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HISTORICAL RETURN ON INVESTMENTS FOR LARGE INDUSTRIAL COMPANIES IN BASIC INDUSTRIES IN THE U.S.A

by

OFER DRESSLER

A dissertation submitted to the graduate faculty in engineering in partial fulfillment of the requirments of Philosophy, The City University of New York.

1985

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Abstract

HISTORICAL RETURN ON INVESTMENTS FOR LARGE INDUSTRIAL COMPANIES IN BASIC INDUSTRIES IN THE U.S.A.

by

Ofer Dressler

Adviser: Professor Reuel Shinnar

Investment decisions are difficult economic decisions as those involving the choice between present and future consumption. In order to guarantee the consumption growth in the future, a growth of capital investment and R&D spending is necessary today. However, in the last twenty years, the growth of capital spending in plant, equipment and R&D has slowed (5).

Most of the large companies are using the discounted cash flow method in their capital budgeting process. In such as analysis, it is highly important to know what rate of return can a company expect to get back on its investments. It is shown that for many of the companies the historic rate of after-tax return on their investment ranged between 3-7%. It is much less than managers are using in their investment decisions. That by itself contributes to a decreased willingness to invest.

However, in order to obtain the historical return on capital invested by a company, none of the methods can be applied. For a single investment we know (assume) an exact cash flow generated by the investment and the investment's lifetime. But in the case of a company, the cash flow and the investment's lifetime are not so easy to detect. In addition, the profitability measures are known to have disadvantages. These depend on accounting rules which in many cases can give an improper picture of the company.

In order to explore the real rate of return on company investments we, therefore, derived a new method. The data base for our research includes twenty three of the larger American corporations. They represent chemical, oil, steel, aluminum consumer products, rubber and paper industries. The data have been collected from the companies' financial reports issued during the period between 1935-1982.

In the last few years inflation has increased to above 10%. Companies have therefore increased their expected rate of return. The effect of inflation on the basic industry is analyzed. It is shown that in basic, capital inteansive industries inflation has an autocatalytic or self-accelerating effect nature.

The inflationary forces that arise from using high expected rate of return reveal another important aspect of the real historic rate of returns obtained in Part I.

להורי

אשר בעמלם הרב
הקנו את היסודות

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PART I

HISTORICAL RETURN ON INVESTMENTS FOR LARGE INDUSTRIAL COMPANIES IN BASIC INDUSTRIES

1. Introduction (Part I)

Estimates of the probable rate of return (ROR) on investments have become an increasingly important tool in planning investment strategies (Ref. 5). These estimates are compared to desired minimum yields and are then used to decide whether projects merit further development or not. These methods are of particular importance today, when the real inflation adjusted cost of money is high and therefore the ROR must be substantial to be profitable. The discounted cash flow method used in such estimates is well known and can be found in any standard textbook. This thesis (Part I) is concerned with analyzing the historial inflation adjusted ROR in capital intensive basic industries such as oil, steel and chemicals.

For cash instruments such as bonds, which are single investments with a known finite life, precise historical data are relatively easy to obtain. Ibbotson has analyzed this problem and has shown that the average pretax inflation adjusted yield of corporate bonds between 1926 and 1978 was 1.3% (Ref. 1). Analyzing the historial ROR for basic industry is more complex as one is seldom dealing with single isolated investments with a finite life and even then the data are not often publicly available. However, large industrial companies registered on the stock exchange have to file each year detailed statements of their earnings, investments and other financial data, such as debts, interest paid, etc. Such data are available since 1931. It will be shown here that for a large class of companies, these data allow one to get an upper and a lower bound for the average historic return on their investments. For companies which had a steady growth and performance, these estimates can be shown to be quite accurate, and the bounds are quite narrow. Many of the leading companies in the chemical and oil industries fall into this category. For the majority of those the historic internal rate of after-tax return on their investment ranged between 3-7%. The methods by which one can obtain these estimates and their accuracy are presented and discussed in Part I.

These estimates for historical inflation adjusted ROR are not average across all industries but for selected large companies which were among the most successful in their fields. The historic estimates of ROR are considerably lower than the criteria used by many companies to justify new investments. It will be shown that some of the current criteria for expected ROR sufficient to justify new investment are unrealistic in terms of historical yields. It is hoped that these results will be useful for the engineer, economist and business manager involved in evaluating new processes, plants and other investment decisions in industry. The fact that the present inflation (1982-1984) adjusted interest rates are higher than historic inflation adjusted returns of our more successful basic industries should also cause concern.

2. ROR Based on Capital Recovery Factor - Methodology

2.1 Definition of terms

Return on investment calculations vary from one industry to another and depend strongly on tax treatment and on methods of financing. They differ widely for various projects and enterprises. Such details are too complex and largely unavailable. However, it is possible to obtain from the data published in the financial reports of the companies a reasonable bound on the average after-tax return on the investment. Here, an estimation of the after-tax return generated by the total investment (depreciable, nondepreciable plus working capital) is given. In these calculations it is assumed that earnings that are used to pay interest on long term debts are considered part of the return on the investment as the bank and/or bondholder can be thought of as partners in the investment. This assumption is necessary as the return on the reported investment is to be estimated, and the interest paid is generated by this investment. Neglecting it would underestimate the ROR. The cost of money will clearly affect the decision on whether a project with a given ROR is profitable, but here we are not concerned with venture analysis but with the historic ROR of an investment.

The rate of return (ROR) on an industrial investment is defined in this work according to the discounted cash flow methods. For a given investment, compute or estimate the yearly net cash flow over the life of the project. One then finds a discount rate that applies equally to each yearly cash flow, such that the total sum of all the discounted cash flows over the life of the investment equals the initial investment in the year zero. This discount rate is defined as the rate of return (ROR) of the industrial investment. This ROR can be computed either in constant (inflation adjusted) or current (not inflation adjusted) dollars. The net cash flow includes net profit after taxes plus depreciation. The estimate of the net cash flow itself will strongly depend on the tax laws. But if the actual net cash flow is known, the ROR can be computed without taking taxes into account. Some recent papers (2) change the name of ROR to IRR (internal rate of return). In the context of this work these two concepts are identical. The estimation of the actual historic ROR obtained after taxes by specific companies will be given. The analysis will be done both in constant and current dollars (no adjustment for inflation), but will concentrate on inflation adjusted (constant dollar) rate of returns.

For many years, the ROR was computed by assuming that all prices, costs, and expenses were going to stay constant during the life of a project. This is equivalent to computing the ROR on a constant dollar basis. It has become common to compute an ROR in current dollars, estimating future income and costs by assuming an inflation rate. Of course, the ROR computed is then higher. The constant dollar approach is best suited for purposes of computing and comparing historic RORs on the investments of companies in basic industries. To use it, net cash flows and investment for past years have been adjusted for inflation to a common year, 1981. The conclusions of the analysis, however, are not changed if the current dollar approach is used. Examples of current dollar estimates have been included for illustration.

Before proceeding further, it may be worth distinguishing between return on equity reported in annual reports and return on investment as used in this analysis. Return on equity is computed by dividing the net after tax return of a company by its current equity value (i.e. book assets minus liabilities). It is normally reported in current dollars, though recent regulations require companies to also report it with inflation adjustments. Equity depends on accounting practice in determining book assets. These book assets are usually different than the sum of past investments used in ROR analysis. Within the scope of accounting practice, a company with an after tax ROR of 5% can show a return on equity ranging from 6-15% depending on the ratio of the real lifetime of its projects to the rate at which they are depreciated and on the way the projects are financed. The rate of return is dependent upon the lifetime of an investment. The lifetime of plants in heavy industry is often much longer than the period used to depreciate them. When the engineer or accountant, years ago, analyzed a new petroleum refinery he may have estimated 20 years as its lifetime and used a 20 year depreciation. In reality that refinery often operated for 50 years. Its real ROR was, therefore, different from his initial "forward" estimate. This analysis is concerned not with such forward estimates, but with a "backward" estimate that includes a more real lifetime.

This method is also different from most investment analyses which include taxes in their cash flows and use the maximum depreciation rates permitted by tax law. In the sense used in this analysis, depreciation corresponds to sums set aside to replace capitalized equipment that is physically depreciating. A corporation net-outs each year a reportable net profit plus the sum set aside for replacement or reinvestment. By using after tax values, confusion with tax law depreciation is avoided. Moreover, it is then the real lifetime of the investment rather than the arbitrary rate of tax depreciation which influences the ROR.

2.2 Methodology

The method will first be presented in a simplified form that allows reasonable estimates of ROR. A more complete analysis of the method including a discussion of its accuracy and the underlying assumptions and problems inherent in the technique will be found in Chapter 5. It is necessary to emphasize from the outset that, although the ROR estimated by that method is conceptually identical to the one used by the engineer in investment computations, there is a basic difference between them. The engineer in investment analysis is trying to make assumptions about the lifetime of the plant or project, the income generated, etc. This shall be termed a forward estimate. On the other hand in the following method an estimation of the actual historical returns is given, a method which will be termed the backward estimate.

Let us begin with the simpler task of estimating the actual historic cost of money for an industrial company. This is equal to the ROR of an industrial bond. For this, there are accurate historic data. There are several numbers that can be quoted here. The first is the interest rate of the bond in current dollars at the year of issue. This is given in Fig. 1 curve A for Aaa bonds from 1935 till the present. As these interest rates are strongly correlated with inflation, (1), it makes sense to relate them to the inflation rate in the year of their issue. If one assumes that inflation will remain constant over the life of the bond, then one can estimate the future inflation free rate of return by

ROR forward estimate (constant dollars) =

$$= \frac{1+r}{1+i} - 1 \qquad (1)$$

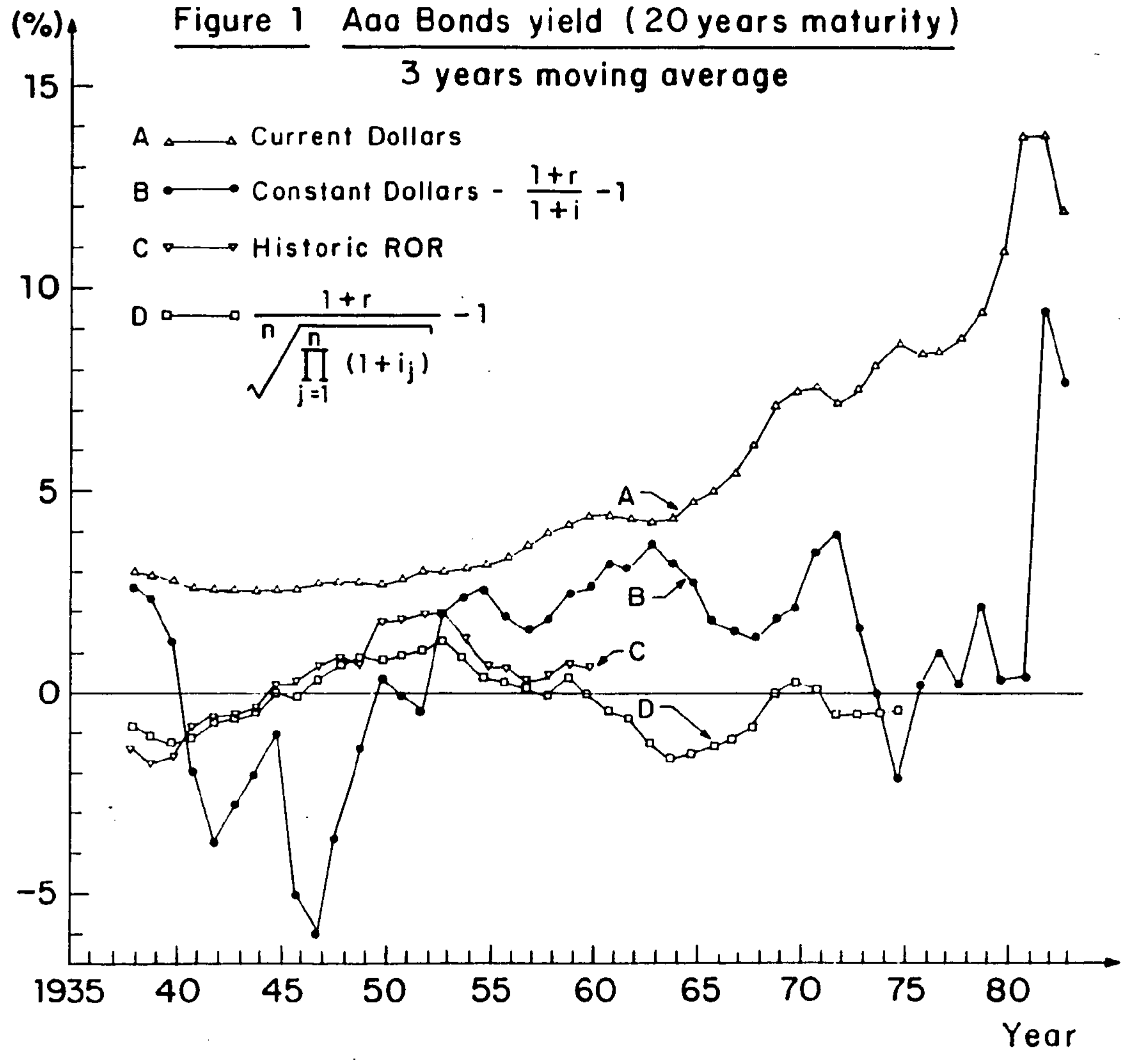

Figure 1 Aaa Bonds yield (20 years maturity) 3 years moving average

where r = the interest rate in the year of issue and i the inflation rate in the same year. This estimate is plotted in curve B. The ROR computed by Eq. 1 assumes that the inflation rate is constant over the life of the bond. For the last twenty years this would not have been a good assumption.

For bonds for which the lifetime expired, one can compute the actual historic return in constant dollars. This is done by taking the interest payment in each year as well as the final payment at redemption, adjust them for the cost index of that year and then compute the ROR at which the discounted value of all these payments is equal to the initial value. Let us designate the fraction of the bond that is repaid in constant dollars in year j as CRF_j, then the correct historic ROR is given by the equation:

$$-1 + \sum_{j=1}^{n} CRF_j / (1+r)^j = 0 \tag{2}$$

where r is the decimal fraction ROR and n is the lifetime of the bound (number of years till maturity). This is shown in curve C. Note that for most of the years, the actual return was lower than curve B, which was predicted by Eq. 1. Due to the rising inflation rate in the late sixties and seventies, the average historic cost of money for industry before taxes was low for the years for which we have complete data*.

There is a simplified way in which we can get an approximate estimate of this historic return. This is given by

$$\text{ROR(historic)} = \frac{1+r}{\sqrt[n]{\prod_{j=1}^{n}(1+i_j)}} - 1 \tag{3}$$

where $\sqrt[n]{\prod_{j=1}^{n}(1+i_j)}$ is the geometric average of the inflation rate over the time of the project. The approximate estimate of ROR (historic) is given in curve D. Note it is reasonably close to curve C. Curve C gives the accurate return, while curve D is an approximation. In the real return it is

---

*The average inflation adjusted ROR in curve C is lower than the rate reported by Ibbotson (1). Ibbotson computes the return obatained by an investor who constantly reinvests the dividends in new bonds. If inflation rate increases the reinvested dividends benefit from higher interest rates.

important when inflation occurred. In Eq. 3 this has no effect. However, the simplified method has one advantage - it allows one to estimate the historic cost of the money over a period before the bond expires. Eq. (3) can be used to compute the geometric average of the inflation rate for the period that expired. Since the inflation rate over the rest of the life of the bond is not known, this is still only an estimate. However, it is a better estimate than
Eq. 1.

Curve D is therefore continued till 1978 (dotted curve for incomplete estimate).

There are many difficulties, however, while applying a similar approach to an industrial company. The available data give yearly investments and also give the yearly net cash flow. The latter is equal to the net profit plus the depreciation plus the interest paid to bondholders, which are partners in the investment. A typical example of the data available from annual reports as given in Table 2 for Exxon. In Table 3, the same data converted to constant dollars are presented. However, there is no easily available data on the real life of the investment or on which investment generated which cash flow.

To describe the analysis, it is instructive to look at some properties of the discounted cash flow rate of return (ROR). Consider a simple equity investment whose amount is adjusted (for inflation, interest, etc.) to a zeroth year. Each year the investment produces a net cash flow after taxes. If each year's net cash flow is divided by the initial investment, a quantity called capital recovery factor, CRF, results. This is shown in Eq. (4).

$$CRF_{(\text{year } j)} = \frac{(\text{net income} + \text{depreciation}) \text{ in year } j}{\text{initial investment}} \qquad (4)$$

Note that as described above, the net cash flow is the sum of net income plus funds set aside for depreciation. The ROR for this simple investment is given by

$$-1 + \sum_{j=1}^{n} (CRF_{(\text{year } j)} / (1+r)^j = 0 \qquad (2)$$

where: n - investment lifetime

r - decimal fraction ROR

In the general case, the CRF can be expected to vary from year to year over the lifetime of an investment. There is a special subcase often used in investment analysis in which the CRF is assumed to be constant. For this special case there is a simple relationship between the CRF, ROR and the investment lifetime which is given by

$$CRF = ROR\ (1 - \frac{1}{(1 + ROR)^n}) \tag{2a}$$

where n is the lifetime of the investment. Thus, if one assumes a constant CRF and has an estimate of the life of the project (industrial plant, etc.) and the average CRF, then one can estimate the ROR. This relationship is shown in tabular form in Table 1.

Consider now an idealized hypothetical company. The company is assumed to be in a steady state with a constant cash flow. The company also replaces obsolete investments each year with new investments in such a way that the total cash flow remains constant. Let us now further assume that the only available data are the figures shown in Table 4 which would correspond to the company's annual report. To estimate a ROR we have to estimate the life of each single investment and the distribution of the cash flow over this life. The simplest

TABLE 1

R.O.R. Obtained by the D.C.F. Method
Calculated for Different C.R.F. Values
and for Different Project's Lifetime

Life-Time (Years) / C.R.F. (%)	10	15	20	25	35
3	-	-	-	-	0.4
4	-	-	-	0	2.1
5	-	-	0	2	3.7
6	-	-	2	3.5	5
7	-	0.8	3.5	5	6.3
8	-	2.5	5	6.4	7.3
9	-	4.1	6.5	7.5	8.4
10	0	5.6	7.8	8.7	9.5
11	2	7	9	10	10.6
12	3.7	8.4	10.3	11.2	11.6
13	5.3	9.8	11.6	12.4	12.6
14	6.8	11.1	12.8	13.5	13.7
15	8.3	12.4	13.9	14.5	14.7
16	9.8	13.7	15.1	15.6	15.8
17	11.2	14.9	16.1	16.6	16.8
18	12.6	16.0	17.2	17.6	17.9
19	13.4	17.2	18.3	18.8	18.9
20	15.2	18.4	19.4	19.7	19.9

estimate is that the CRF remains constant. Then if we assume an average lifetime n for each investment we obtain

$$(\mathrm{CRF})_j = \frac{\text{TOTAL CASH FLOW IN YEAR } j}{\sum_{K=j-n}^{j-1} (\text{INVESTMENT IN YEAR } K)} \qquad (5)$$

The denominator is simply the sum of all investments in the n years preceding the year for which the CRF is computed. If one knows the CRF over the total life of the investment, one can then compute the ROR using Eq. 2.

