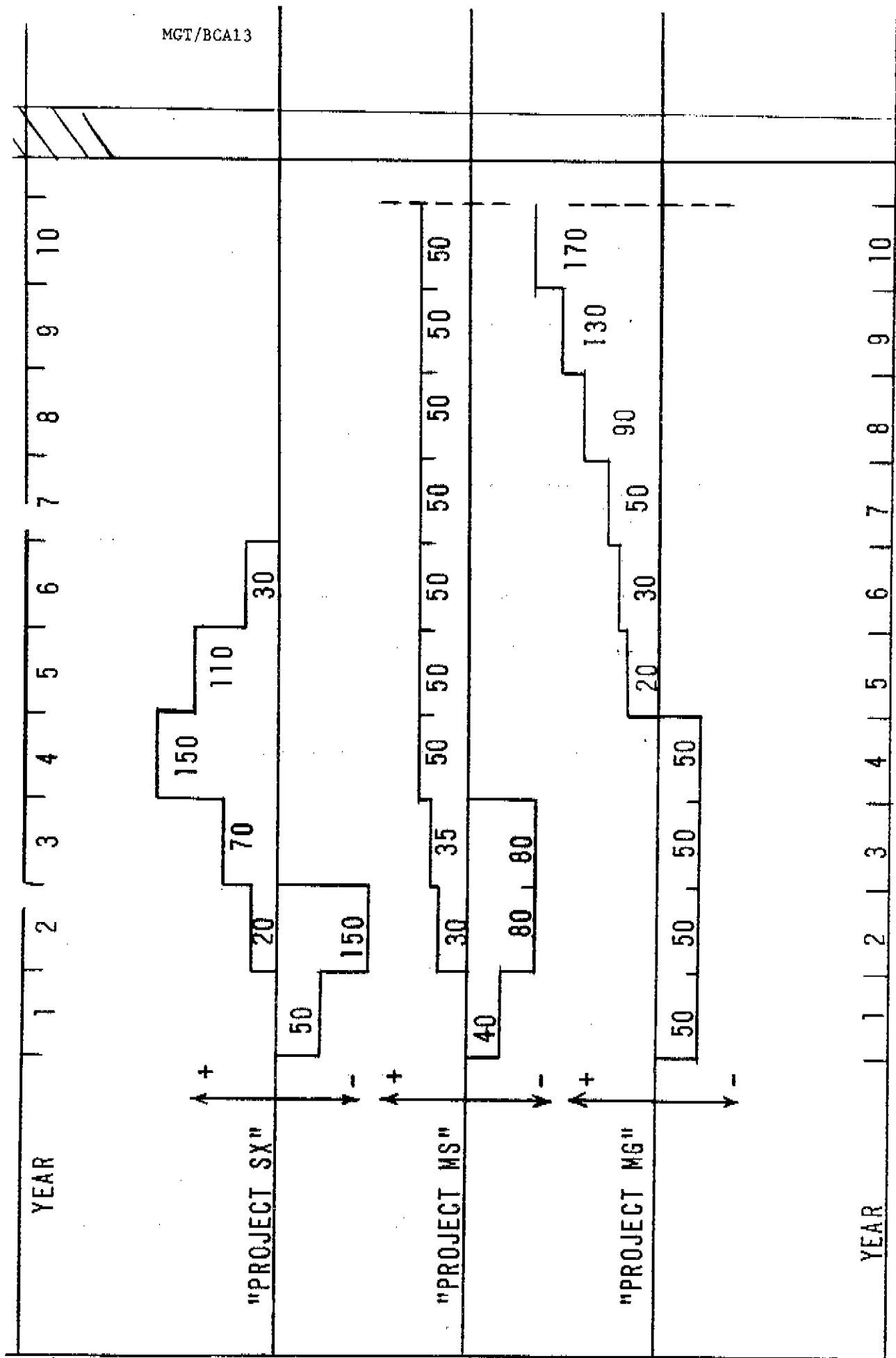
	<u>r</u>
MINISTRY OF TRANSPORT (England)	10-12%
NATIONAL ROAD BOARD (Sweden)	9%
MINISTRY OF PUBLIC WORKS (Mexico)	12%
WORLD BANK	8%