For the above hypothetical company, the CRF is assumed constant. Therefore, the ROR is a function of the assumed lifetime n and can be derived from Eq. 5 and Table 1 or Eq. 2a for each n. This is shown in Table 5. Note that n corresponds to the real lifetime of the project and may not be identical to the reported depreciation figures in the annual report which, in general, underestimate n. The ROR (or decimal fraction representation r) shown in Table 5 strongly depends on the assumed n. Thus, the data in the hypothetical annual report in Table 4 would be consistent with many companies with

Table2

EXXON: EXAMPLE OF DATA TAKEN FROM ANNUAL REPORTS IN MILLION DOLLARS (CURRENT)

YEAR	SALES	NET ASSET	NET INCOME	DEPRECIATION	INTEREST	INVESTMENT	EXPLORATION	R.D.	DIVIDENDS	W. CAPITAL
1931	1085	1236	9	109	3	394	99	17	51	587
1933	780	1152	25	105	4	101	25	9	32	407
1935	1076	1095	63	109	3	117	29	8	51	427
1937	1309	1218	145	101	3	286	71	11	66	435
1939	934	1275	89	85	4	150	38	8	52	469
1941	978	1316	141	84	4	161	40	13	68	506
1943	1303	1355	121	95	6	135	24	11	71	586
1945	1636	1540	154	138	5	185	46	19	88	780
1947	3332	1818	268	143	4	426	106	35	138	690
1949	3232	2327	269	184	5	442	110	23	154	847
1951	4269	2979	528	208	11	442	112	38	292	1206
1953	6041	3572	553	269	12	585	161	40	317	1334
1955	6966	4680	709	351	16	690	172	59	382	1642
1957	8509	5756	805	449	18	1131	246	57	486	1761
1959	8714	6688	630	528	26	829	197	48	506	1704
1961	9356	7036	758	546	33	735	133	71	524	1795
1963	11391	7950	1019	584	33	886	204	70	678	1861
1965	13586	8598	973	655	36	971	234	80	679	1830
1967	15873	9375	1155	763	52	1619	206	98	779	2009
1969	18697	10093	1243	857	115	1691	213	102	844	1844
1971	10297	11593	1517	1086	156	1811	193	98	895	2461
1973	28507	13718	2443	1136	188	22910	255	124	1007	3534
1975	48764	16638	2503	1524	266	4500	382	187	1118	4660
1977	57529	19121	3000	1558	312	4600	642	230	1395	4619
1979	83555	22552	4300	2027	390	7300	1052	381	1719	4595
1981	113197	28517	5567	2948	552	11100	1653	630	2594	6105

Table 3

EXXON: EXAMPLE OF DATA TAKEN FROM ANNUAL REPORTS IN MILLIONS OF DOLLARS

INFLATION ADJUSTED TO CONSTANT DOLLARS (USING CONSUMER INDEX)

BASE YEAR 1981

YEAR	SALES	NET (*) ASSET	NET INCOME	DEPRECIATION	INTEREST	INVESTMENT	EXPLORATION	R.D.	DIVIDENDS	(**) W. CAPITAL
1931	8297	9452	67	834	23	3013	757	127	390	3410
1933	5919	8742	190	797	30	766	190	71	243	2364
1935	7722	7858	452	782	22	840	208	58	366	2484
1937	9394	8741	1041	725	22	2052	510	81	474	2530
1939	6648	9075	633	605	28	1068	207	59	370	2728
1941	6041	8128	871	519	25	994	247	80	420	2932
1943	7511	7811	698	548	35	778	138	63	409	3309
1945	8372	7881	788	706	26	947	235	95	450	4196
1947	13916	7593	1119	597	17	1779	43	147	576	3866
1949	13498	9719	1123	768	21	1846	459	98	643	4396
1951	16323	11390	2019	795	42	1690	428	144	1116	5524
1953	22743	13448	2082	1013	45	2206	606	151	1193	5929
1955	25445	17344	2627	1301	59	2557	637	219	1415	6861
1957	30032	20315	2841	1585	67	3992	868	202	1715	7090
1959	29730	22818	2149	1801	89	2828	672	164	1726	6930
1961	31370	23591	2542	1831	111	2666	614	237	1757	6683
1963	37523	26188	3357	1924	109	2919	672	230	2233	6959
1965	42356	26806	3033	2042	112	3027	730	250	2117	6877
1967	45752	27022	3329	2199	150	4667	594	282	2245	7312
1969	49392	26123	3217	2218	298	4377	551	264	2184	6951
1971	49909	27960	3659	2619	375	4368	465	236	2159	8185
1973	58691	28243	5030	2339	387	5991	525	255	2073	10229
1975	83186	28382	4270	2600	454	7676	652	319	1907	11945
1977	87986	29244	4588	2383	477	7035	982	352	2134	11895
1979	103215	27858	5312	2504	482	9018	1300	471	2123	11870
1981	113197	28517	5567	2948	552	11100	1653	630	2594	12936

(*) ASSETS: Annual reports do not give enough data to allow a correct translation to constant dollars.
The value under assets is taken from annual reports and is expressed in 1981 dollars

(**) Working capital is a cumulative term. In this table it is translated from current to constant dollars by converting the yearly increments in working capital to 1981 dollars and adding up all the increments to the working capital of the first year.

Table 4

A PROFILE OF A COMPANY OBSERVED IN A STEADY STATE
n=20 ROR=5%
DEPRECIATION IS REINVESTED

YEAR OF OBSERVATION	YEARLY INVESTMENT	DEPRECIATION	NET INCOME	CASH FLOW
1	95	95	58	153
2	95	95	58	153
3	95	95	58	153
4	95	95	58	153
5	95	95	58	153
j	95	95	58	153

Table 5.

SENSITIVITY OF ROR TO ASSUMED LIFE TIME (n)*
IN A GROWTH COMPANY

Performance data are given in Table 4.

ASSUMED LIFE TIME (YEARS)	10	15	20	25	30	35
ESTIMATED CRF	.161	.107	.080	.064	.053	.046
ESTIMATED ROR %	9.6	6.3	5.0	4.0	3.3	3.0

(*) LIFE TIME OF COMPANY'S INVESTMENTS IS 20 YEARS WITH A ROR = 5%

different ROR's and n's.

If data on the initial formation of the company is available, one can differentiate between the different alternatives, as the net capital needed to form the company and the return during the initial years would be a function of both ROR and n. However, if data on the initial stage are not available and one can only observe the overall results in the steady state, then an accurate estimate of ROR cannot be obtained unless an approximate estimate of the average lifetime of typical investments is available. Fortunately, for a basic industry, one would have an approximate estimate of n, usually between 15 and 25 years. This would then bracket the estimate of the ROR to 4-6% for the company.

The above example was simplistic in the sense that cash flow was assumed to be constant. If the annual cash flow varied, one can still use Eq. 5 to compute the CRF over a number of years and then use Eq. 2 to compute an equivalent r and ROR for each assumed n.

If the company illustrated in Table 4 remains forever in steady state, then for a given n, the estimate of Eq. 2 gives the true ROR.

Unfortunately, this is not a reasonable assumption. To get a valid estimate of ROR it is necessary to have data over a long period, much longer than for bonds. To compute CRF from eq. (5), one needs data from investments for n years prior to the first year for which one needs to estimate the CRF. In order to estimate an average historic CRF for the next twenty years, for an assumed n of 20 years, one needs forty more years of data as the last investment is going to be around for twenty more years. Fortunately, although one always needs data for the n years prior to a first estimate of the CRF, one can relax the requirement for knowledge of the additional twenty years. In this case an estimate of the ROR similar to the approximate estimate for bonds in Eq. (3) is obtained. If n = 20, then for the years 1960-70, all one can say is that the company behaves during these years like a company with an ROR of x percent. This would be true even if very complete data is available.

The estimate of the ROR for this hypothetical company shown in Table 4 is strongly dependent on n. This is due to the assumption that the company is in steady state with constant cash flow. If the company has even a small growth rate, the estimate of ROR is relatively insensitive to n. Table 6 illustrates a hypothetical company which is the same as the one shown in Table 4, except that all profits are reinvested. For simplicity, it is assumed that profits are reinvested in new projects with the same ROR and n. The company then experiences growth. Eventually it would reach a steady state growth stage in which all items (sales, net profit, depreciation, net cash flow and investments) will be (1+r) times greater than the previous year. The data in Table 6 were generated by assuming that (n=20) and ROR=0.05. The data were reported at the time the company reached a steady state growth. However, in the steady state growth state one would get identical results for any value of n as long as the net cash flow for each investment is consistent with an ROR of 5%. In fact, such a company can be constructed by using individual investments in which the net cash flow changes with time over the life of the investment. As long as the cash flow over the total life of the project is consistent with an ROR of 5%, the observed results will be the same. This

Table 6. A PROFILE OF A GROWTH COMPANY
n=20 ROR=5%
DEPRECIATION AS WELL AS PROFITS ARE REINVESTED

YEAR OF OBSERVATION	YEARLY INVESTMENT	DEPRECIATION	NET INCOME	CASH FLOW
1	331	251	97	348
2	348	264	101	365
3	365	277	106	383
4	383	291	111	402
5	402	305	117	423
j	$331 \times 1.05^{j-1}$	$251 \times 1.05^{j-1}$	$97 \times 1.05^{j-1}$	$348 \times 1.05^{j-1}$

is true if the company is observed in a steady state growth stage*.

In the case of this growth company, the estimating procedures outlined by Eq. 2 and 5 will produce an accurate estimate of the ROR, even if the estimate of n is inaccurate, as shown in Table 7. The problem of a sufficiently long period of observation remains as well as that of forward prediction. Thus, if one has data for the period 1970-1980, the data contain investments which still have a future life. However, the method does give a reliable estimate of past performance.

The fact that the estimate of the ROR for a growth company is relatively insensitive to n is, at first glance, paradoxical. For a given CRF, a longer life clearly implies a higher ROR. Thus, in calculating forward estimates, the predicted lifetime n has a strong impact on the predicted ROR. However, in the backward analysis one is matching

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*In the initial stage differences would be noticed. In some ways this is similar to observing a bank account of which interest payments are reinvested. The growth of the bank account is exactly related to return on investment.

Table 7

SENSITIVITY OF ROR TO ASSUMED LIFE TIME (n) IN A STEADY STATE COMPANY

Profile of company is given in Table 6.

ASSUMED LIFE TIME (YEARS)	10	15	20	25	30	35
ESTIMATED CRF	0.130	0.096	0.080	0.071	0.065	0.061
ESTIMATED ROR %	5.0	5.0	5.0	5.0	5.0	5.0

the overall observed behavior of the company. In the case of constant cash flow and no growth, for an assumed longer n, the CRF in Eq. 5 decreased, as for the same cash flow, the investment increased.

Therefore, as n increased, the ROR decreased. For the growth company, one also matches the observed behavior with a different series of investments, each with a constant lifetime n. Once again, as one increases n, the investments in the denominator of Eq. 5 increase. However, as there is also an increase due to growth, the increase is substantially less than for a steady state company. The CRF still decreases but the overall estimate of ROR remains unaffected over a large range of n. It is not that ROR does not depend on the real lifetime but rather that the backwards estimator of ROR for this growth company is insensitive to n. Note that the assumption of constant growth is crucial if the estimate of the ROR is independent of n. However, for any growth company, it will be far less sensitive than for a steady state company for the reasons stated above.

Many of the successful large companies in that study were growth companies. Most large American companies reinvest a significant part of their earnings and show some growth. It can be tested by applying these methods to the data of a given company and check how sensitive the estimate of ROR is to the life length of the investment chosen. (Other sensitivity tests will be given in Chapter 5).

2.3 Estimate of the Historic Rate of Return for Exxon Oil Company

As an example of the application of the discussed method, we give here a detailed examination of the available data for Exxon. Exxon is chosen as a successful large oil company. The historic performance of Exxon in constant dollars is given in Table 3.

Before proceeding with the analysis a few modifications must be made in the simplified model used for Eq. 5. First, one must take into account the working capital which was omitted from Eq. 5. This is not depreciated and does not have a finite life. Each year one must also calculate the ROR on the working capital as well as the other investments. The working capital, which is defined as the difference between current assets and current liabilities, is shown in Table 2.

Note that as the working capital is really a cumulative item, one has to trace its history and apply the inflation adjustment to the increment in each year to convert it to constant dollars. This is done for the data shown in Table 3.

When Eq. 5 is modified to include the working capital, one obtains

$$\mathrm{CRF}_j = \frac{\text{(NET CASH FLOW) year } j - \mathrm{ROR}_j \times \text{(WORKING CAPITAL) year } j}{\sum_{k=j-n}^{j-1} \text{(INVESTMENT IN YEAR K)}} \tag{6}$$

Eq. 6 includes the ROR and must be solved simultaneously with Eq. 2a. Note that Eq. 6 assumes a constant ROR in Eq. 2. One is therefore computing an equivalent ROR for the CRF. In reality, the correction for working capital has only a minor effect on the calculation of the ROR for all the companies discussed in the thesis.

The second decision one must make before applying the model is what items are included in net investment and net cash flow. One simple choice is to include only capitalized investments. In this case the net cash flow in year j would include net income after taxes, depreciation and long term interest paid. This would correspond to the ROR used in investment decisions. In such cases one expects the investment to earn enough to cover for all overhead and other expenses, such as research. This ROR shall be defined as the ROR on capitalized investments.

However, one of the goals in that thesis was to estimate the true return of the companies on their investments or, in other words, to estimate the historic time value of money in industrial investments. Therefore, it makes sense to include in the investment any expense that is not directly related to the current production, but is really an investment for the future. This would include research and in oil companies a revised estimate should include exploration expenses. This estimate is defined as the ROR on the total investment and is the one which is most interesting. If any item which is expensed in the annual report is included in the total cumulative investments over n years, it should also be considered as an income in the year j. In such a case it is considered as reinvested earnings. The net cash flow in this case includes therefore exploration and research. Therefore, rewriting Eq. 6 explicity for the CRF on capitalized investments:

$$\mathrm{CRF}_j\ \text{(CAPITAL INVESTMENT)} = \frac{\text{(NET INCOME + DEPRECIATION + INTEREST PAID)}j - \mathrm{ROR}_j \times \text{W. CAPITAL}_j}{\sum_{k=j-n}^{j-1} \text{(CAPITALIZED INVESTMENT)}_k} \tag{7a}$$

and for total investments:

$$\mathrm{CRF}_j\ \text{(TOTAL INVESTMENT)} = \frac{\text{(N. INCOME + DEPRECIATION + INTEREST + RESEARCH + EXPLORATION)} - \mathrm{ROR}_j \text{xW. CAPITAL } j}{\sum_{k=j-n}^{j-1} \text{(CAPITALIZED INVESTMENT + RESEARCH + EXPLORATION)}_k} \tag{7b}$$

Both (7a) and (7b) have to be solved simultaneously with Eq. 2a.

Using Eq. (7a), (7b) and (2) to compute the historic ROR for a company requires an assumption. Namely, that the CRF for any year applies equally to all investments in the portfolio for that year. With this assumption and with knowledge of the CRF's for each past year, one can readily compute an equivalent ROR for the investments made in a given year. If one has data both for the investments n years back and for the CRF n years ahead, one can with this assumption compute a true historic ROR as in curve C, Fig. 1. However, for reasonable n this will allow to compute the ROR for very few years.

(For n=20 the true ROR can be computed for 1955 to 1962). Therefore, Eq. 7a and 7b have been used to estimate the equivalent historic ROR (curve D, Fig. 1) for longer periods of time. In Chapter 5 this estimate is compared with the true historic ROR for shorter periods.

In Figs. 2 and 3 estimates of CRF and the equivalent ROR are given for Exxon, using the data in Table 2. Both CRF_j and ROR_j are estimated using three different values of n - 15, 20 and 30 years.

In Figs. 2 and 3 a five year moving average for both CRF and ROR is used. (The CRF is averaged over five years and the equivalent ROR is computed from the average value of CRF). This is done to smooth out short term fluctuations, which is justified as one is dealing with long term investments. In Fig. 4 the ROR on capitalized investment is compared with the ROR on total investments assuming an n = 20.

The CRF in constant dollars is remarkably constant in both figures. It shows some cyclic behavior but in the case of Exxon their impact was small. Furthermore, while the CRF strongly depends on the value of n chosen, the estimate of the equivalent ROR is insensitive to n. Therefore, for a company like Exxon the method leads to a rather

Figure 2 EXXON: Yearly CRF (capitalized) for different lifetimes.

(5 years moving averages)

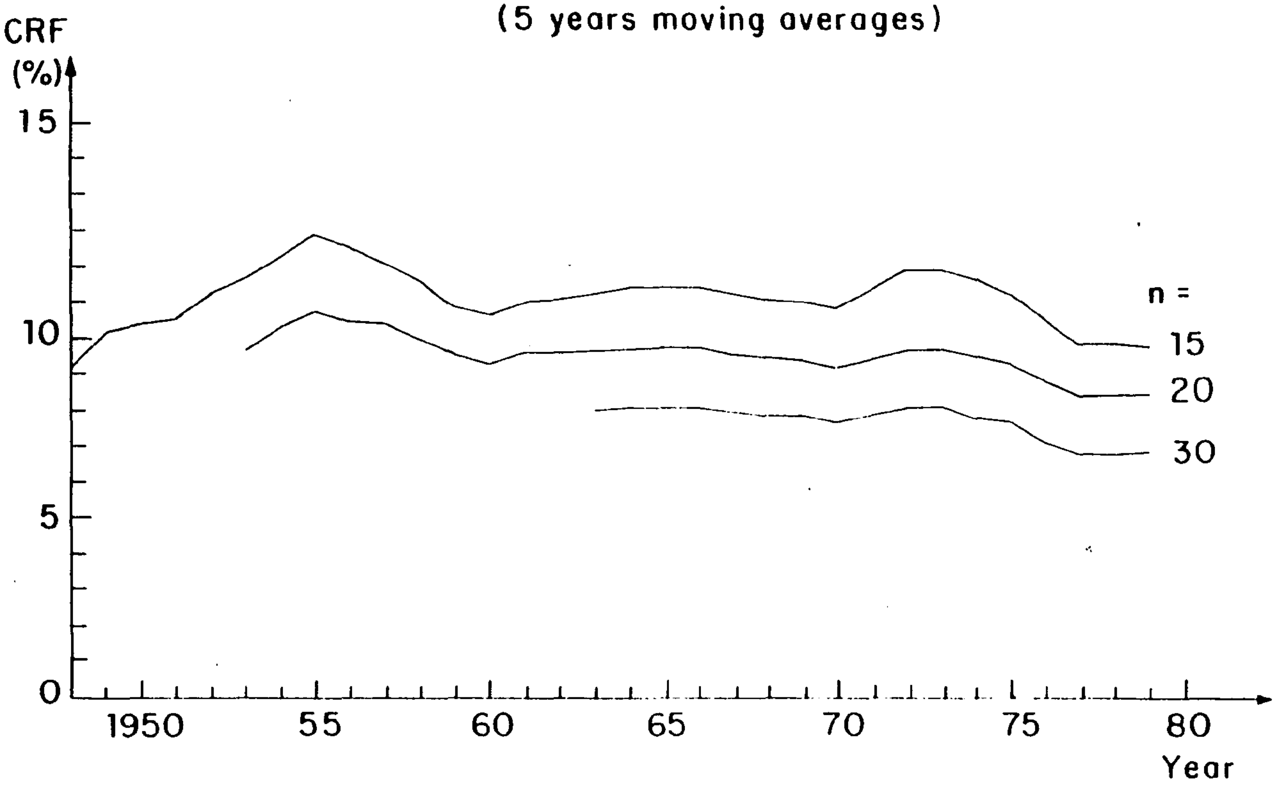


Figure 3 EXXON: Estimate of equivalent ROR based on CRF in figure 2

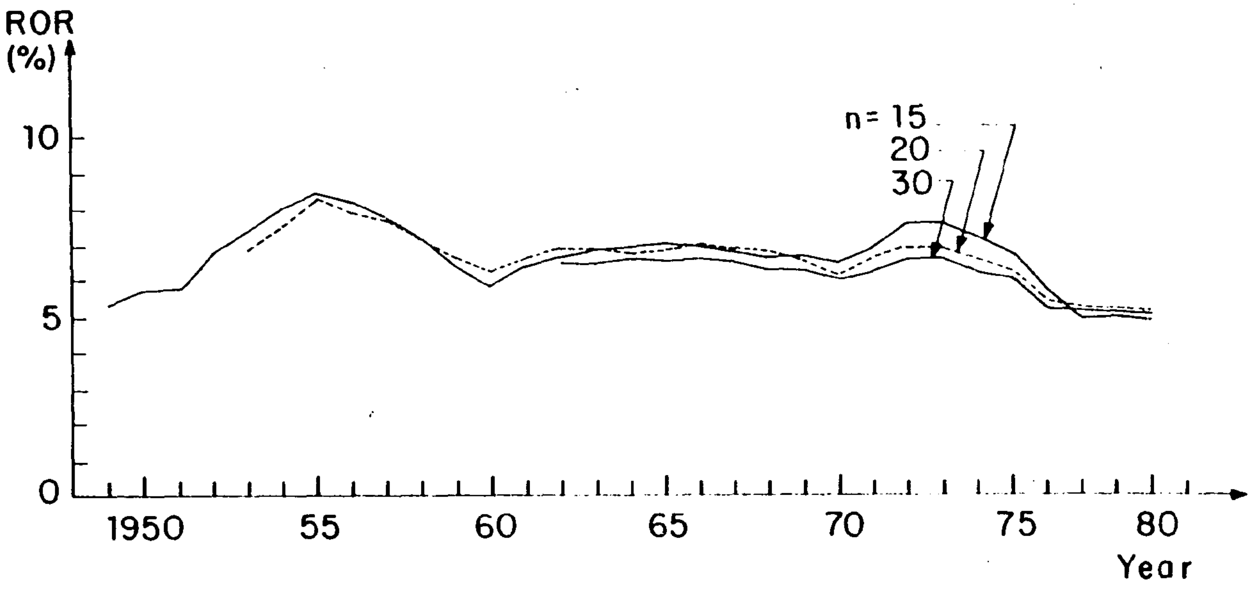
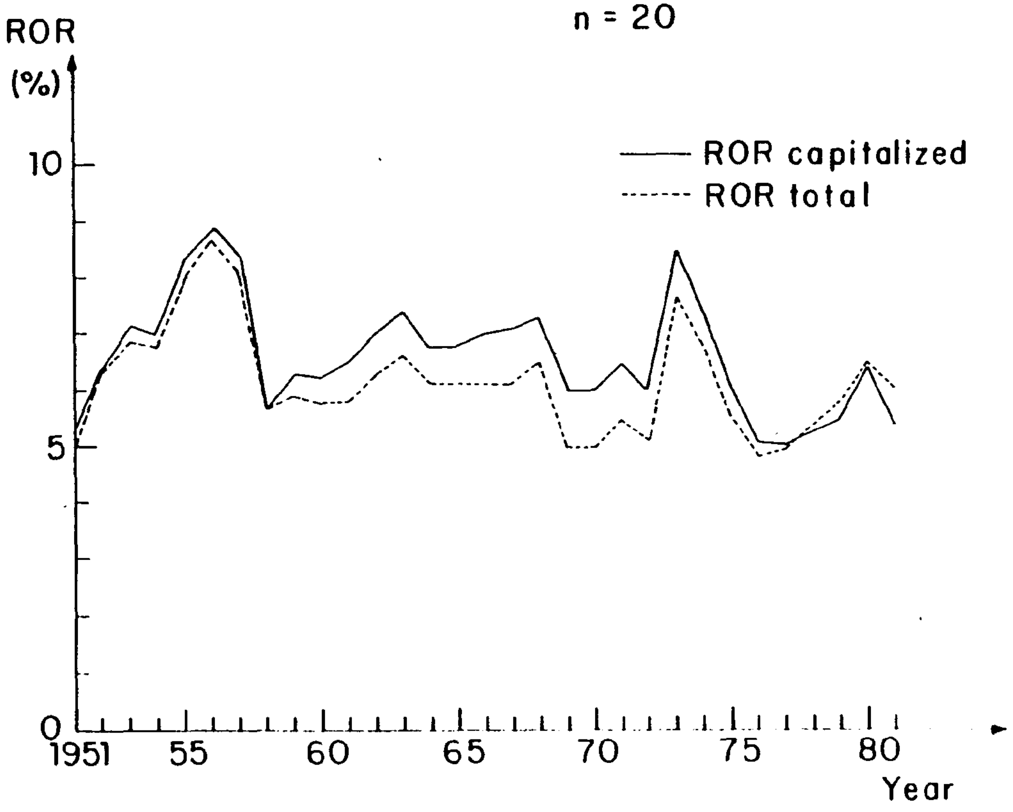


Figure 4 EXXON: ROR capitalized and ROR-total

n = 20



reliable estimate of the historic rate of return. Note that including exploration and research costs reduces the ROR but the impact is rather small (about 0.1%). This will be discussed further in the section on the sensitivity of the estimates.

The results were surprising in several ways. It is remarkable how little the CRF in constant dollars for Exxon fluctuated between 1951 to 1982, a period with major changes in oil prices and policies. In current dollars the CRF increased more in times of inflation but the constant dollar CRF remained remarkably constant, varying between 5-7%. The ROR in constant dollars also remained firmly constant even after 1973. Few of the companies analyzed showed so little variation. However, when analyzed in constant dollars, the fluctuations in the CRF usually were far smaller than expected.

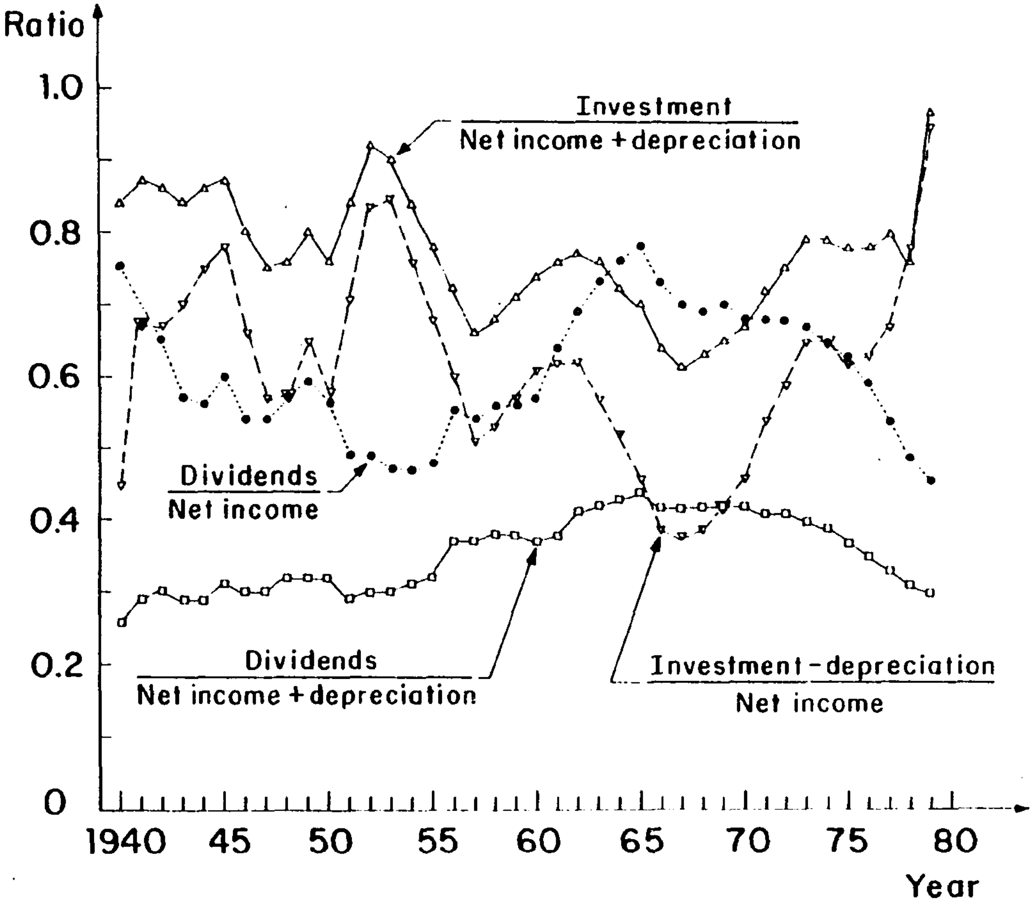
The second surprise is the insensitivity of the results to the assumptions on the lifetime n of an investment. This led to setting up the growth model discussed earlier. For Exxon and for most of the companies discussed in this work, this growth model applies reasonably well. Historically, Exxon has reinvested a large fraction of its earnings. The insensitivity of the results to n also gives more confidence in the validity of the results as it is difficult to obtain an exact estimate of n.

The percentage of capital recovery (based on capitalized investment) that was reinvested by Exxon is shown in Fig. 5. It is fairly constant, with a weighted average of .85. The percentage that Exxon used to pay its dividends is also given in Fig. 5 and the weighted average of the ratio of dividends paid to net cash flow is .36. Fig. 5 is given in current dollars. Historically, Exxon reinvested 85% of its capital recovery, and paid 36% as dividends giving a total of 121%. The difference between net cash flow and the sum of dividends and reinvestments comes from the increase in long term liabilities. The total accumulation of debts in terms of long term liabilities of Exxon since 1931 is approximately 60% of the total dividends paid. One reason Exxon could do this is that the real inflation free interest rate was much lower than the ROR (see Fig. 1) and, if considered after taxes, their inflation-free interest rate was negative between 1950 and 1978.

Fig. 5 also gives the fraction of the net income that is reinvested and given out as dividends. To obtain the fraction reinvested we

Figure 5 EXXON: Cash flow disposition (1948-1981)

Fluctuations were smoothed by 5 years moving average.



first deduct from the capitalized investment the depreciation and divide the difference by the net income.* The fact that the total debt for Exxon is about half the cumulative dividends over the last 50 years is in itself an interesting observation. For many large companies, this ratio is even greater and will be given later.

Many of the basic industries in the U.S. grew during the period we are interested in together with the GNP. The rate of growth of the GNP in constant dollars, 1951 to 1981, was 4% (3), which, as will be shown, is not too far from the ROR of most large, successful industrial companies. The growth of the GNP and these companies results in estimates that are insensitive to n and therefore reasonably accurate. If the growth rate would have been zero then the estimate would have a much stronger

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*The division of the capital recovery into depreciation and net income is accurate only in the absence of inflation. In the presence of inflation the depreciation reported in the annual report is too small and therefore the net income too large. Therefore, we give the reinvestment ratio both in terms of capital recovery and net income.

dependence on the lifetime assumed. As all companies investigated in this thesis grew, the estimate should not be too sensitive to n. Furthermore, for most capital intensive industries a reasonable estimate of the average lifetime n of the bulk of their investments is available, and having bounds on n gives bounds on the ROR obtained.

The idealized company in Table 6 had an equal growth in all items. This is not true for real companies. The growth data for Exxon are given in Table 11 Note that growth rates vary from item to item, but the growth rate of the capital recovery accounts for more than half of the estimate of ROR.

3. The Model of Growth

3.1 The Model's Concept

A company which is: 1. reinvesting all its income; 2. does not use any external source of financing, has a rate of growth (see definition of terms) identical to the rate of return (ROR) on its investments (assuming a constant ROR calculated by the discounted cash flow method). The idea is clear while considering an investment of initial amount P_o in the bank. If the annual interest paid on that principal is r (r given in fractional form), then the principal is increasing at the rate of r x 100 percent in a year. Therefore, the available amount at year j is given by:

$$P_o(1+r)^j.$$

In the following a proof is given so that this same result can be applied to an investment in plants, equipment or any other capital expenditures. The results, however, are not obviously a priori, since investment in a company and the income generated by that investment are affected by different accounting rules. Some of the rules are quite arbitrary (depreciation, etc.).

The rate of a growth of a company, therefore, can provide a good estimation of the profitability of the company, measured by ROR. If the company behaves according to the conditions stated above, then that estimator is a very good one.

There is a big advantage in using the rate-of-growth estimator for profitability measures. As indicated by (I), all that is needed to estimate the company profitability is the company's size determined in two different years. If other methods are used, detailed information such as net income, depreciation and capital expenditures over a long period of time is required.

3.2 Definition of Terms

$$\text{(I) rate of growth} = \left[\frac{\text{ASSETS AT YEAR (I+N)}}{\text{ASSETS AT YEAR (I)}}\right]^{I/N}$$

τ_j lifetime of investment j. (It is assumed $\tau_j = \tau \forall \tau_j$)

P_j amount invested at year j.

$C_{j,k}$ income generated by investment j and has been collected k years later

r ROR rate of return on investment

D_j depreciation at year j.

3.3 Proof

An investment of P_j dollars which generates the following cash flow: $C_{j,1}$, $C_{j,2}....C_{j,}$ (dollars), and has a rate of return of r% imply the following relation between the given parameters:

$$(8) \quad P_j = \sum_{k=1}^{\tau} C_{j,k}/(1+r)^k$$

On the other hand, the amount invested in year j (P_j) is the amount that had been collected as income in the same year. That is given by (9)

$$(9) \qquad P_j = \sum_{k=j-\tau}^{j-1} C_{k,j-k}$$

Let us rewrite (8). Let us substitute R=1/1+r and substitute (8) into (9). We obtain:

$$(10) \qquad P_j = \sum_{k=1}^{\tau} C_{j,k}R^k = \sum_{k=j-\tau}^{j-1} C_{k,j-k}$$

Let us write (10) for P_{j+1}:

$$(11) \qquad P_{j+1} = \sum_{k=1}^{\tau} C_{j+1,k}R^k = \sum_{k=j+1-\tau}^{j} C_{k,j+1-k}$$

Let us subtract P_j from P_{j+1}:

$$P_{j+1} - P_j = \sum_{k=j+1-\tau}^{j} C_{k,j+1-k} - \sum_{k=j-\tau}^{j-1} C_{k,j-k} = \sum_{k=1}^{\tau} C_{j+1,k}R^k - \sum_{k=1}^{\tau} C_{j,k}R^k$$

$$(12a) \qquad (C_{j-\tau+1,\tau} - C_{j-\tau,\tau}) + (C_{j-\tau+2,\tau-1} - C_{j-\tau+1,\tau-1}) + \ldots\ldots + (C_{j,1} - C_{j-1,1}) = 0$$

$$(12b) \qquad R^{\tau}(C_{j+1,\tau} - C_{j,\tau}) + R^{\tau-1}(C_{j+1,\tau-1} - C_{j,\tau-1}) + \ldots + R(C_{j+1,1} - C_{j,1})$$

Eq. (12) includes $4\tau-1$ unknowns: $(C_{j,1}, C_{j,2} \ldots C_{j+1,1} \ldots C_{j+1,\tau}$

and $C_{j-\tau,\tau} \ldots C_{j-1,1}\, C_{j+1-\tau}, \ldots C_{j,1})$

On the other hand there is 1 EQ and $\tau-1$* initial values. (The cash flow of the initial investment).

Let us assume a solution: $(13) \quad C_{j,k} = C_{j+n,k} \cdot R^n$

Eq. 13 gives us another $3\tau-1$ connections between the variables. As a result we have a set of $4\tau-1$ equations, and $4\tau-1$ unknowns. That set has one unique solution, if any.

Hence (13) is a solution and the only solution if it satisfies (12). In order to show it, let us substitute (13) into (12b):

$$R(C_{j-\tau+1,\tau}\cdot R - C_{j-\tau,\tau}\cdot R) + R\,(C_{j-\tau+2,\tau-1}\cdot R - C_{j-\tau+1,\tau-1}\cdot R) + \ldots. + R(C_{j,1}R - C_{j-1,1}R)$$

which is identical to 12a.

Therefore, $C_{j,k} = C_{j+n,k}R^n$ is the one and only solution.

*The cash flow includes τ terms. $\tau-1$ terms are unknowns, the extra term is determined once the rate of return of the investment is given.

3.4 Some Properties and Observations

Given here are some observations based on (13). The observations are true for any company with an ROR of r%.