TABLE A  
PRESENT VALUE OF \$1

Year Hence	1%	2%	4%	6%	8%	10%	12%	14%	15%	16%	18%	20%	22%	24%	25%	26%	28%	30%	35%	40%	45%	50%
1	0.990	0.980	0.962	0.943	0.926	0.909	0.893	0.877	0.870	0.862	0.847	0.833	0.820	0.806	0.800	0.794	0.781	0.769	0.741	0.714	0.690	0.667
2	0.980	0.961	0.925	0.890	0.857	0.826	0.797	0.769	0.756	0.743	0.718	0.694	0.672	0.650	0.640	0.630	0.610	0.592	0.549	0.510	0.476	0.444
3	0.971	0.942	0.889	0.840	0.794	0.751	0.712	0.675	0.658	0.643	0.609	0.579	0.551	0.524	0.510	0.500	0.477	0.455	0.406	0.364	0.328	0.296
4	0.961	0.924	0.855	0.792	0.735	0.683	0.636	0.592	0.572	0.552	0.516	0.482	0.451	0.423	0.410	0.397	0.373	0.350	0.301	0.260	0.226	0.198
5	0.951	0.906	0.822	0.747	0.681	0.621	0.567	0.519	0.497	0.476	0.437	0.402	0.370	0.341	0.328	0.315	0.291	0.269	0.223	0.186	0.156	0.132
6	0.942	0.888	0.790	0.705	0.630	0.564	0.507	0.456	0.432	0.410	0.370	0.335	0.303	0.275	0.262	0.250	0.227	0.207	0.165	0.133	0.108	0.088
7	0.933	0.871	0.760	0.665	0.583	0.513	0.452	0.400	0.376	0.354	0.314	0.279	0.249	0.222	0.210	0.198	0.178	0.159	0.122	0.095	0.074	0.059
8	0.923	0.853	0.731	0.627	0.540	0.467	0.404	0.351	0.327	0.305	0.266	0.233	0.204	0.179	0.168	0.157	0.139	0.123	0.091	0.068	0.051	0.039
9	0.914	0.837	0.703	0.592	0.500	0.424	0.361	0.308	0.284	0.263	0.225	0.194	0.167	0.144	0.134	0.125	0.108	0.094	0.067	0.048	0.035	0.026
10	0.905	0.820	0.676	0.558	0.463	0.386	0.322	0.270	0.247	0.227	0.191	0.162	0.137	0.116	0.107	0.099	0.085	0.073	0.050	0.035	0.024	0.017
11	0.896	0.804	0.650	0.527	0.429	0.350	0.287	0.237	0.215	0.195	0.162	0.135	0.112	0.094	0.086	0.079	0.066	0.056	0.037	0.025	0.017	0.012
12	0.887	0.788	0.625	0.497	0.397	0.319	0.257	0.207	0.187	0.168	0.137	0.112	0.092	0.076	0.069	0.062	0.052	0.043	0.027	0.018	0.012	0.008
13	0.879	0.773	0.601	0.469	0.368	0.290	0.229	0.182	0.163	0.145	0.116	0.093	0.075	0.061	0.055	0.050	0.040	0.033	0.020	0.013	0.008	0.005
14	0.870	0.758	0.577	0.442	0.340	0.263	0.205	0.160	0.141	0.125	0.099	0.078	0.062	0.049	0.044	0.039	0.032	0.025	0.015	0.009	0.006	0.003
15	0.861	0.743	0.555	0.417	0.315	0.239	0.183	0.140	0.123	0.108	0.084	0.065	0.051	0.040	0.035	0.031	0.025	0.020	0.011	0.006	0.004	0.002
16	0.853	0.728	0.534	0.394	0.292	0.218	0.163	0.123	0.107	0.093	0.071	0.054	0.042	0.032	0.028	0.025	0.019	0.015	0.008	0.005	0.003	0.002
17	0.844	0.714	0.513	0.371	0.270	0.198	0.146	0.108	0.093	0.080	0.060	0.045	0.034	0.026	0.023	0.020	0.015	0.012	0.006	0.003	0.002	0.001
18	0.836	0.700	0.494	0.350	0.250	0.180	0.130	0.095	0.081	0.069	0.051	0.038	0.028	0.021	0.018	0.016	0.012	0.009	0.005	0.002	0.001	0.001
19	0.828	0.686	0.475	0.331	0.232	0.164	0.116	0.083	0.070	0.060	0.043	0.031	0.023	0.017	0.014	0.012	0.009	0.007	0.003	0.002	0.001	0.001
20	0.820	0.673	0.456	0.312	0.215	0.149	0.104	0.073	0.061	0.051	0.037	0.026	0.019	0.014	0.012	0.010	0.007	0.005	0.002	0.001	0.001	0.001
21	0.811	0.660	0.439	0.294	0.199	0.135	0.093	0.064	0.053	0.044	0.031	0.022	0.015	0.011	0.009	0.008	0.006	0.004	0.002	0.001	0.001	0.001
22	0.803	0.647	0.422	0.278	0.184	0.123	0.083	0.056	0.046	0.038	0.026	0.018	0.013	0.009	0.007	0.006	0.004	0.003	0.001	0.001	0.001	0.001
23	0.795	0.634	0.406	0.262	0.170	0.112	0.074	0.049	0.040	0.033	0.022	0.015	0.010	0.007	0.006	0.005	0.003	0.002	0.001	0.001	0.001	0.001
24	0.788	0.622	0.390	0.247	0.158	0.102	0.066	0.043	0.035	0.028	0.019	0.013	0.008	0.006	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0.001
25	0.780	0.610	0.375	0.233	0.146	0.092	0.059	0.038	0.030	0.024	0.016	0.010	0.007	0.005	0.004	0.003	0.002	0.001	0.001	0.001	0.001	0.001
26	0.772	0.598	0.361	0.220	0.135	0.084	0.053	0.033	0.026	0.021	0.014	0.009	0.006	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001
27	0.764	0.586	0.347	0.207	0.125	0.076	0.047	0.029	0.023	0.018	0.011	0.007	0.005	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
28	0.757	0.574	0.333	0.196	0.116	0.069	0.042	0.026	0.020	0.016	0.010	0.006	0.004	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
29	0.749	0.563	0.321	0.185	0.107	0.063	0.037	0.022	0.017	0.014	0.008	0.005	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
30	0.742	0.552	0.308	0.174	0.099	0.057	0.033	0.020	0.015	0.012	0.007	0.004	0.003	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
40	0.672	0.453	0.208	0.097	0.046	0.022	0.011	0.005	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
50	0.608	0.372	0.141	0.054	0.021	0.009	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