1. The company's cash flow is increasing every year at a rate of r%.

Proof:

$$(\text{Cash Flow})_{j+1} = \sum_{k=j+1-\tau}^{j+1} C_{k,j-k+1} = R^{-1} \sum_{k=j+1-\tau}^{j+1} C_{k-1,\tau} -(k-1) = R^{-1} \sum_{k=j-\tau}^{j} C_{k,j-k} =$$

$$= R^{-1}(\text{Cash Flow})_j$$

2. The company net assets are increasing at an annual rate of r%.

Proof:

$$[\text{Net Assets}]_j = \sum_{k=0}^{j} P_k = \sum_{k=1}^{j} D_k$$

but: $P_k = [\text{cash flow}]_k$ (income is reinvested)

$$\text{and } [\text{depreciation}]_k = \frac{1}{\tau} \sum_{j-\tau}^{j-1} P_k = \frac{1}{\tau} \sum_{j-\tau}^{j-1} (\text{cash flow})_k = f\ (\text{cash flow})_k$$

$$\text{so: } [\text{Net Assets}]_j = \sum_{k=0}^{j} (\text{Cash Flow})_k - \frac{1}{\tau} \sum_{j-\tau}^{j-1} (\text{Cash Flow})_k = f\ (\text{Cash Flow})_j$$

similarly: $[\text{net assets}]_{j+1} = f\ (\text{cash flow})_{j+1}$ (14)

Based on result 1 and Eq. (14) we get:

$$[\text{net assets}]_{j+1} = [\text{net assets}]_j\ R^{-1}$$

3. The rate of growth of a company is equal to its ROR, for

any distribution over the years, of the cash flow.

Proof: No assumption has been made for $C_{i,j}$. (One special case is a constant cash flow:

$$C_{j,K} = C \quad j=1\ldots\tau$$

which is usually being used).

4. The rate of growth of a company equal to the rate of return on the company investments, even if delays exist. Delays indicate NO revenues at the first N years after an investment has been completed.

Proof: Since there are no restrictions for $C_{i,j}$ one can choose

$$C_{i,j} = 0 \quad j = 1,\ldots N \quad (N < \tau)$$

Conclusion

Using the idea of the model of growth, one can calculate the average rate of return (profitability) of a company by observing the company at two different points of time, and by using the following equation:

ROR = rate of growth =

$$\text{ROR} = \text{rate of growth} = \left[\frac{[\text{ASSETS}]_{j+N}}{[\text{ASSETS}]_j}\right]^{1/N} = \left[\frac{[\text{CASH FLOW}]_{j+N}}{[\text{CASH FLOW}]_j}\right]^{1/N}$$

4. Estimates of ROR for Different Industries

4.1 Estimate of ROR in Constant Dollars

The approach given in Chapter 2 was used to estimate the ROR in constant dollars for both catitalized and total investments for a representative sample of other large companies in basic industries. For comparison several other companies which are less capital intensive were also analyzed. A list of the companies as well as a summary of financial data for these companies at three time periods is given in Table 16. For study purposes the companies were grouped into 5 categories:

1) oil companies
2) chemical companies
3) metals (steel and aluminum)
4) rubber, paper, GE and Westinghouse
5) others (less capital intensive, including GM, IBM and Kodak)

In some of the results categories two to four were lumped together as basic industries. All companies chosen were large companies. Most of them are in the Dow Jones stock market index. They are all considered successful companies. The estimate for their average ROR should therefore be higher than the average for all similar industries. Companies who failed were not included. The companies grew mainly by their own investments. Companies which grew by merger are harder to study, as one would have to follow each acquired company over its history. The total sales of those companies in 1980 was billions of dollars, approximately 30% of the total industrial output.

Once again, a five year moving average is used to smooth out short term fluctuations. The results, which are given for each industrial category, are shown in Fig. 6. In Fig. 6 as in all the following tables, the starting year is 1935. This year was chosen since, for many of the companies, sufficient data was not available prior to 1935.

Consider the other three oil companies analyzed, Mobil, Shell and Amoco, again with an assumed n of 20. The CRF on capitalized investments for Mobil and Shell behaved in a manner analagous to the CRF at Exxon, fairly constant over a long time. Amoco shows a different behavior. Prior to 1973 its CRF was significantly lower than Exxon. After the formation of OPEC it increased to a higher value. This may be explained by noting that U.S. oil holdings comprise a much larger fraction of Amoco's

Figure 6.1 Oil companies: CRF capitalized and equivalent ROR.

Fluctuations were smoothed by 5 years moving average.

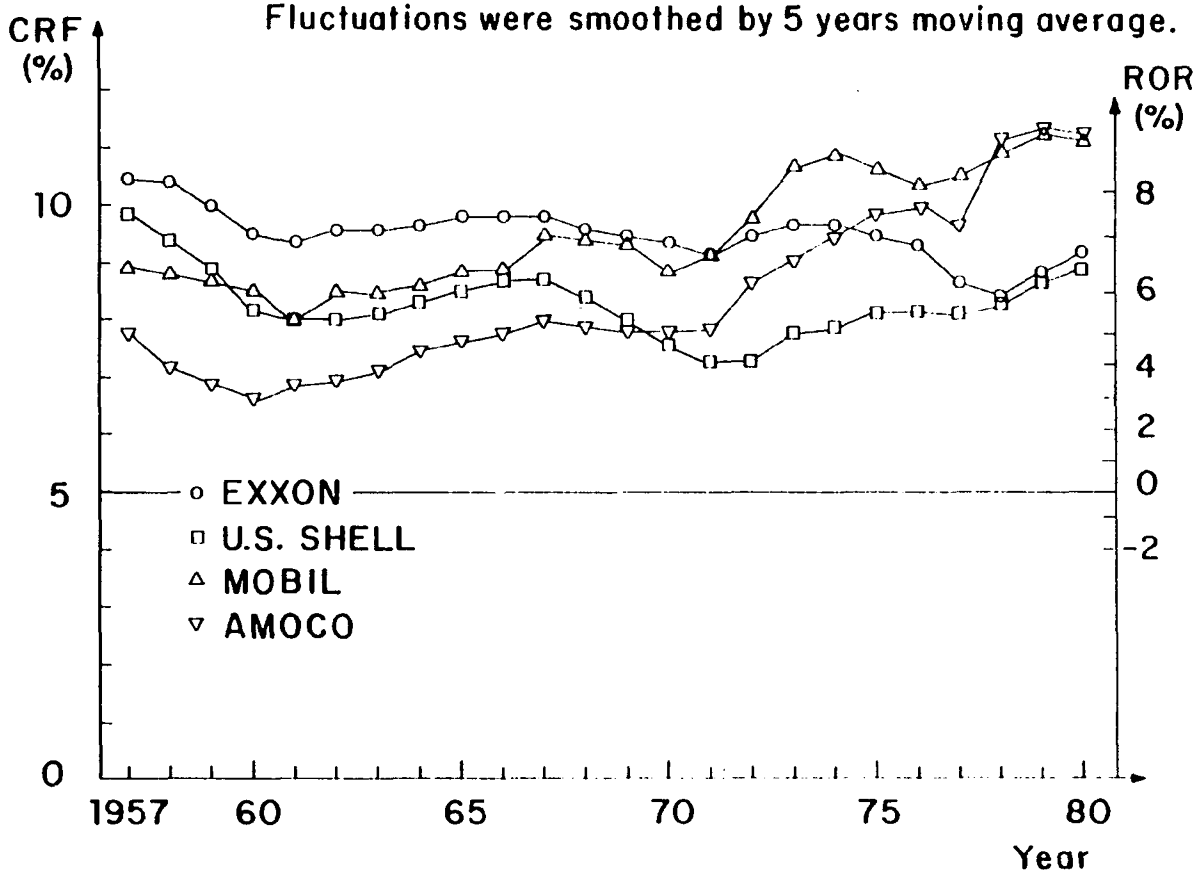


Figure 6.2 Chemical companies: CRF capitalized and equivalent ROR.

Fluctuations were smoothed by 5 years moving average.

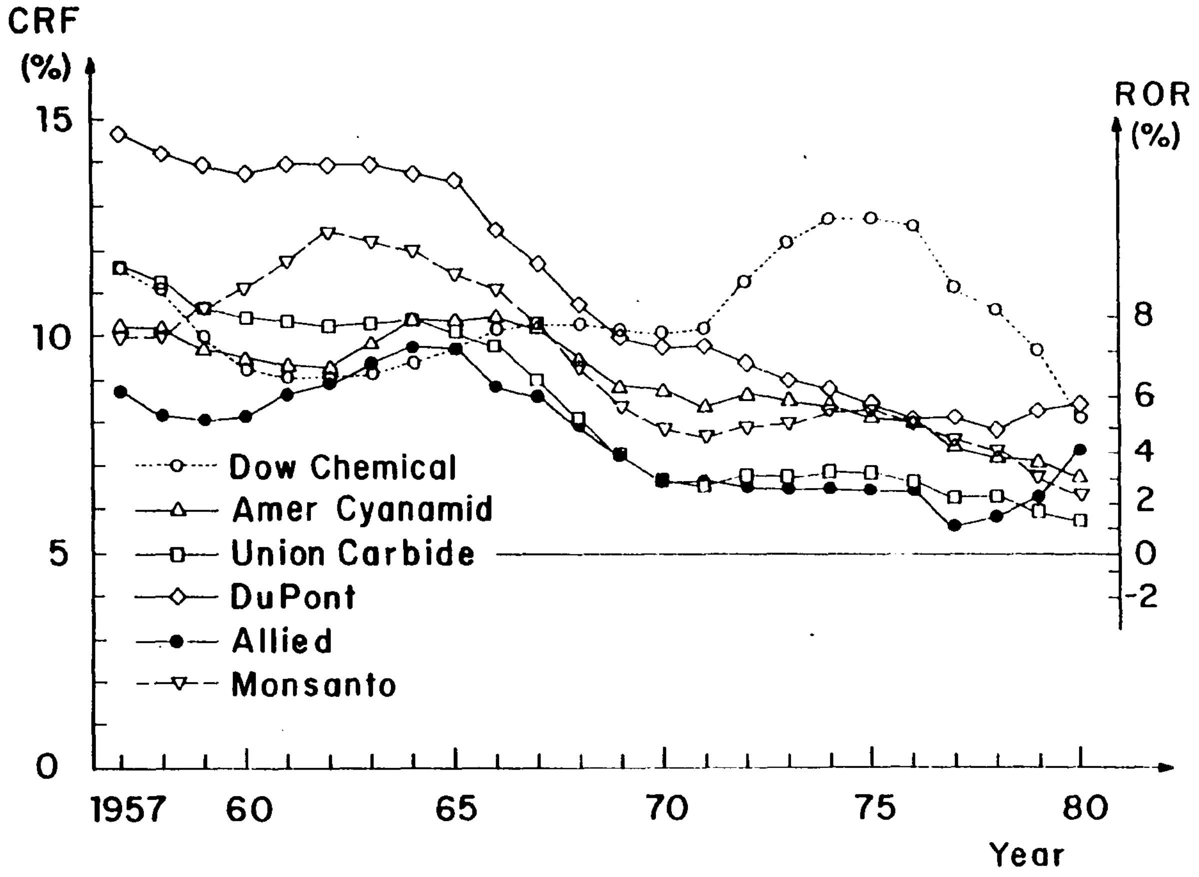


Figure 6.3 **Metal companies: CRF capitalized and equivalent ROR.**

Fluctuations were smoothed by 5 years moving average.

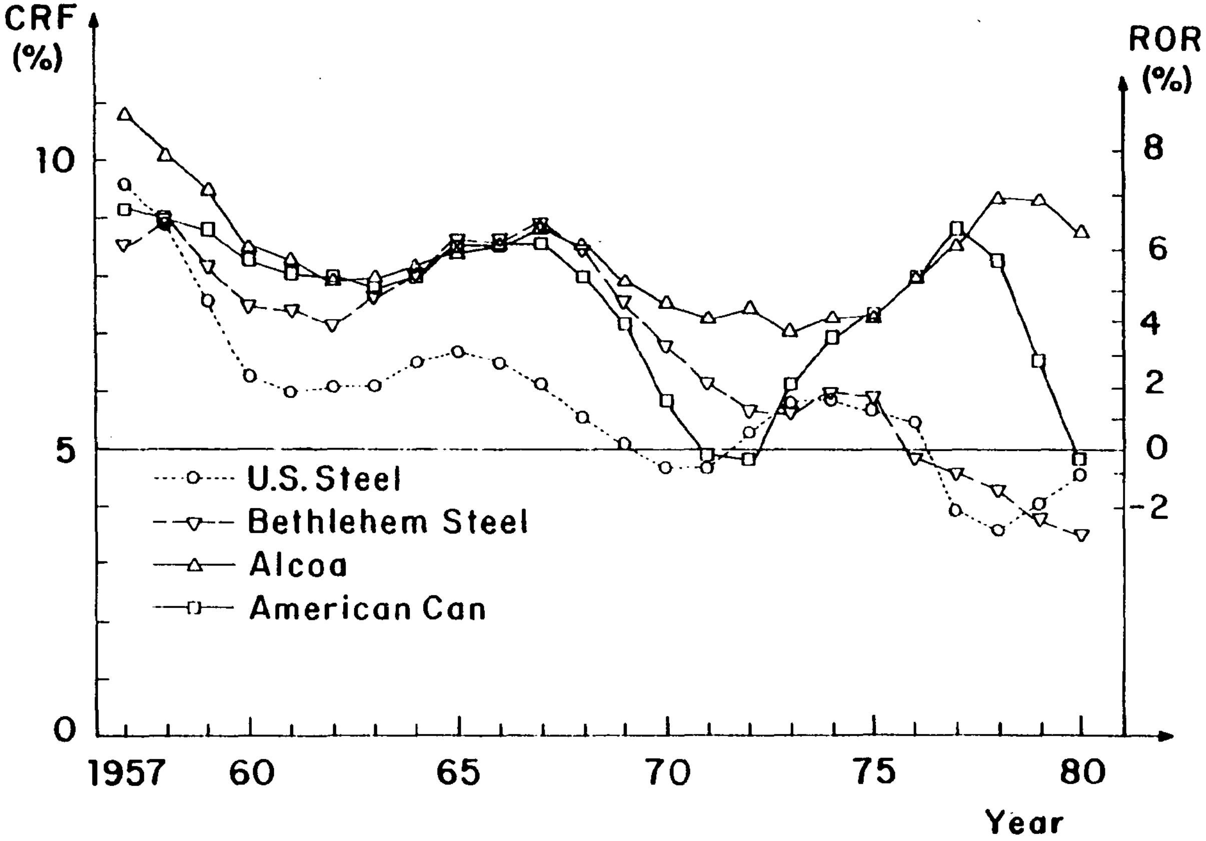
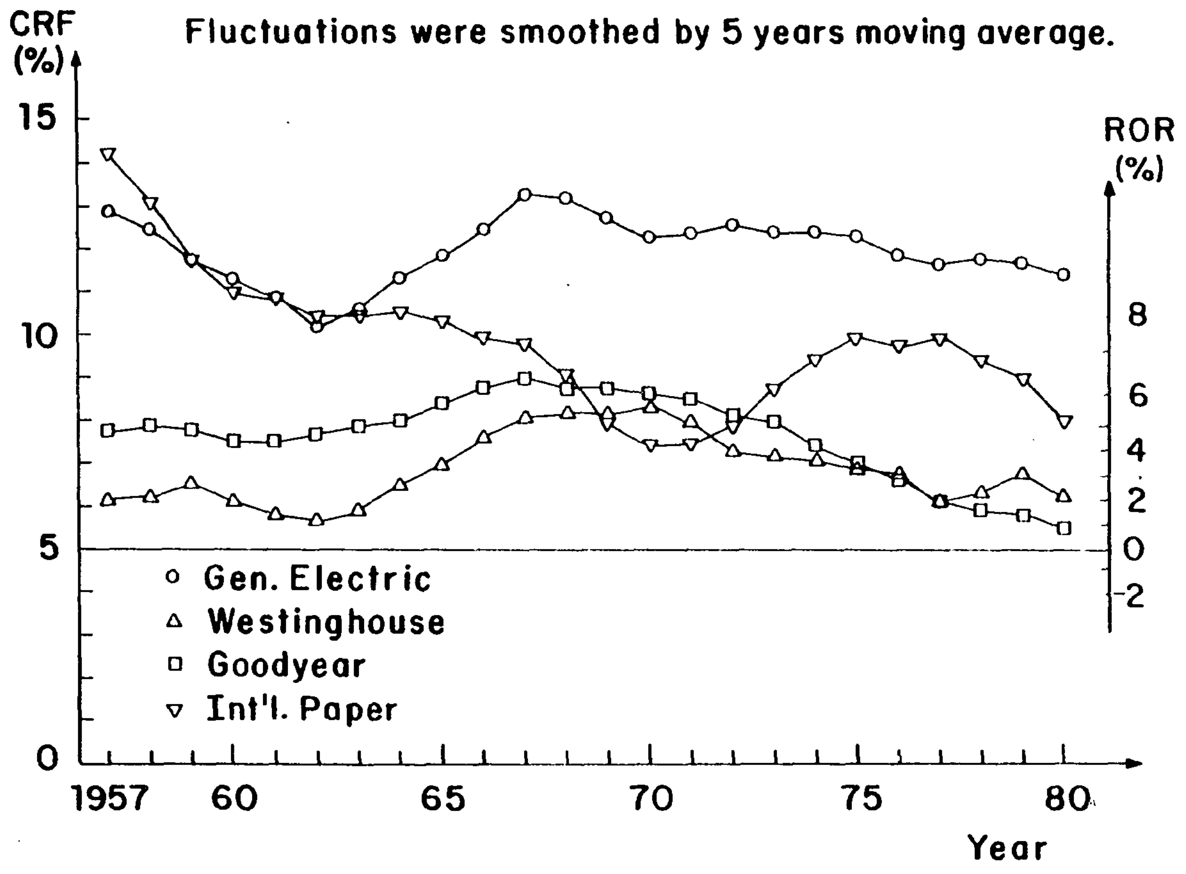
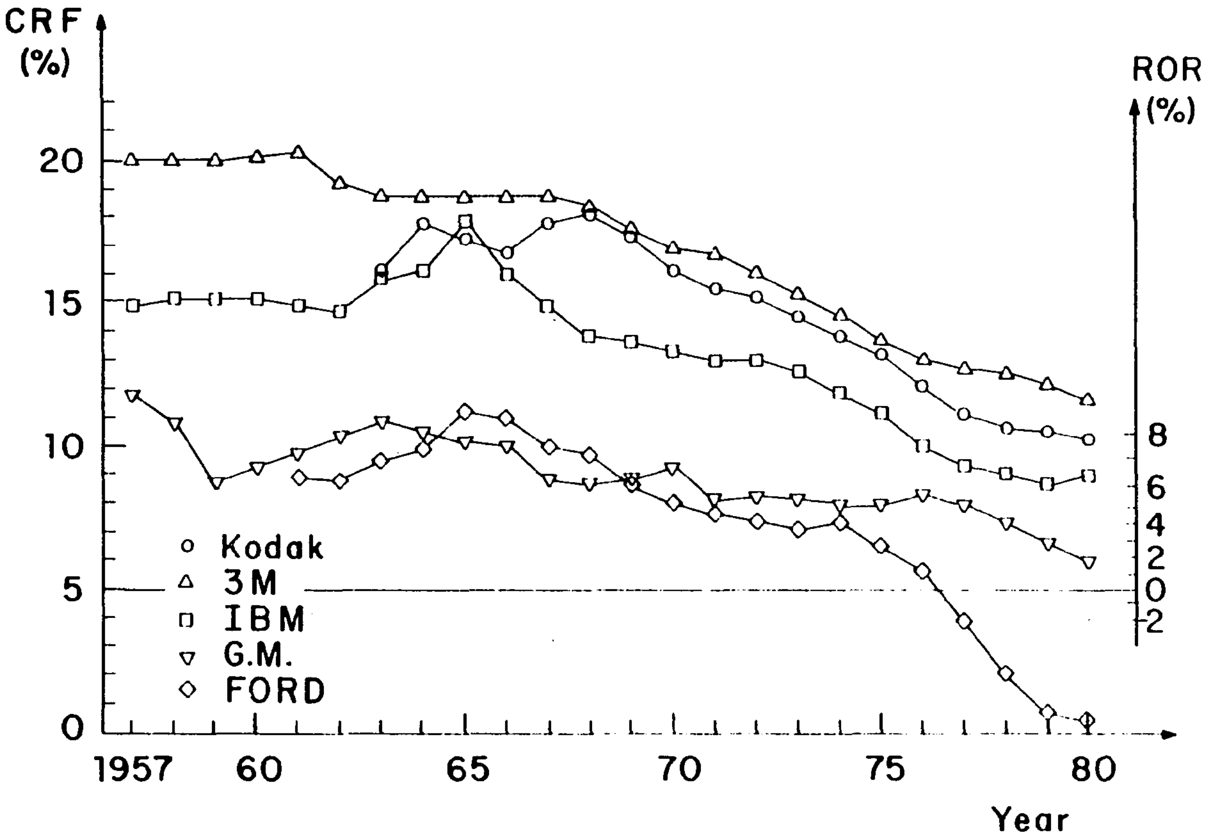


Figure 6.4 General Electric, Westinghouse, Goodyear Rubber Co., Int'l Paper CRF capitalized and equivalent ROR.



Fluctuations were smoothed by 5 years moving average.

Figure 6.5 CRF capitalized and equivalent ROR for companies with a shorter investment's life time.



total business than for the three other oil companies and therefore the oil crisis had a much stronger effect on Amoco. However, aside from this jump in 1973 the CRF is fairly constant over long periods of time even for Amoco, which allows a reasonable estimate of the ROR.

Chemical companies also show a different pattern. Aside from Dow, all companies chosen show a drop in the CRF in the middle sixties continuing into the seventies. For some companies such as Dupont, Monsanto, and Union Carbide, the drop is very sharp, while for the others it is less pronounced. Dow shows a similar drop in the late seventies. Again, aside from this abrupt drop, the CRF is fairly constant over long periods, with some superimposed cyclic behavior. This allows one to average and obtain reasonable estimates for the average CRF and ROR.

Metal companies do not show such a sharp drop but show a much stronger cyclic behavior. In addition the two steel companies show a long term downward trend of the ROR which reached the critical region of CRF equal to 5% (ROR equal to zero) around 1970 and continued to drop below it in recent years. Note that these figures are in constant dollars.

Due to the high inflation rate of the seventies, the two steel companies continue to show a net profit until 1978 and paid income tax and had very generous labor contracts during this time, despite the lack of any inflation adjusted return on their investments. This illustrates the advantage of using a constant dollar approach.

The two aluminum companies also show cyclic behavior. However, Alcoa has consistently had a higher ROR than American Can. The rubber company shown has a low ROR, whereas the paper company had a very high equivalent ROR in the early 50s, dropping later. It also shows stronger cyclic behavior.

The trends for several other industries, which are harder to classify as basic industries, are also shown in Fig. 6. GE and Westinghouse are very similar diversified large companies, the products of which vary from atomic power plants to consumer products. GE has a consistently higher CRF than Westinghouse and for both the CRF is fairly constant. The two car companies, GM and Ford chosen, show a significant down trend in the last 10 years. The three other companies chosen, 3M, Kodak and IBM, show much higher values of CRF.

The equivalent ROR for the above companies are also shown in Fig. 6. Note that for most companies the historical ROR is 3-7%. For many companies this has declined over the last 10 years. These numbers are the main results of the paper.

In Fig. 7 the same results are given in an averaged form. The CRF and the equivalent ROR are given for four groups, the four oil companies, the six chemical companies, the four metal companies and as a fourth group we lump together all companies in Table 8.1 except the oil companies. The oil companies were excluded from the total average as they are so large that they would overshadow all trends. The companies in each group are treated as if they were a single company. Both their net cash flow as well as their investment are summed up to compute the CRF.

As our sample was not random, these averages do not present industry averages. But as our sample contains the largest companies in each group, it still gives trends for the industry. Averaging makes the trends clearer. One notes that aside from the oil industry, all other groups show a decline in the last fiften years, starting several years before the oil crisis.

The important variables in estimating the ROR were the CRF and n. If the CRF is reasonably constant over long periods, as with the case for Exxon, the average CRF allows one to get a good estimate of ROR. If it varies, all one can obtain are upper and lower bounds for ROR. For the purpose of the thesis, this is sufficient. If the CRF varies, then the equivalent ROR for a given year is not very meaningful. First, the CRF must be averaged over a sufficiently long period to get an equivalent ROR. This is done in Table 8, which gives estimates for the equivalent ROR on capitalized investments for different periods using the moving 5 year averaging method. For each period estimates of the ROR are given as a function of n. For basic industries n is allowed to vary from 10-30 (Table 8.1). For the other companies n is allowed to vary from 7-20 (Table 8.2). Table 8 together with Fig. 6 contains the main results of the paper in a concise form, and allows judgement of the probable average value of ROR obtained by each company.

In the analysis used in Fig. 6, an n of 20 was assumed. For many basic industries, this is a good estimate of the average lifetime of an investment. For oil and steel companies n is probably higher.

For automotive companies such as GM and Ford, the average lifetime is probably 10-15 years. For companies such as IBM, Kodak and 3M, which are not really basic industries, a 10 year lifetime would be more realistic due to obsolescence. The companies with a shorter assumed n are therefore treated separately in the analysis (Table 8.2). However, as was shown previously, as long as these companies exhibit continuing growth, the estimate of the ROR is insensitive to the assumed n. The results of Table 8 confirm that for the majority of companies analyzed, the results are indeed insensitive to the assumed lifetime of the investment. The reason for this is that most companies experienced a growth based on reinvestment of their earnings. Also note that aside from Amoco, there are no companies for which the average rate of return has significantly increased over the last 10 years. For some it has remained constant whereas for many it declined. The grand average over the last 25 years, using n=20, is probably a good estimate for the real performance of the investments made in basic industries. For the others the estimate for n=10 is probably the best to use.

The ROR in recent years has fluctuated between

3-7%. In the 1950s, several chemical companies had an average ROR significantly higher than 7%, but this declined below 7% in the mid-sixties. In the last 10 years, the only large chemical company with an equivalent ROR of 7% or better is Dow Chemical. The few other companies with an average ROR higher than 7%, such as Minnesota Mining and Manufacturing, Kodak and IBM, are not really basic industries. For such companies which are much more labor intensive, the ROR is probably a less important criterion to judge investments. It is also much harder to define the investment accurately.

In Table 8.3 the results are also given for the same industry grouping that were plotted in Fig. 7. The results are also insensitive to n and confirm the results of Fig. 7.

Table 8 gives the RORs on capitalized investments. Sufficient data were available for Exxon and a few other companies to also calculate the ROR on total investments. These data are summarized in Table 9. The ROR on total investments was slightly lower than on capitalized investments, but the difference was rather small, 0.1% to 0.9% for the companies studied.

In reality, the total investments shown in

Table 8.1

SENSITIVITY OF AVERAGE EQUIVALENT ROR TO ASSUMED INVESTMENT LIFE TIME (n)

INDUSTRIES WITH LONG LIFE TIME OF INVESTMENTS

PERIOD OF YEARS	1960–1970				1971–1982				1955–1982			
ASSUMED LIFE TIME (YEARS)	25	20	15	10	25	20	15	10	25(***)	20(**)	15	10
1. EXXON	6.8	6.8	6.9	7.0	6.5	6.5	6.6	6.7	6.5	6.6	6.7	6.9
2. MOBIL	5.9	5.9	6.0	6.3	7.9	8.0	8.2	8.4	7.0	7.0	7.0	7.3
3. U.S. SHELL	6.0	6.2	6.3	6.4	5.4	5.5	5.4	5.6	5.6	5.8	5.9	5.8
4. AMOCO	3.9	3.9	4.0	4.2	7.4	7.4	7.5	7.7	5.5	5.6	5.7	6.0
(*) 5. DUPONT	8.9	9.0	9.4	10.1	5.7	5.9	6.3	6.9	7.4	7.7	8.7	9.3
6. DOW CHEMICAL	6.3	6.4	6.4	6.5	7.3	7.3	7.3	7.4	7.3	7.4	7.7	7.8
7. A. CYANAMID	6.7	6.7	6.5	6.6	3.9	4.0	3.9	4.2	4.7	4.9	5.0	5.1
8. ALLIED	5.6	5.7	5.9	6.0	2.9	2.9	2.8	3.0	3.8	3.9	3.9	4.0
9. UNION CARBIDE	6.9	7.0	7.2	7.3	2.9	3.0	3.1	3.3	5.0	5.1	5.0	5.2
10. MONSANTO	8.7	8.7	8.8	9.0	5.0	5.0	4.9	5.1	7.0	7.1	7.3	7.6
(*) 11. U.S. STEEL	3.0	2.9	2.7	2.3	0.5	0.2	0.1	0	2.2	1.9	1.7	1.3
(*) 12. BETHLEHEM STEEL	4.0	4.0	3.8	3.2	−1.1	−1.6	−2.3	−2.9	2.7	2.4	1.9	.9
13. AMERICAN CAN	4.6	4.5	4.3	4.1	3.0	3.0	2.9	2.8	3.6	3.6	3.5	3.3
14. ALCOA	4.1	4.1	4.0	4.0	5.5	5.3	5.3	5.6	4.3	4.4	4.3	4.1
15. GOODYEAR	4.9	5.0	5.2	5.1	2.0	2.0	2.0	2.1	3.8	3.8	3.7	3.8
16. INT. PAPER	6.7	6.8	6.8	7.0	5.8	5.9	6.1	6.2	6.5	6.6	6.6	6.8
17. GENERAL ELECTRIC	4.1	9.3	9.9	10.9	8.9	9.0	9.3	10.3	8.9	9.0	9.7	10.9
18. WESTINGHOUSE	3.5	3.6	3.5	3.3	2.9	3.0	3.1	3.1	3.5	3.5	3.4	3.3

(*) The Year 1982 is Not Included for Dupont Because of Merger with Conoco and for the Steel Companies because of their large losses in that year

(1) The Case of n=20 for the Period of 1955–1982 is Used in The Analysis as a Base Case for Sensitivity Studies

(2) The Period is 1960–1982

Table 8.2

SENSITIVITY OF AVERAGE EQUIVALENT ROR TO ASSUMED INVESTMENT LIFE TIME (n)

INDUSTRIES IN WHICH A SUBSTANTIAL PART OF THE INVESTMENTS HAS A LIFE TIME LESS THAN TWELVE YEARS

	1955–1970				1971–1982				1955–1982			
	7	10	15	20	7	10	15	20	7	10	15	20
19. GENERAL MOTORS	5.9	7.3	7.5	7.6	4.3	5.0	5.1	5.2	4.9	6.0	6.4	6.5
20. FORD	6.6	5.2	6.3	6.4	4.6	4.3	4.2	4.2	5.6	4.7	5.2	5.3
21. 3M	15.3	16.2	16.7	16.4	9.0	9.9	10.2	10.2	12.2	13.9	14.0	13.8
22. KODAK	11.3	10.9	10.8	11.0	9.2	9.3	9.4	9.2	9.9	9.7	9.7	9.7
23. IBM	12.3	13.4	13.8	14.0	7.8	7.9	7.8	7.9	9.9	10.9	11.0	11.0

Table 8.3

ESTIMATE OF AVERAGE EQUIVALENT ROR FOR COMPANIES GROUPED BY INDUSTRY(*)

Companies in such groups are treated as one company

	1960–1970				1971–1982				1955–1982			
ASSUMED LIFE TIME	10	15	20	25	10	15	20	25	10	15	20	25
(1,2,3,4) OIL COMPANIES	6.3	6.2	**6.1**	6.1	7.1	7.0	**6.9**	6.9	6.7	6.5	**6.4**	6.4
(5,6,7,8,9,10) CHEMICAL COS.	7.9	7.6	**7.5**	7.4	5.4	5.2	**5.1**	5.1	6.5	6.2	**6.1**	6.1
(11,12,13,24) METAL COMPANIES	3.0	3.4	**3.6**	3.7	0.2	0.6	**0.9**	1.1	2.8	2.8	**2.6**	2.1
(5–18) ALL COMPANIES EXCLUDING OIL COMPANIES	6.6	6.5	**6.5**	6.5	4.6	4.5	**4.4**	4.4	6.7	6.5	**6.4**	6.4

(*) The numbers reported under oil, chemical, metal and basic industries do not refer to those industries as whole but only to the average of the companies chosen in the sample.

Figure 7 Yearly CRF and equivalent ROR of several industries

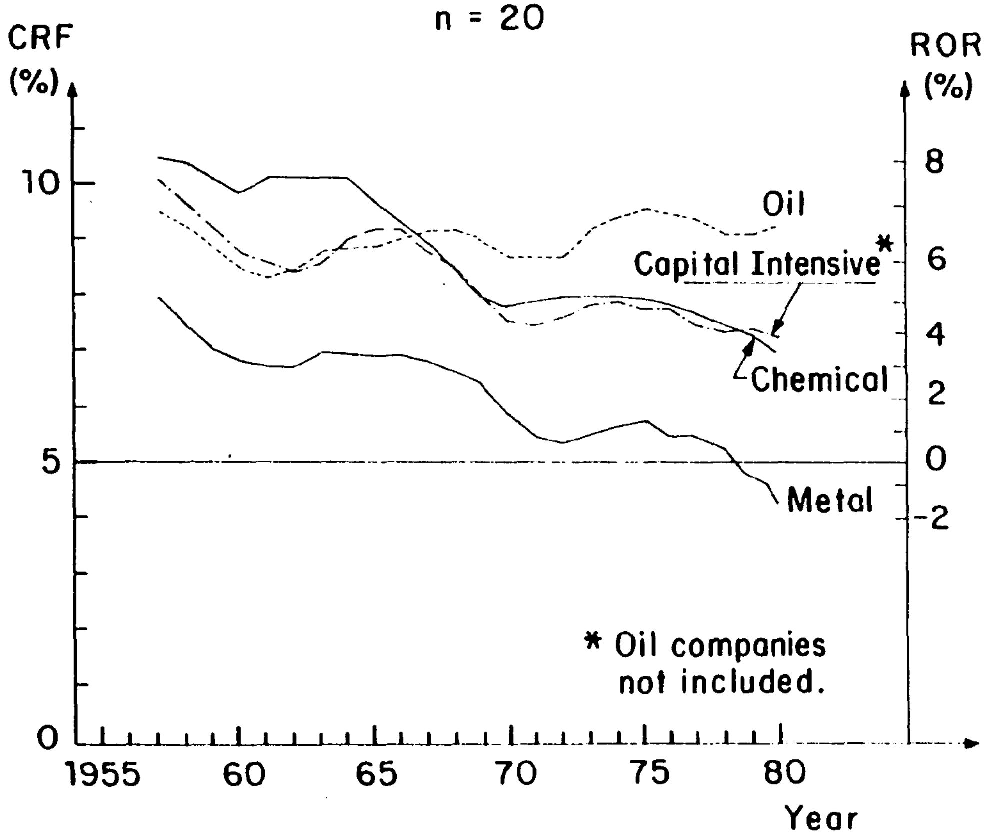


Table 9 underestimate the real total investments, as quite a number of expenses, such as engineering or geology in an oil company, are partially dedicated to investments. The effect of underestimating the total investment on the estimate of ROR is discussed in Chapter 5. For most of the companies discussed here, the impact is small and reduces the ROR. The numbers in Table 8 are therefore an upper bound. The sensitivity analysis presented in Chapter 5 shows that these estimates are quite robust.