TABLE B  
PRESENT VALUE OF \$1 RECEIVED ANNUALLY FOR N YEARS

Years (N)	1%	2%	4%	6%	8%	10%	12%	14%	15%	16%	18%	20%	22%	24%	25%	26%	28%	30%	35%	40%	45%	50%
1	0.990	0.980	0.962	0.943	0.926	0.909	0.893	0.877	0.870	0.862	0.847	0.833	0.820	0.806	0.800	0.794	0.781	0.769	0.741	0.714	0.690	0.667
2	1.970	1.942	1.886	1.833	1.783	1.736	1.690	1.647	1.626	1.605	1.566	1.528	1.492	1.457	1.440	1.424	1.392	1.361	1.289	1.224	1.165	1.111
3	2.941	2.884	2.775	2.673	2.577	2.487	2.402	2.322	2.283	2.246	2.174	2.106	2.042	1.981	1.952	1.923	1.868	1.816	1.696	1.589	1.493	1.407
4	3.902	3.808	3.630	3.465	3.312	3.170	3.037	2.914	2.855	2.798	2.690	2.589	2.494	2.404	2.362	2.320	2.241	2.166	1.997	1.849	1.720	1.605
5	4.853	4.713	4.452	4.212	3.993	3.791	3.605	3.433	3.352	3.274	3.127	2.991	2.864	2.745	2.689	2.635	2.532	2.436	2.220	2.035	1.876	1.737
6	5.795	5.601	5.242	4.917	4.623	4.355	4.111	3.889	3.784	3.685	3.498	3.326	3.167	3.020	2.951	2.885	2.759	2.643	2.385	2.168	1.983	1.824
7	6.728	6.472	6.002	5.582	5.206	4.868	4.564	4.288	4.160	4.039	3.812	3.605	3.416	3.242	3.161	3.083	2.937	2.802	2.508	2.263	2.057	1.883
8	7.652	7.325	6.733	6.210	5.747	5.335	4.968	4.639	4.487	4.344	4.078	3.837	3.619	3.421	3.329	3.241	3.076	2.925	2.598	2.331	2.108	1.922
9	8.566	8.162	7.435	6.802	6.247	5.759	5.328	4.946	4.772	4.607	4.303	4.031	3.786	3.566	3.463	3.366	3.184	3.019	2.665	2.379	2.144	1.948
10	9.471	8.983	8.111	7.360	6.710	6.145	5.650	5.216	5.019	4.833	4.494	4.192	3.923	3.682	3.571	3.465	3.269	3.092	2.715	2.414	2.168	1.965
11	10.368	9.787	8.760	7.887	7.139	6.495	5.937	5.453	5.234	5.029	4.656	4.327	4.035	3.776	3.656	3.544	3.335	3.147	2.752	2.438	2.185	1.977
12	11.255	10.575	9.385	8.384	7.536	6.814	6.194	5.660	5.421	5.197	4.793	4.439	4.127	3.851	3.725	3.606	3.387	3.190	2.779	2.456	2.196	1.985
13	12.134	11.343	9.986	8.853	7.904	7.103	6.424	5.842	5.583	5.342	4.910	4.533	4.203	3.912	3.780	3.656	3.427	3.223	2.799	2.468	2.204	1.990
14	13.004	12.106	10.563	9.295	8.244	7.367	6.628	6.002	5.724	5.468	5.008	4.611	4.265	3.962	3.824	3.695	3.459	3.249	2.814	2.477	2.210	1.993
15	13.865	12.849	11.118	9.712	8.559	7.606	6.811	6.142	5.847	5.575	5.092	4.675	4.315	4.001	3.859	3.726	3.483	3.268	2.825	2.484	2.214	1.995
16	14.718	13.578	11.652	10.106	8.851	7.824	6.974	6.265	5.954	5.669	5.162	4.730	4.357	4.033	3.887	3.751	3.503	3.283	2.834	2.489	2.216	1.997