4.2 Estimates of ROR in Current Dollars

The preceding analysis was carried out in constant dollars. The same analysis can be done in current dollars also, though this can be quite misleading, especially in times of high inflation rates. Table 10 compares the ROR on capitalized investments in both constant and current dollars for the companies analyzed in Table 8. The investment lifetime n is assumed to be 20 years for chemical, oil and metal companies and 10 years for companies with shorter investment lifetimes. The ROR in current dollars is obviously higher than in constant dollars. However, the ranking of different companies is still the same. Caution must be used when interpreting an ROR which is not inflation

Table 9. A COMPARISON OF EQUIVALENT ROR TOTAL WITH CAPITALIZED ROR

	ASSUMED LIFE	ROR CAPITALIZED	ROR TOTAL
EXXON	20 Years	6.6 %	6.5 %
MOBIL	20	7.0	6.9
DUPONT	20	7.7	7.5
CYANAMID	20	4.9	4.9
DOW CHEMICAL	20	7.4	7.4
IBM	10	10.9	10.8
3M	10	13.9	13.0

Table 10.1 COMPARISON OF ROR (CAPITALIZED) IN CURRENT AND CONSTANT DOLLARS

ASSUMED LIFETIME OF INVESTMENT – 20 YEARS

PERIOD OF YEARS	CURRENT DOLLARS			CONSTANT DOLLARS		
COMPANY	1955–1970	1971–1982	1955–1982	1955–1970	1971–1982	1955–1982
EXXON	9.1	11.1	10.3	6.8	6.5	6.6
MOBIL	9.6	13.2	11.6	6.1	8.0	7.0
U.S. STEEL	8.5	10.3	9.2	6.1	5.5	5.8
AMOCO	7.4	12.6	10.1	4.0	7.4	5.6
(**) DUPONT	12.0	11.0	11.8	9.4	5.9	7.7
DOW CHEMICAL	10.6	12.3	11.4	7.4	7.3	7.4
AMERICAN CYANAMID	9.1	8.3	8.8	6.9	4.0	4.9
ALLIED	8.3	6.3	7.3	5.3	2.9	3.9
UNION CARBIDE	10.1	7.2	8.6	7.3	3.0	5.1
MONSANTO	11.1	9.4	10.5	8.9	5.0	7.1
(**) U.S. STEEL	5.7	3.4	4.5	3.3	.20	1.9
(**) BETHLEHEM STEEL	9.4	0.2	4.7	4.8	1.6	2.4
AMERICAN CAN	7.8	6.8	7.2	4.4	3.0	3.6
ALCOA	7.1	9.8	8.4	4.1	5.3	4.4
INTERNATIONAL PAPER	10.6	10.6	10.6	7.3	5.9	6.6
GOODYEAR	8.0	5.2	6.7	5.2	2.0	3.8
GENERAL ELECTRIC	13.9	16.1	15.0	10.3	9.9	10.2
WESTINGHOUSE	6.9	7.3	7.0	3.9	2.8	3.5
(*) GENERAL MOTORS	10.1	9.4	9.7	7.3	5.0	6.0
(*) FORD	8.3	8.7	8.5	5.2	4.3	4.7
(*) KODAK	15.3	15.0	15.1	11.1	9.3	9.7
(*) 3M	18.4	16.2	17.4	16.2	9.9	13.9
(*) IBM	17.6	13.5	15.9	13.4	7.9	10.9

(*) ASSUMED LIFETIME IS 10 YEARS

(**) THE YEAR 1982 IS NOT INCLUDED

Table 10.2

COMPARISON OF ROR (CAPITALIZED) IN CURRENT DOLLARS AND CONSTANT DOLLARS ASSUMED LIFE TIME OF INVESTMENT 20 YEARS FOR COMPANIES GROUPED BY INDUSTRY*

PERIOD OF YEARS / COMPANY	CURRENT DOLLARS			CONSTANT DOLLARS		
	1955–1970	1971–1982	1955–1982	1955–1970	1971–1982	1955–1982
OIL COMPANIES	9.0	11.7	10.5	6.2	6.9	6.4
CHEMICAL COMPANIES	10.3	10.1	10.6	7.0	5.1	6.1
METAL COMPANIES	7.1	3.8	5.4	3.6	0.9	2.6
BASIC INDUSTRY (EXCLUDING OIL COMPANIES)	9.4	8.9	7.4	6.5	4.4	5.5

(*) The numbers reported under oil, chemical, metal and basic industries do not refer to those industries as whole but only to the average of the companies chosen in the sample.

adjusted as it may be positive even though the inflation adjusted ROR is zero or negative. Thus, in the 1970s, the steel companies still showed a healthy ROR in current dollars despite the fact that their real inflation adjusted ROR was less than 0.5%. Aside from the oil companies, almost all companies have had a decrease in real ROR (constant dollars) in the last fifteen years. This decrease is much less noticeable when ROR is computed in current dollars.

4.3 Comparison between Growth Rates and ROR

For most companies the estimate of ROR in the previous two sections was quite insensitive to the assumed lifetime of the average investment. It was previously shown that this is due to the fact that most of the profits were reinvested and the companies grew by investing their profits. Table 11 compares the ROR and the average growth rate for the companies. The average growth rate of an item for the years 1955-1980 was computed by first averaging the item over the years 1953-1957 and 1978-1982. The annual growth rate is then computed by

$$\text{average growth rate} = \left[\frac{\textbf{average years 1978--82}}{\textbf{average years 1953--57}}\right]^{1/25}$$

Note that, for many companies, sales grew more rapidly than the net cash flow and interest payments grew more

Table 11.1

RATE OF GROWTH COMPUTED FOR SEVERAL FINANCIAL ITEMS AND ROR DURING YEARS 1955–1980

COMPANY	SALES	INVEST–MENTS *	NET INCOME & DEPRECI–ATION	INTEREST	ROR (n=20 Years)
EXXON	5.8	3.9	3.0	9.0	6.6
MOBIL	7.6	5.7	4.4	12.1	7.0
U.S. SHELL	5.2	6.3	3.4	11.1	5.8
AMOCO	6.1	5.2	5.0	9.3	5.4
(**)DUPONT	4.7	4.9	1.3	10.8	7.9
DOW CHEMICAL	7.4	5.3	5.4	10.6	7.6
A. CYANAMID	3.4	1.9	1.4	5.6	5.1
ALLIED	4.0	5.0	2.3	5.6	3.8
UNION CARBIDE	3.8	3.4	1.4	5.6	5.2
MONSANTO	6.0	3.9	4.9	8.1	7.4
(**)U.S. STEEL	0.7	1.5	–0.3	12.4	1.9
(**)BETHLEHEM STEEL	0.1	0.4	0.4	6.0	2.4
AMERICAN CAN	2.3	1.3	0	10.8	3.8
ALCOA	2.8	1.6	2.1	4.0	4.4
GOODYEAR	3.1	2.1	1.7	8.7	3.9
INT. PAPER	3.0	3.8	1.8	–	6.7
GENERAL ELECTRIC	3.3	5.0	3.4	11.6	9.0
WESTINGHOUSE	4.4	1.9	3.9	3.5	3.5
(***)GENERAL MOTORS	3.1	3.1	1.6	11.4	6.2
(***)FORD	3.0	3.5	1.6	12.8	5.0
(***)3M	7.8	8.3	7.6	–	14.2
(***)KODAK	6.0	6.3	5.8	–	9.8
(***)IBM	10.2	9.4	9.7	8.7	11.0

(*) – Capitalized Investment Plus Change of Working Capital
(**) – The Year 1982 is Not Included
(***) – ROR Was Calculated Based on 10 Years Life Time

TABLE 11.2 ROR AND RATE OF GROWTH COMPUTED FOR SEVERAL FINANCIAL ITEMS FOR COMPANIES GROUPED BY TYPE OF INDUSTRY *

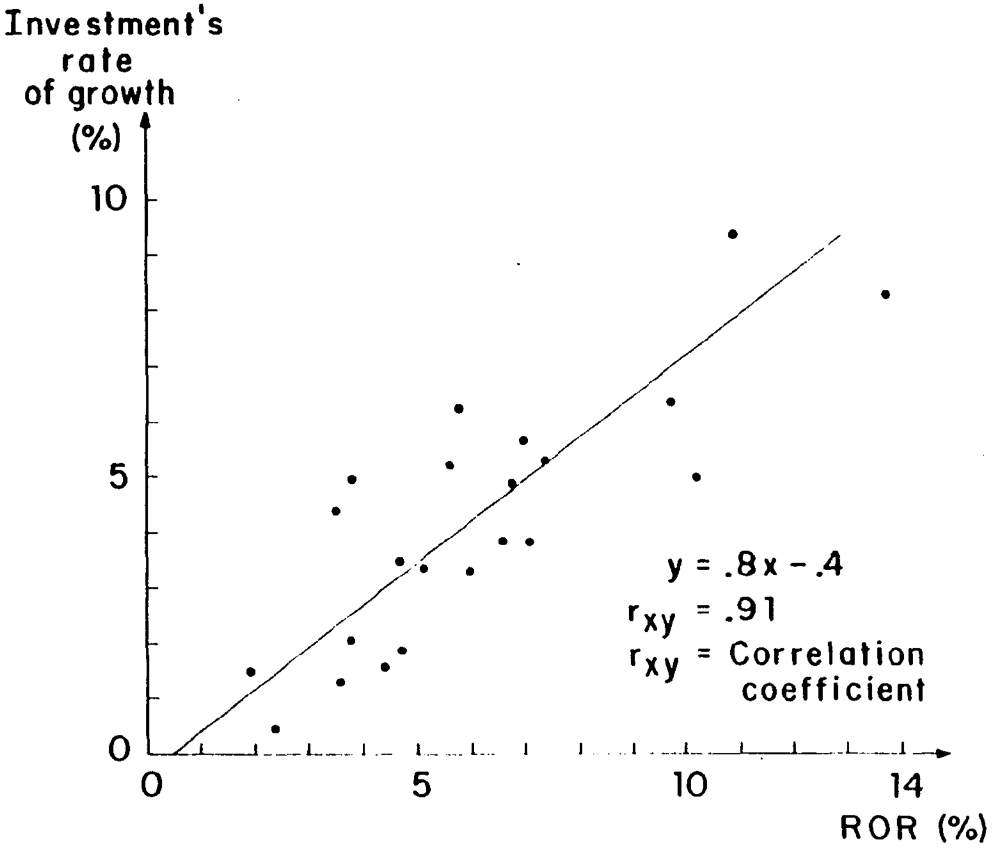
PERIOD OF ESTIMATE – 1955-1980

	SALES	INVEST-MENTS**	DEPRECI-ATION & NET INCOME	NET INCOME	n=20 ROR
OIL COMPANIES	6.3	5.2	3.6	5.3	6.3
CHEMICAL COMPANIES	5.0	4.4	2.4	2.1	6.3
METAL COMPANIES	1.4	1.4	0	–0.6	2.2
BASIC INDUSTRY (EXCLUDING OIL COMPANIES)	3.5	3.8	2.0	1.6	5.5

(*) The numbers reported under oil, chemical, metal and basic industries do not refer to those industries as whole but only to the average of the companies chosen in the sample.

(**) Capitalized Investment & Change of Working Capital

Figure 8 Correlation between rate of growth and ROR



than any other item. In general, most companies with a high ROR also had a significant growth rate. The only exception is GE, which shows only a moderate growth but has a high ROR. The relation between growth of investments and ROR is plotted in Fig. 8 and the correlation is quite good. This explains why our estimates of ROR are quite robust.

Table 11 also gives the growth rates for the industry groupings in Fig. 7 (or Table 8.3). In addition the growth rate for all manufacturing industries as reported in Ref. (3) is given. For the last item we lack the details available in annual reports and therefore can only report the growth rate (in constant dollars) of sales, capitalized investments and net income.

To show this in a different way, we give in Table 12 a comparison of the industry groupings in Fig. 7 to the total manufacturing industry. Table 12 compares the total sales and investments of each group to the numbers reported for all manufacturing industries for three typical years. The comparison is on a percentage basis. The numbers are only given to indicate relative growth. As many of the companies reported are multinational, the percentages do not reflect their relative contribution to the U.S.

Table 12

CONTRIBUTION OF COMPANIES IN SAMPLE TO TOTAL SALES, INVESTMENTS AND EARNING OF ALL MANUFACTURING GIVEN IN 1980 DOLLARS

(ALL NUMBERS IN BILLION DOLLARS)

	SALES			CASH FLOW			NET INCOME			INVESTMENTS		
	1939	1955	1980	1939	1955	1980	1939	1955	1980	1939	1955	1980
ALL MANUFACTURING*	527	862	1776	63	80	195	-	--	-	25	59	121
OIL COMPANIES**	12.5	35.5	221	3.3	3.8	17.3	2.25	6.41	19.2	1.0	3.3	11.9
CHEMICAL COMPANIES	5.2	12.7	49	1.3	1.1	4.9	1.23	2.75	5.25	.83	1.5	2.6
METAL COMPANIES	5.2	17	30	1.2	1.4	2.1	1.82	2.35	2.80	.86	1.2	1.2
BASIC INDUSTRY EXCLUDING OIL COMPANIES	13.8	47.4	127	2.9	3.3	10.5	2.15	7.35	12.7	1.6	3.8	6.2

(*) As Reported in (5)

(**) The numbers reported under oil, chemical, metal and basic industries do not refer to those industries as whole but only to the average of the companies chosen in the sample.

Table 13.1

AVERAGE INDICATORS OF CASHFLOW DISPOSITION FOR THE PERIOD 1955–1982

RATIO	INVESTMENT / N. INCOME & DEPRE. (1)	INVESTMENT / N. INCOME	INV - DEPRE. / N. INCOME (2)	DIVIDENDS / N. INCOME	DIVIDENDS / N INCOME & DEPRE.	LONG T. LIAB. / DIVIDENDS	LONG T. LIAB. / INVES. (3)
1. EXXON	.95	1.28	.92	.52	.33	.64	.24
2. MOBIL	1.13	1.70	1.23	.40	.23	1.08	.25
3. U.S. SHELL	1.14	2.20	1.20	.36	.19	1.52	.26
4. AMOCO	.98	1.82	.97	.38	.21	1.03	.21
5. DUPONT	.63	1.09	.37	.66	.39	.27	.12
6. DOW CHEMICAL	.90	1.82	.80	.43	.21	1.35	.32
7. A. CYANAMID	.65	1.12	.40	.54	.31	.40	.19
8. ALLIED	1.01	2.18	1.00	.58	.27	1.98	.33
9. UNION CARBIDE	.89	1.60	.79	.58	.26	.90	.23
10. MONSANTO	.89	1.87	.77	.41	.19	.84	.13
11. U.S. STEEL	.85	1.77	.68	.50	.24	.92	.48
12. BETHLEHEM STEEL	.91	2.05	.80	.57	.26	.96	.37
13. AMERICAN CAN	.92	1.98	.82	.75	.35	.79	.42
14. ALCOA	.81	1.70	.60	.37	.18	1.35	.52
15. GOODYEAR	.79	1.50	.60	.41	.22	.82	.47
16. INT. PAPER	.83	1.40	.70	.46	.27	.72	.59
17. GENERAL ELECTRIC	.62	.96	.40	.53	.32	.36	.66
18. WESTINGHOUSE	.84	1.41	.72	.48	.28	.38	.75
19. GENERAL MOTORS	.85	1.71	.69	.69	.34	.34	.14
20. FORD	.83	1.94	.62	.49	.19	.78	.29
21. 3M	.54	.76	.36	.49	.35	.21	.08
22. KODAK	.52	.70	.35	.49	.36	.10	.05
23. IBM	.90	1.63	.81	.52	.29	.23	.07

(1) -- N. Income = Net Income, Depre. = Depreciation (2) -- Inves. = Investment = Capital Expenditures

(3) - Long T. Liab. - Increase In Long Term Liabilities

Table 13. 2

AVERAGE INDICATORS OF CASHFLOW DISPOSITION FOR THE PERIOD 1955–1982

	$\frac{\text{INVESTMENT}}{\text{N. INCOME \& DEPRE.}}$ (1)	$\frac{\text{INVESTMENT}}{\text{INVESTMENT N. INCOME}}$	$\frac{\text{INVES.–DEPRE.}}{\text{N. INCOME}}$ (2)	$\frac{\text{DIVIDENDS}}{\text{N. INCOME}}$	$\frac{\text{DIVIDENDS}}{\text{N. INCOME}}$	$\frac{\text{LONG T. LIAB.}}{\text{DIVIDEND}}$	$\frac{\text{LONG T. LIAB.}}{\text{INVES.}}$ (3)
OIL COMPANIES	.92	1.57	.87	.45	.26	.90	.24
CHEMICAL COMPANIES	.88	1.77	.77	.62	.30	.81	.20
METAL COMPANIES	1.72	3.90	2.64	.58	.25	.98	.45
BASIC INDUSTRY (EXCLUDING OIL COMPANIES)	1.02	2.02	1.21	.56	.28	.72	.46

(1) – N.Income= Net Income, Depre.= Depreciation (2) – Inves.= Investment = Capital Expenditures

(3) – Long T. Liab.= Increase In Long Term Liabilities

(*) The numbers reported under oil, chemical, metal and basic industries do not refer to those industries as whole but only to the average of the companies chosen in the sample.

economy.

In order to provide the reader a clearer picture of how this growth was achieved, Table 13 gives the average fraction of the net cash flow and the net profit that was reinvested over this period. Table 13 also gives the fraction of investment that was financed by an increase in debt and also the ratio of the total increase in debt to total dividends paid. For many companies this ratio is larger than 0.7. Some companies such as the steel companies had a low growth rate despite the fact that they reinvested most of their profits and increased their debt. This is due to their low real profits. Tables 8-13 give an interesting profile of a typical sample of large American companies in the process industries, and the reader can draw from it his own conclusions.

5. Reliability of Estimates

In the preceding sections an equivalent ROR was estimated using a single filter. To do this, it was assumed that the investments have an equal life of n years, and that during that life they provide a return which is independent of age and equal to the average capital average of all the investments. For each year the net cash flow attained in that year is divided by the total cumulative investment in constant dollars to yield a capital recovery factor. Averaging the capital recovery factor over a period one obtains an average CRF for that period, which can be converted into an equivalent ROR using Eq. 2a.

How does this average equivalent ROR relate to the real ROR. In principle, one can compute a real average ROR similar to the ROR of bounds given in Fig. 1 for any assumed n. However, unless n is small, one can get these results only for a very brief period. For example, observing the investments in the year 1950, and if n=15, then in order to compute the real average ROR for the period 1950-1966, one needs to know the CRF 15 years forwards and backwards or from 1935 to 1981. If n=20 then having data for 1935-1981 only allows a computation of the real ROR for the period 1955-1961. In Table 14 the calculation of the real historical ROR is given for all companies for 1950-1966 using an annual n of 15 years.

This is compared with estimates of the equivalent ROR for the periods 1950-1966 and 1950-1982 with n=15. Note that the detailed estimate of the real ROR is between these two estimates. For companies with a nearly constant CRF (see Fig. 6), they are essentially identical. For those with a declining CRF, the real average ROR was smaller than the equivalent ROR during the same years. As the real lifetime is larger than 15 years the results of the detailed estimate (Eq. 7a) for the ROR for investments in the years 1956-1961 is probably a good upper bound for the real average historic ROR obtained by investments over these years.

Averaging overall investments is unavoidable if one only has access to the data in the annual reports. It is true that by averaging the ROR, good investments in 1950 are penalized by bad investments in 1960 and vice versa. However, this should not affect the validity of the estimate of the average ROR of the company which is what we are after. There are several other assumptions that are made. For example, it is assumed that income is constant over the lifetime of an investment and changes with the average CRF of the company. It was also assumed that there is no delay between the time of investment and the time it begins to generate income, which is usually the case in real life.

The effect on this estimated ROR of assuming a two year delay before an investment generates income is shown in Table 15 with n=20. In other words, to obtain the CRF for 1960, the investments for 1938-1957 are used. The delay must also be considered when using Eq. 2. to connect CRF to ROR. The effect of the delay is to reduce the ROR. Fortunately, the effect is small for all the companies studied and so does not significantly alter the conclusions. Note that this would not be true in the usual forward estimate of ROR where introducing a delay substantially alters the predicted ROR. It would also not be true even for the backward estimate for a steady state no growth company. However, for a growth company, the estimate of ROR is relatively insensitive to a delay.