17	15.562	14.292	12.166	10.477	9.122	8.022	7.120	6.373	6.047	5.749	5.222	4.775	4.391	4.059	3.910	3.771	3.518	3.295	2.840	2.492	2.218	1.998
18	16.398	14.992	12.659	10.828	9.372	8.201	7.250	6.467	6.128	5.818	5.273	4.812	4.419	4.080	3.928	3.786	3.529	3.304	2.844	2.494	2.219	1.999
19	17.226	15.678	13.134	11.158	9.604	8.365	7.366	6.550	6.198	5.877	5.316	4.844	4.442	4.097	3.942	3.799	3.539	3.311	2.848	2.496	2.220	1.999
20	18.046	16.351	13.590	11.470	9.818	8.514	7.469	6.623	6.259	5.929	5.353	4.870	4.460	4.110	3.954	3.808	3.546	3.316	2.850	2.497	2.221	1.999
21	18.857	17.011	14.029	11.764	10.017	8.649	7.562	6.687	6.312	5.973	5.384	4.891	4.476	4.121	3.963	3.816	3.551	3.320	2.852	2.498	2.221	2.000
22	19.660	17.658	14.451	12.042	10.201	8.772	7.645	6.743	6.359	6.011	5.410	4.909	4.488	4.130	3.970	3.822	3.556	3.323	2.853	2.498	2.222	2.000
23	20.456	18.292	14.857	12.303	10.371	8.883	7.718	6.792	6.399	6.044	5.432	4.925	4.499	4.137	3.976	3.827	3.559	3.325	2.854	2.499	2.222	2.000
24	21.243	18.914	15.247	12.550	10.529	8.985	7.784	6.835	6.434	6.073	5.451	4.937	4.507	4.143	3.981	3.831	3.562	3.327	2.855	2.499	2.222	2.000
25	22.023	19.523	15.622	12.783	10.675	9.077	7.843	6.873	6.464	6.097	5.467	4.948	4.514	4.147	3.985	3.834	3.564	3.329	2.856	2.499	2.222	2.000
26	22.795	20.121	15.983	13.003	10.810	9.161	7.896	6.906	6.491	6.118	5.480	4.956	4.520	4.151	3.988	3.837	3.566	3.330	2.856	2.500	2.222	2.000
27	23.560	20.707	16.330	13.211	10.935	9.237	7.943	6.935	6.514	6.136	5.492	4.964	4.524	4.154	3.990	3.839	3.567	3.331	2.856	2.500	2.222	2.000
28	24.316	21.281	16.663	13.406	11.051	9.307	7.984	6.961	6.534	6.152	5.502	4.970	4.528	4.157	3.992	3.840	3.568	3.331	2.857	2.500	2.222	2.000
29	25.066	21.844	16.984	13.591	11.158	9.370	8.022	6.983	6.551	6.166	5.510	4.975	4.531	4.159	3.994	3.841	3.569	3.332	2.857	2.500	2.222	2.000
30	25.808	22.396	17.292	13.765	11.258	9.427	8.055	7.003	6.566	6.177	5.517	4.979	4.534	4.160	3.995	3.842	3.569	3.332	2.857	2.500	2.222	2.000
40	32.835	27.355	19.793	15.046	11.925	9.779	8.244	7.105	6.642	6.234	5.548	4.997	4.544	4.166	3.999	3.846	3.571	3.333	2.857	2.500	2.222	2.000
50	39.196	31.424	21.482	15.762	12.234	9.915	8.304	7.133	6.661	6.246	5.554	4.999	4.545	4.167	4.000	3.846	3.571	3.333	2.857	2.500	2.222	2.000



CALCULATION OF NET PRESENT VALUE AND B/C RATIO

YEAR	PVF*
n	r = 8%
1	0.93
2	.86
3	.79
4	.74
5	.68
6	.63
7	.58
8	.54
9	.50
10	.46

UNDISCOUNTED AND PRESENT VALUES

PROJECT SX			
BENEFITS		COSTS	
0%	8%	0%	8%
20	17.2	50	46.5
70	55.3	150	129.0
150	111.0		
110	74.8		
30	18.9		
380	277.2	200	175.5

PROJECT MS			
BENEFITS		COSTS	
0%	8%	0%	8%
30	25.8	40	37.2
35	27.7	80	68.8
50	37.0	80	63.2
50	34.0		
50	31.5		
50	29.0		
50	27.0		
50	25.0		
50	23.0		
415	260.0	200	169.2

PROJECT MG			
BENEFITS		COSTS	
0%	8%	0%	8%
20	13.6	50	46.5
30	18.9	50	43.0
50	29.0	50	39.5
90	48.6	50	37.0
130	65.0		
170	78.2		
490	253.3	200	166.0

\* PRESENT VALUE FACTOR =

$$= \frac{1}{(1 + r)^n}$$

	NET PRESENT VALUE	BENEFIT/COST RATIO
PROJECT SX	277.2 - 175.5 = 101.7	277.2 / 175.5 = 1.58 (1)
PROJECT MS	260.0 - 169.2 = 90.8	260.0 / 169.2 = 1.54 (2)
PROJECT MG	253.3 - 166.0 = 87.3	253.3 / 166.0 = 1.53 (3)