The effect of assuming constant CRF can also be analyzed. In Table 15 this is done for a special case where n=20 and the income generated in the first ten years is assumed to be twice that generated in the last ten years.

$$\text{CRF}_j \left(\begin{array}{c}\text{CAPITALIZED INVESTMENT}\\ \text{ACCELERATED,}\quad n=20\end{array}\right) = \frac{(\text{N. INCOME} + \text{DEPRECIATION} + \text{INTEREST PAID}) - \text{ROR}_j \times \text{W. CAPITAL}_j}{\sum_{k=j-11}^{j-1} (\text{CAPITALIZED INVESTMENT})_k + \frac{1}{2} \sum_{k=j-21}^{11} (\text{CAPITALIZED INVESTMENT})_k} \tag{15}$$

Table 14 A COMPARISON BETWEEN A REAL ROR AND AN EQUIVALENT ROR

ASSUMED LIFETIME IS 15 YEARS

PERIOD OF YEARS / COMPANY	1950–1966 REAL ROR	1950–1966 EQUIVALENT ROR	1950–1982 EQUIVALENT ROR
EXXON	7.1	7.2	7.1
MOBIL	6.4	5.8	7.2
U.S. STEEL	6.6	6.9	6.0
AMOCO	4.3	3.4	5.4
(*) DUPONT	10.6	11.5	8.9
DOW CHEMICAL	7.2	6.6	7.9
AMERICAN CYANAMID	5.8	6.6	5.1
ALLIED	4.8	5.9	4.1
UNION CARBIDE	6.4	7.8	5.4
MONSANTO	8.2	8.6	7.6
(*) U.S. STEEL	3.7	4.4	2.7
(*) BETHLEHEM STEEL	3.7	5.0	2.9
AMERICAN CAN	4.4	5.3	4.0
ALCOA	5.1	5.6	4.8
GOODYEAR	3.8	3.8	3.8
INTERNATIONAL PAPER	7.9	9.2	7.1
GENERAL ELECTRIC	9.3	9.4	9.1
WESTINGHOUSE	3.2	3.0	3.4
(**) GENERAL MOTORS	7.6	0.1	6.6
(**) FORD	N.A.	N.A.	N.A.
(**) 3M	14.9	16.0	14.3
(**) KODAK	10.1	10.3	9.9
(**) IBM	11.6	12.6	11.0

(*) THE YEAR 1982 IS NOT INCLUDED

(**) ASSUMED LIFETIME IS 10 YEARS

Table 15

THE EFFECTS OF DELAY, ACCELERATED CASH FLOW, INVESTMENTS THAT ARE UNDERESTIMATED AND DIFFERENT ASSUMED LIFE TIME ON AVERAGE ROR

Period of Estimate:1955–1982

COMPANY	BASE CASE n=20	n=15	n=25(**)	2 YEAR DELAY	(***) ACCELERATED CASH FLOW	UNDERESTIMATED INVESTMENTS(*)
EXXON	6.6	6.7	6.5	6.1	6.9	6.0
MOBIL	7.0	7.0	7.0	6.3	7.1	6.6
U.S. SHELL	5.8	5.9	5.6	5.6	6.0	5.5
AMOCO	5.6	5.7	5.5	5.4	5.6	5.2
DUPONT (1)	7.7	8.7	7.4	7.1	8.1	7.0
DOW CHEMICAL	7.4	7.7	7.3	6.9	7.5	7.0
A. CYANAMID	4.9	5.0	4.7	4.4	5.0	4.4
ALLIED	3.9	3.9	3.8	3.4	4.0	3.5
UNION CARBIDE	5.1	5.0	5.0	4.6	5.3	4.8
MONSANTO	7.1	7.3	7.0	6.8	7.2	6.9
U.S. STEEL (1)	1.9	1.7	2.2	1.6	2.3	1.1
BETHLEHEM STEEL (1)	2.4	1.9	2.7	2.4	2.6	1.7
AMERICAN CAN	3.6	3.5	3.6	3.0	4.3	2.9
ALCOA	4.4	4.3	4.3	4.1	5.0	3.9
GOODYEAR	3.8	3.7	3.8	3.3	4.3	3.3
INTERNATIONAL PAPER	6.6	6.6	6.5	6.1	6.7	6.3
GENERAL ELECTRIC	9.0	9.7	8.9	8.2	9.6	8.5
WESTINGHOUSE	3.5	3.4	3.5	3.1	3.4	2.9
GENERAL MOTORS (2)	6.0	4.9	6.5	5.3	6.4	5.4
FORD (2)	4.7	5.6	5.3	4.4	4.9	4.4
3M (2)	13.9	12.2	13.8	12.4	14.4	12.7
KODAK (2)	9.7	9.7	9.7	9.0	9.7	8.9
IBM (2)	10.9	9.9	11.0	10.6	11.4	10.7

(1) – The Year 1982 is not Included

(2) – The Base Case Was Calculated for Assumed Life Time (n) of 10 Years
The Other Two Cases are 7 and 20 Respectively

(*) The Investment of the Base Case Was Increased by Adding 5% of Operating Expenses

(**) Period of Estimate 1960–1982

(***) See Text Equation A–1

TABLE 16 Financial Data for Several Companies in Constant Dollars - (1981) in Millions of Dollars

	(*) Year	Sales	Net Assets	Net Income	Depreciation	Interest	Investment	Exploration	R.D.	Dividends	Working Capital
Exxon	1940	5032	7917	606	528	26	1016	189	N.A.	293	2906
	1960	26745	20325	2103	1528	89	2093	615	N.A.	56	7610
	1980	110370	28088	5672	2641	493	8978	1353	523	2595	18252
Mobil (**)	1940	3160	3822	245	298	26	426		N.A.	78	1184
	1960	2025	8073	391	668	35	892	234	N.A.	298	3429
	1980	62621	15072	2641	1391	571	4379	625	156	810	4502
U.S. Steel	1940	1672	1610	98	172	17	155	N.A.	N.A.	N.A.	562
	1960	6201	3948	441	596	15	792	192	N.A.	181	1473
	1980	19254	8962	1421	1053	236	2442	523	176	471	259
Amoco	1940	2053	4117	268	189	5	334	N.A.	N.A.	148	1105
	1960	6104	6763	435	603	48	871	N.A.	N.A.	174	2702
	1980	28961	10193	1478	1424	273	3421	982	N.A.	649	2785
DuPont	1940	2325	4033	296	113	-0-	232	-o-	N.A.	267	895
	1960	6624	8210	1235	482	31	651	-o-	249	1002	5523
	1980	18521	8671	780	1023	358	1798	-o-	627	450	7929
Dow Chem.	1940	N.A.	236	40	34	2	83	-o-	15	19	N.A.
	1960	3035	1808	195	260	17	360	-o-	143	118	581
	1980	11349	4980	671	779	399	1179	-o-	361	364	4628
Amer.	1940	N.A.	380	33	26	1	89	-o-	N.A.	25	198
Cyanamid	1960	1801	1295	154	147	14	193	-o-	N.A.	102	1421
	1980	3998	1586	159	151	41	203	-o-	156	85	1908
Allied	1940	1197	1050	121	76	-o-	76	-o-	N.A.	100	508
	1960	2355	1489	153	183	20	233	-o-	80	110	612
	1980	5601	1786	233	288	136	373	155	127	102	902
Monsanto	1940	322	298	37	18	-o-	41	N.A.	N.A.	23	72
	1960	2407	1687	187	213	30	302	11	N.A.	74	1108
	1980	6915	3357	359	427	114	701	-o-	219	130	32951
Un.Carbide	1940	2672	1887	294	102	8	173	-o-	N.A.	314	1010
	1960	4649	2946	476	394	52	549	-o-	N.A.	325	2022
	1980	10661	5219	817	332	183	1393	-o-	195	229	5420

(*) The values are average over five years around the indicated year.

(**) Exploration is considered as an investment.

TABLE 16 (Continued)

	Year	Sales	Net Assets	Net Income	Depreciation	Interest	Investment	Exploration	R.D.	Dividends	Working Capital
U.S. Steel	1940	6715	8705	521	523	28	504	-o-	N.A.	382	468
	1860	10733	10010	741	653	49	1201	-o-	N.A.	564	1002
	1980	15513	6195	261	638	217	938	-o-	N.A.	172	3305
Beth.Steel	1940	4673	3058	195	204	35	163	-o-	N.A.	94	3305
	1960	6328	5034	369	341	15	378	-o-	N.A.	330	987
	1980	7227	2537	-141	401	83	502	-o-	N.A.	66	1925
Amer. Can	1940	982	761	95	35	1	63	-o-	N.A.	67	302
	1960	2905	1406	112	88	29	169	-o-	N.A.	94	1036
	1980	4605	1102	58	98	176	198	-o-	46	59	1725
Alcoa	1940	281	936	177	75	1	52	-o-	N.A.	84	208
	1960	2352	2128	142	213	46	224	-o-	N.A.	78	1492
	1980	4764	2788	320	335	104	518	-o-	60	110	2280
Gen. Elec.	1940	2787	1563	236	68	1	114	-o-	N.A.	220	497
	1960	12292	4144	689	336	26	342	-o-	N.A.	498	2407
	1980	24205	8581	1593	752	266	1588	-o-	713	669	3905
Int. Paper	1940	853	780	46	51	-o-	43	-o-	N.A.	26	199
	1960	2873	2324	204	172	-o-	203	-o-	N.A.	118	988
	1980	4805	2864	354	204	66	562	-o-	41	126	1792
Good. Year	1940	1414	655	56	52	8	59	-o-	N.A.	8	912
	1960	4256	1671	202	148	26	213	-o-	N.A.	81	3607
	1980	8503	2295	226	229	216	320	-o-	191	95	5802
Westing-House	1940	1456	235	95	44	-o-	46	-o-	N.A.	61	516
	1960	5376	2640	203	140	27	162	-o-	N.A.	115	3517
	1980	8517	2692	289	211	116	572	-o-	196	122	2475
Gen. Motors	1940	11321	7371	1200	317	-o-	595	-o-	N.A.	865	431
	1960	38195	17437	2893	1243	51	2835	-o-	N.A.	1933	4412
	1980	69565	19890	1611	4261	784	7621	-o-	2391	1351	7996
Ford	1940	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	1960	19751	8697	1037	1515	41	1621	-o-	N.A.	469	1267
	1980	43971	9876	-583	2178	299	3014	-o-	1907	345	1438
3M	1940	151	68	31	8	-o-	16	-o-	N.A.	15	5
	1960	1679	1013	194	73	-o-	142	-o-	67	92	221
	1980	6531	3656	682	286	33	551	-o-	304	364	4607
Kodak	1940	1196	1152	122	55	-o-	67	-o-	N.A.	96	68
	1960	2947	2110	362	127	-o-	192	-o-	N.A.	240	562
	1980	10349	4781	1251	445	11	987	-o-	587	571	6925
IBM	1940	353	358	63	44	25	73	-o-	6	42	8
	1960	4953	3207	592	682	45	994	-o-	N.A.	163	684
	1980	29601	18373	3875	2675	392	7793	-o-	2878	2153	8015

ROR has to be computed by Eq. 2 based on the cash flow given by Eq. (15). Note that the estimate of ROR always falls between that for n=20 and n=10 assuming constant CRF. As for a growth company, these are nearly equal, the effect is quite small. Assuming a changed CRF over the lifetime of the project is in our estimating procedure equivalent to varying n. As has already been shown, the estimate is insensitive to n for a growth company, and it should also be insensitive to this assumption.

The annual reports contain sufficient information to allow an estimate of the ROR on capitalized investments. Sufficient data for estimating the ROR on total investment is usually unavailable. However, one can check the sensitivity of the estimate of ROR to underestimating the total investment. In Table 15, the RORs are recalculated (n=20 for basic industries, n=10 for companies with shorter investment life) assuming that 5% of the total operating expense is really an investment expense. This increases the total investment each year. However, this investment must also be considered as a reinvested profit in that year. In a pure growth company, this should have no effect. In a steady state company it will strongly reduce the ROR. Thus, for example, if the ROR (capitalized) in a steady state company is 6%, increasing the yearly investment by 50% (counting it also as a reinvested profit) would reduce the ROR to 3.4%. The results are also given in Table 15. For most companies the sensitivity of the estimate of ROR to increasing the investment is small. ROR is reduced by 0.5 to 1.0%. As would be expected, companies with low growth rates, such as U.S. Steel and DuPont, show a higher sensitivity than companies with a growth rate close to the ROR. Therefore, if one is interested in the real time value of money, the results in Table 8 slightly overestimate the rate of return on total investment.

6. Summary

6.1 Discussion

In the preceding, a method was described that allows one to estimate the overall historic return on investment of industrial companies for which annual reports are available for long periods. The method does not allow evaluation of individual projects, but it gives reasonable bounds on the actual return on investment obtained. Of special interest are the estimates for the periods of 1950-1970 which was the period where American industry grew and became a powerful force in the world economy. The main interest here was in large, successful companies, especially in basic industries such as oil, chemicals and steel.

If one considers only the basic industries (which in that study are represented by Exxon, Mobil, U.S. Shell, Amoco, Dow, American Cyanamid, Allied, duPont, Union Carbide, Monsanto, U.S. Steel, Bethlehem Steel, Alcoa, American Can, Good Year and International Paper), then over this time span, the rate of return on actual capital investment on a constant dollar basis was 5-7% for the four oil companies, 3-8% for the six chemical companies, and 1-6% for the steel companies. Note that these estimates probably overestimate the average ROR for these industries as only the largest and most successful companies were chosen for analysis. Thus, the RORs given here represent the historical ROR for successful companies.

These RORs computed by a backwards estimating technique cannot be directly compared to the ROR that was originally used in estimating the return of investment by the decision makers in each company. For example, in most chemical plants and refineries, the lifetime is limited in the estimate to 15-20 years. In fact most refineries of Exxon, Mobil, U.S. Shell and Amoco are more than 25 years old and the same applies to many chemical plants of the chemical companies. Part of the 6-7% ROR was obtained by a much longer life than originally assumed. If they would have only lived for 20 years, the ROR of these companies would have decreased by 1-2%.

The RORs given in this work are considerably lower than the investment criteria used by many companies. Today, the "hurdle rate" for investment in the oil and chemical industries is often 15-20%. A hurdle rate is the minimum ROR required by a company to justify a new investment. These rates are far higher than any historical rates and if stringently applied will cause a cessation of new investments with disastrous, long term results to the industry (Ref. 4, 5).

It is true that these hurdle rates contain risks, but often they are applied in a uniform way. Risk analysis should be done separately.

It is somewhat ironic that the pressure for higher returns caused by inflation and higher real interest rates occurs at a time when the ROR of large industries has been steadily declining for 15 years.

A little reflection will show that while a company may earn ROR of 15% in its formative years, it is not possible to maintain that kind of ROR once a certain size is achieved. In the distant past, when the oil industry was young, it probably had much higher rates of return. Otherwise it could not have been able to accumulate the wealth for self-financed growth. But once it grew it had to obtain a lower return and growth rate. If the companies that split from Standard Oil all had a real return of 12% a year over the long run and reinvested it at this return, they would today own the U.S. and their production would be equal to the GNP. Thus, there is a limit to growth and high returns in every industry. The following argument illustrates it: The annual inflation adjusted growth rate for the GNP was 4.0% for the period 1939-1980. Over the same time period manufacturing sales grew at a rate of 3.0%. The average growth rate in sales for the companies is shown in Table 11.2. The percentage of all manufacturing sales represented by these companies for 1939, 1955 and 1980 is shown in Table 12. Note that the four oil companies account for 2.4% of sales in 1939 and 12.5% in 1980. The 23 index companies represent 7.1% of sales in 1939 and 27.1% in 1980. These percentages are consistent with the growth rate of 5-8% shown. If one assumes a real inflation adjusted growth rate of 10%, then the oil companies would account for 35% of all manufacturing sales and the 23 companies would account for 105%. If one assumes a growth rate of 15%, then the four oil companies alone would account for 218% of total manufacturing sales and the 23 companies for 650% of all manufacturing sales.

The implications of this analysis are that large companies by virtue of their size alone have to accept lower average RORs, even though individual smaller projects may have higher RORs. Smaller companies which are also higher risk may generate higher RORs but cannot do so indefinitely. That does not necessarily imply that small companies on the average have a higher ROR on growth. The fact that the groups reported have a better performance than the total average of manufacturing industries also does not support such a conclusion. High risk ventures can bring high returns as well as losses.

For a very large chemical company, concentrating on investments with potential high returns may simply mean investing in high risk ventures. The average return on these may not be that high, and may not fit the structure and strength of the company. Before investing solely in specialty chemicals or biotechnology, it may be worthwhile to make a mass balance of the total potential market.

The analysis of historical ROR also has troubling implications for today's high interest economy. If the real inflation free interest rate is 6%, then it is hard to justify investments with a mean ROR of 5-7%. Historically, industry grew by borrowing at real interest rates of 0.5-1.5% and earning 4-6% on their investments.

Perhaps increased tax credits, accelerated depreciation and inflation adjustments for depreciation of old investments would allow internal generation of funds for investment, reducing the need to borrow. In other words, lower effective tax rates reduce the burden of high interest rates (Ref. 6).

It is hoped that the methods outlined here will be useful to the professional and managerial segments of our industry. A knowledge of the real past returns on investment is crucial to formulating rational investment decisions for the future. In this thesis a method is given for obtaining estimates on the true ROR for a wide number of industries using publicly available information. The manager of a given company with access to the detailed records of his own company will be able to obtain even more accurate estimates.

These results have implications at the national level. In Part II it is shown that high expected rates of returns produce inflationary forces on the economy. The policy makers should therefore take into account those effects while considering a fiscal and monetary policy.

6.2 Directions for Further Research

The long range growth of a company and the strength of the economy in an increasing competitive society, depends on a series of prudent investment decisions. More research is required to better understand and redefine the limits of the tools we use in investment analysis. One problem management faces in the investment-decision process is coping with the uncertainties of the future. Research is needed to locate and evaluate a company's pattern and its investment policy over the years. A solid knowledge, such as of relationships, can be be very helpful for management, and can reduce uncertainties of the future.

A study of the following three problems can contribute to improving the investment decision process in basic industry:

(1) The limits, the proper use and the correct interpretation of the discounted cash flow method (D.C.F.) should be further analyzed. It was shown in Chapters 4 and 5 that companies are using unrealistic rates of return in the process of investment analysis. One of the results of using unrealistic rates of return (companies use 15%, while on the average they obtained 3-7%) is to favor a short-term over long-term investments. Basic investments, research and development and other similar investments which have a good real rate of return, become unattractive if a high discounted rate is being used.

Some other points should be studied. Is the DCF a unique criterion? Have all costs been counted and is the DCF method independent of our objective function? (i.e., when investing money does one want to live off the investment dividends or is it preferable to achieve the maximum growth of the investment, then sell it at the end of the period). These are not two identical objective functions.

(2) Comparing studies of corporates from USA and other countries can give a quantitative description of the relationship between investment policy and the financial strength of a company. A better understanding of long-term effects based on historical analysis of an essential period of fifty to sixty years can help the company's plans and strategies.

(3) Further studies should focus on adjusting the modoel of growth to a real company. Corrections should be taken to include external flows in the model. The convenience of the model of growth (which requires much less data than all the other methods) causes it to be a very attractive method. It is also helppful in understanding the company's development.