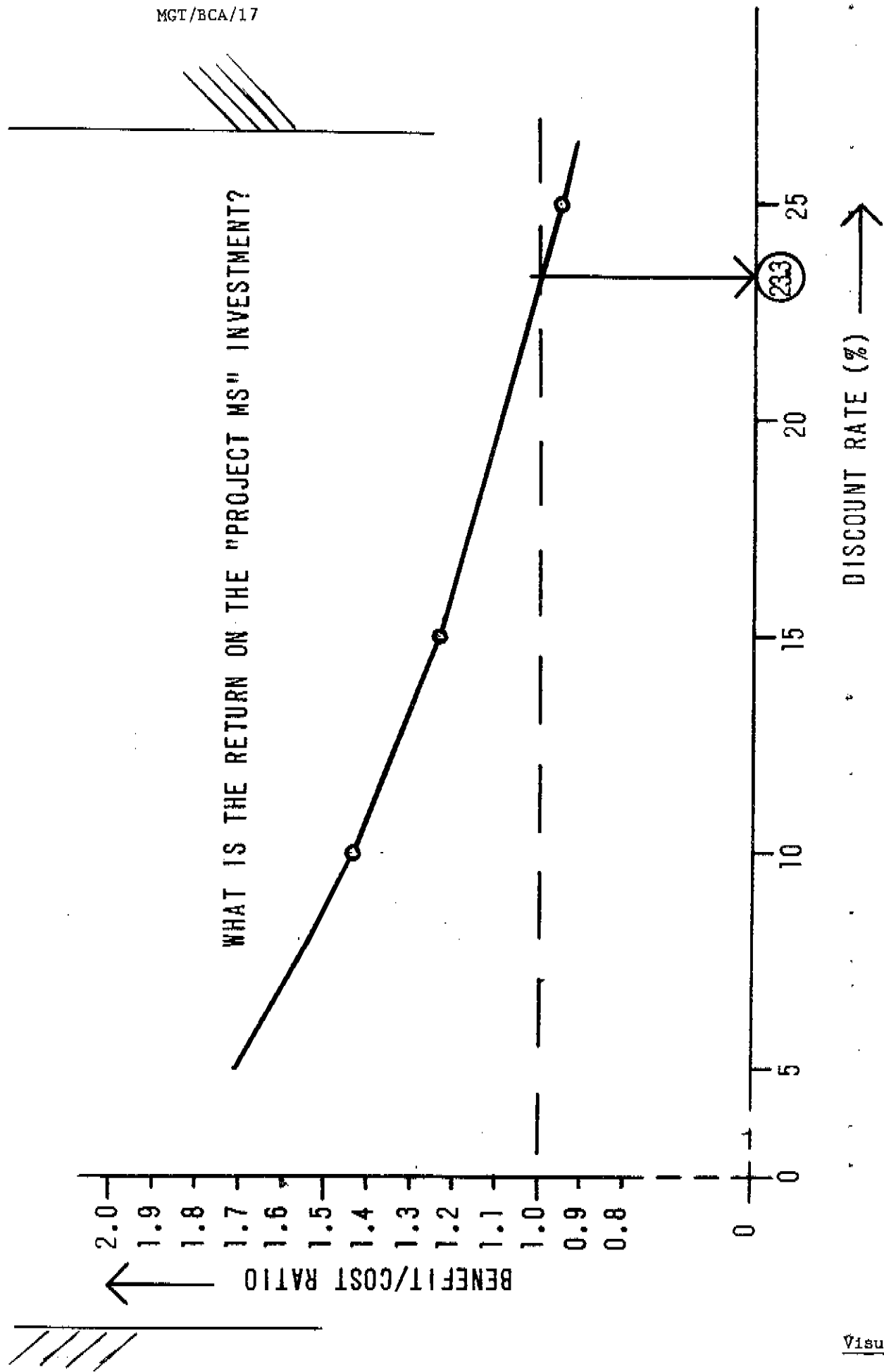
PROJECT	UNDISCOUNTED EVALUATION		B/C ANALYSIS AT 8%	
	BENEFITS-COSTS	RANK OF PREFERENCE	NPV	RANK OF PREFERENCE
SX	\$ 180,000	3	\$ 101,700	1
MS	215,000	2	90,800	2
MG	290,000	1	87,300	3

CALCULATION OF B/C RATIOS AT DIFFERENT DISCOUNT RATES

YEAR	PRESENT VALUE FACTOR			PROJECT MS							
				BENEFITS			COSTS				
	10%	15%	25%	0%	10%	15%	25%	0%	10%	15%	25%
1	0.91	0.87	0.80	30	24.9	22.8	19.2	40	36.4	34.8	32.0
2	0.83	0.76	0.64	35	26.3	23.1	17.9	80	66.4	60.8	51.2
3	0.75	0.66	0.51	50	34.0	28.5	20.5	80	60.0	52.8	40.8
4	0.68	0.57	0.41	50	31.0	25.0	16.5				
5	0.62	0.50	0.33	50	28.0	21.5	13.0				
6	0.56	0.43	0.26	50	25.5	19.0	10.5				
7	0.51	0.38	0.21	50	23.5	16.5	8.5				
8	0.47	0.33	0.17	50	21.0	14.0	6.5				
9	0.42	0.28	0.13	50	19.5	12.5	5.5				
10	0.39	0.25	0.11								
					233.7	182.9	118.1		162.8	148.4	124.0

PRESENT VALUE →

	BENEFIT/COST RATIO
10%	233.7/162.8 = 1.44
15%	182.9/148.4 = 1.23
25%	118.1/124.0 = 0.95



The strict application of economic criteria tends to favour:

- educated over non-educated
- rich over poor
- young over old
- short run over long run services
- treatment of acute illness over chronic illness.