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PART II

RETURN ON INVESTMENT
DURING TIMES OF INFLATION.
THE AUTOCATALYTIC EFFECT OF INFLATION

7. Introduction

In the last few years, especially since the oil crisis in 1973, the rate of inflation in the U.S. has accelerated to above 10%. This sometimes lets us forget that inflation of a lower rate of 1-3% has been with us for the last 30 years at least. This sudden increase had a special impact on capital intensive industries such as the process industries. In the following a special aspect of inflation of interest to the chemical industry or any capital intensive industry is discussed. That is the autocatalytic or self-accelerating nature of inflation. Part II focuses on the effect of inflation on product cost in capital intensive new plants. In addition to escalation of the cost of putting up the plant, inflation is also affecting the expected rate of return and the interest rate. A quantitative study of these effects is given.

We live in a society in which a large fraction of the goods that we consume or export come from capital intensive industries. In a chemical plant the amount of labor that goes into the construction of a plant, (including steel production and equipment manufacture) is almost equal to total labor needed for operating the plant over its total projected life. Our wealth comes mostly from production which is heavily front loaded in the sense that a large part of the total production cost during the life of the plant occurs during the construction of the plant. This is not only true for chemical industry but increasingly true for a large number of other industries.

In capital intensive industries the cost of capital represents 50-70% of the total product cost. The more efficient a plant becomes, the higher the percentge of capital cost in total product cost. Since 1965 the general inflation has increased costs by a factor of 2.5 (see Ref. 3). Equipment and construction cost have inflated even more so that a new plant costs at least 2.5 times more today than in 1965 (see Ref. 7). In 1965 the estimated investment in a refinery was $2000/barrel per day (see Ref. 13). This gives an investment of $6 to refine a barrel per year. In 1965, if one borrowed $6 from a bank at the prime rate (5%), the yearly payment for a twenty year loan would have been 43.6 cents. In 1981 the prime rate was 13%-15%. This correlates well with inflation, as in both cases the inflation free interest rate is 3%. At 13% the yearly payment on the same yearly payment for a $6 loan would be 85.4 cents or practically double.

Between 1965 and 1981, the consumer price index rose approximately by a factor of 2.5. If the cost of building ar refinery had kept pace exactly with inflation, it should have cost $5,000 per barrel/day or $15 per barrel per year. If the interest rate would have stayed at 5%, the yearly payment would have been 109 cents (which is the same as general inflation). However, the interest rate rose to 13% and the loan therefore cost 212 cents per year or almost five times as much. If instead of loaning the money we would have invested our own money, we would have to pay taxes on it before recovering our investment. Furthermore, an equity investment requires a higher return than the prime rate. The risk is higher and the company has to pay taxes before it can obtain any return. The common DCF rate of return was 7% in 1965 and 15% in 1981. An investment of $6 would have required a return of 83 cents per year or a cost of 83 cents/barrel. An investment of $15 at 15% in 1981 would have required a return of 409 cents/barrel, again almost five times as much.

The capital charge is 60% of refining cost and therefore the cost of refining oil in a newly built refinery has increased much more than general inflation. While the general inflation increased the cost of building a refinery, the higher interest rate caused by the increased inflation amplified the effect of this increase on the cost of refining a barrel in a new refinery. This is the essence of the self-accelerating or autocatalytic nature of inflation. It applies to all capital intensive or front loaded industries.

8. The Effect of Inflation on Product Cost

8.1 Background

The actual effect on refineries (and all other industries) was made worse by the fact that investment cost to refine a barrel of oil per day did not just increase to $5,000 (due to a general inflation of a factor of 2.5) but to $10,000 (see Ref. 13). $3,500 of this incremental cost was due to differential inflation in construction (7), mainly caused by lower labor productivity. Approximately $2,000 was caused by environmental laws and regulations. The higher construction cost and lower labor productivity in construction (7) are another underlying effect that increases inflation in the sense that it makes all production from new plants much more expensive than production from older plants.

The increase in interest rate was justified by inflation. In 1965 the average inflation rate was close to 2%. Before 1981 there was a period of continuous inflation at a rate close to 10%. The lender adds the expected rate of inflation to the interest to preserve his capital. This increase in capital cost not only increases the capital charge for the investment but increases the relative cost of the working capital.

An inflation of 10% will increase the plant cost and operating cost by 10%. However, if the inflation increases the interest cost from 5% to 13% it increases capital cost from a loan by a factor of 1.8. If capital cost is 50% of product cost, the total increase in product cost in a new plant is 54% instead of 10% [1.1(0.5x1.8+0.5)=1.59]. In many industries such a large factor is hard to overcome by technological innovation. To justify new plants, product prices have to rise 50% above inflation. This creates a strong inflationary pressure on products for which there is not sufficient production capacity. This self-accelerating or autocatalytic effect of inflation will be discussed in the following sections.

8.2 The Effect of Capital Cost on Product Cost

The importance of capital cost is illustrated in Table 17. A published cost estimate for gasoline from coal (8) is given. Capital cost is here defined as the cost of depreciation, plus the after tax profit required to assume a minimum return on investment (which represents the time value of money) and the taxes that have to be paid to realize this return. All these are prorated per unit of product and included in standard cost estimates as capital cost (for an example see appendix Table AI). Similar considerations are applied to almost all chemical materials. Observing Table 17, it shows that about 70% of the total cost is for the return of the capital investment. The added

Table 17

BREAKDOWN OF COST OF FINANCING OF COAL TO GASOLINE PLANT

PLANT CAPACITY = 45.000 BBL/day = 89.1×10^{12} BTU/year

	$\$10^6$ (1977 $)	
DIRECT PLANT INVESTMENT (Including Start-up)	$ 1708.00	
INTEREST DURING CONSTRUCTION	$ 473.10	
WORKING CAPITAL	$ 58.0	
TOTAL CAPITAL INVESTMENT		$ 2239.1
OPERATING		$ 131.7
COAL		$ 64.3

BREAKDOWN OF PRODUCT COST ($/MM BTU)	
CAPITAL CHARGES (When 12% rate of return, no investment credit, 13 year depreciation, 20 year plant life, 48% tax)	4.81
OPERATING EXPENSE	1.46
COAL	0.72
TOTAL COST	6.99

BREAKDOWN OF CAPITAL CHARGES	
DEPRECIATION (1/20 of Total Investment)	1.21
PROFIT AT 12% RATE OF RETURN	1.76
INCOME TAX	1.76
INTEREST ON WORKING CAPITAL	0.07
	4.81

TCRR OF METHANOL PLANT

TCRR = THE RATIO OF THE TOTAL AMOUNT OF MONEY RECOVERED OVER THE PROJECT LIFE TO THE INITIAL INVESTMENT.

TOTAL RETURN OVER PLANT LIFE (20 Years) =

$$(6.99 - 2.8) \times 89.1 \times 10^6 \times 20$$

TOTAL INITIAL INVESTMENT = $(1708 + 58) \times 10^6 \equiv 1766 \times 10^6$

$$\text{TCRR} = \frac{((6.99-2.18) \times 89.1 \times 10^6 \times 20}{(1708 + 58) \times 10^6} = 4.85$$

value of the plant, excluding the raw material cost, increases to about 80%. Added value reflects the effect of capital cost on the cost of the product better than the total price, because the raw material cost itself is the added value in some other parts of the total production process. The percentage of the total investment including the mine, to the cost of the product, is quite similar to the added value. Therefore, in capital intensive industry 60-80% of the added value in a new plant represents return on the capital. Capital return is also important due to the fact that in this industry it is customary to compute the required profit from a new project almost solely based on capital return.

8.3. Effect of Inflation on Capital Costs

The autocatalytic effeect of inflation can be explained by the effect of inflation on capital cost or capital charge per unit of product, which is here defined as the total charges related to the investment in the plant (depreciation return on investment and income tax). Inflation affects the capital cost of a new product in two ways:

a) It increases the cost of putting up the plant, or the cost of the initial investment.

b) It increases the expected return of capital for two reasons:

Inflation increases the average rate of interest and therefore increases the rate of return the company expects to get on the project (9).

It also makes new investment riskier. The new plant has an inherent disadvantage compared to an old plant with lower capital cost. If demand or prices fall, it will be hurt more than older plants. Higher risks require a higher expected rate of return before an investment can be justified.

The method commonly used for analyzing the profitability of new ventures is called discounted cash flow analysis, and the resulting costs is a function of the rate of return expected on capital investments (ROR), and the tax laws. Computing the expected return on a capital project involves some quite complex computations that have been adequately described in detail in the literature (12). For our purposes we can strongly simplify that (4). In that paper the concept of total capital return ratio TCRR was introduced. It simply measures the ratio of capital cost that has to be charged to the product for the specific investment per unit produced. The specific investment is computed by dividing the total investment by the total number of units that are expected to be produced in the life of the project (see Table 17). The TCRR can be obtained by computing the total capital charge during the life of the plant and dividing it by the actual initial investment.

The TCRR therefore summarizes all the considerations that go into calculations, such as interest during construction, depreciation, after tax return on capital, and taxes that have to be paid in order to obtain this return. The standard method in most industries is to do this computation without estimating the effect of inflation on production cost. The estimate of the total cost of the plant at construction includes inflation, and from then on everything is frozen and costs are computed on the basis of the first year. All we need to know to compute the capital charge is the expected rate of return and accounting rules for depreciation and taxes. The expected rate of return is normally tied to the common interest rate of the country or to what one can expect to get from risk free investment in treasury bonds. It is therefore affected by inflation, as the rate of interest of government bonds is strongly tied to inflation (9). It may not be true for any individual year but on the average it has to be true. A correlation for the last 20 years is reproduced in Table 18.

The years 1982-1984 are an exception as the prime interest rate exceeds expected inflation by more than 10%. In the long run, such a high inflation free interest rate is impossible (10). Thirty years ago when the average inflation rate was 2-3%, the standard

Table 18 EFFECT OF INFLATION ON INTEREST RATE

YEAR	% U.S. TREASURY BILLS, 3 MOS. NOMINAL	ADJUSTED INTEREST	% 4–6 MOS. PRIME COMMERCIAL PAPERS NOMINAL	ADJUSTED INTEREST	PRIME RATE CHARGED BY BANKS (%) NOMINAL	PRIME RATE CHARGED BY BANKS (%) ADJUSTED INTEREST	$ INFLATION RATE
1960	2.93	1.31	3.85	2.21	4.82	3.17	1.6
1961	2.38	1.37	2.97	1.95	4.50	3.47	1.0
1962	2.78	1.66	3.26	2.14	4.50	3.36	1.1
1963	3.16	1.94	3.55	2.32	4.50	3.26	1.2
1964	3.55	2.22	3.97	2.64	4.50	3.16	1.3
1965	3.95	2.21	4.38	2.64	4.54	2.79	1.7
1966	4.88	1.92	5.55	2.58	5.63	2.65	2.9
1967	4.32	1.38	5.10	2.14	5.61	2.63	2.9
1968	4.34	1.09	5.9	1.63	6.30	2.02	4.2
1969	6.68	1.31	7.83	2.40	7.96	2.53	5.3
1970	6.49	0.56	7.72	1.72	7.91	1.90	5.9
1971	4.35	0.05	5.11	0.78	5.72	1.36	4.3
1972	4.07	0.75	4.69	1.35	5.25	1.89	3.3
1973	7.04	0.79	8.15	1.84	8.03	1.72	6.2
1974	7.89	-2.80	9.87	-1.02	10.81	-0.17	11.0
1975	5.84	-2.99	6.33	-2.54	7.86	-1.14	9.1
1976	4.99	-1.71	5.35	-0.43	6.84	0.98	5.8
1977	5.27	-1.15	5.60	-0.15	6.83	0.74	6.5
1978	7.22	-0.45	7.99	0.27	9.06	1.26	7.7
1979	10.04	-1.13	10.91	-0.35	12.67	1.23	11.3
1980	11.62	-2.26	12.83	-1.20	14.70	0.44	14.2
1981	14.54	4.13	15.10	4.64	16.22	5.65	10.0

Table 19a TCRR FOR DIFFERENT INFLATION RATES AND DEPRECIABLE LIFE (INCOME TAX RATE IS 50%)

CASE		RATE OF INFLATION	ROR (%)	REAL RATE(%) OF RETURN	TCRR 10% TAX CREDIT	TCRR NO TAX CREDIT
1.a	D.L. = 13 YEARS	0	5	5	1.87	2.23
(*) 2.a	D.L. = 13 YEARS	2	7	4.9	2.44	2.84
3.a	D.L. = 13 YEARS	5	10	4.8	3.54	4.12
4.a	D.L. = 13 YEARS	10	15	4.5	5.85	6.73
5.a	D.L. = 13 YEARS	15	20	4.3	9.00	10.21
1.b	D.L. = 10 YEARS	0	5	5	1.80	2.16
2.b	D.L. = 10 YEARS	2	7	4.9	2.33	2.75
3.b	D.L. = 10 YEARS	5	10	4.3	3.39	3.91
4.b	D.L. = 10 YEARS	10	15	4.5	5.66	6.54
5.b	D.L. = 10 YEARS	15	20	4.3	8.74	9.95
1.c	D.L. = 5 YEARS	0	5	5	1.71	2.04
2.c	D.L. = 5 YEARS	2	7	4.9	2.10	2.54
3.c	D.L. = 5 YEARS	5	10	4.8	3.19	3.70
4.c	D.L. = 5 YEARS	10	15	4.5	5.17	6.04
5.c	D.L. = 5 YEARS	15	20	4.3	8.16	9.34

* Income Tax Rate is 48%

Table 19b TCRR FOR DIFFERENT INCOME TAX RATES

CASE		TCRR INFLATION RATE = 0%	TCRR INFLATION RATE = 10%
I.T. = 0%	D.L. = 10 years	1.68	3.40
I.T. = 10%	D.L. = 10 years	1.78	4.16
I.T. = 25%	D.L. = 10 years	1.90	5.10
I.T. = 50%	D.L. = 10 years	2.16	6.54

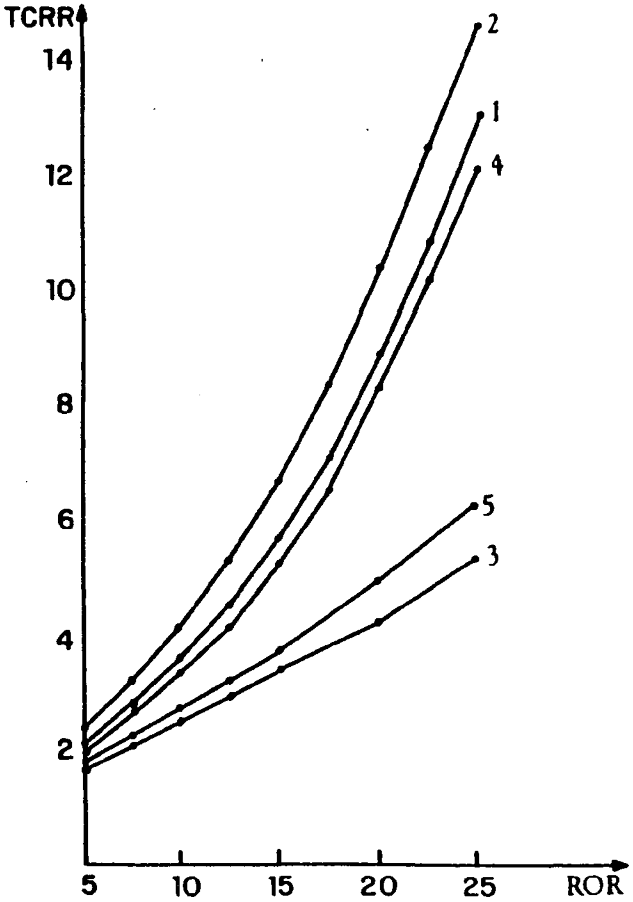
I. R. = Inflation Rate

D.L. = Depreciable Life (sum of the year digits)

I.T. = Income Tax Rate

rate of return on investment (ROR) in the chemical industry was about 7%, today it is about 15 or 20%. An inflation adjusted return of 5% is very good for any investment. A rate of return of 15% in a basic heavy industry therefore implies that the expected inflation rate is at least 10%. However, increasing the ROR on the base case from 5% for no inflation to 15% with 10% inflation, increases the capital cost much more than 10% as can be seen in Table 19, (the TCRR increases approximately 180% for each of the cases), which gives total capital return ratio as a function of rate of return, taxes and life of project. In Table 19, it is assumed that for all cases the desired inflation-free return on investment is close to 5% by taking ROR, which is 5% above the inflation rate. We can then compare the increase of capital cost due to the increase of rate of return with the average inflation rate, by putting the ROR on a consistent base with inflation. One way of doing that is to assume that we want our capital and interest back in constant dollars. This gives the relation between ROR (r), the inflation rate (i), both calculated annually, and the inflation adjusted return (J) (see 10): $J = (r-i)/(1+i)$. For inflation less than 15% this is approximately the difference between the interest rate to be charged and the inflation rate. In some of the cases, inflation rate of 10% can triple the TCRR and inflation rate of

FIG. 9 EFFECT OF ROR ON TCRR FOR DIFFERENT CASES



CASE	D.L.	I.T.	INVESTMENT TAX CREDIT
1	13	50 %	10%
2	13	50 %	0%
3	13	0 %	0%
4	5	50 %	10 %
5	INSTANT DEPRECIATION	50 %	0 %

D.L. = DEPRECIABLE LIFE (SUM OF THE YEARS DIGIT)

I.T. = INCOME TAX

15% can almost increase it by a factor of 5.

The increase of capital cost due to inflation is a strong function of taxes, rate of depreciation, and length of the project life. Tables 19 and 20 give therefore several base cases, a hypothetical case without taxes, as well as the standard computation common in 1967, and different asumed investment lifetime. To measure the effect of the latest 1981 changes in tax laws (investment tax credit, faster depreciation, etc.), Table 20 includes cases based on these changes. To illustrate the effect, the inflation of capital costs versus the inflation rate for several typical cases is plotted in Fig. 9. Numbers in Fig. 9 give only the effect of inflation on TCRR and they do not include the additional effect of inflation on the cost of the plant itself. Therefore, the total impact of inflation is obtained by multiplying those two effects. The trends in Fig. 9 also show that corporate taxes have a strong effect on increasing TCRR in times of inflation.

9. Self-accelerating Effects of Inflation

9.1 Non-inflation Adjusted Cost Accounting

Consider, for example, a typical chemical project in 1967 when inflation rate was about 2-3% and ROR required normally for basic industry was around 7%. The TCRR was 2.5. For the same project in 1981 the average economy has inflated by 150% or by a factor of 2.5. The direct investment cost of the plant has increased more than that, probably by a factor of 3.5 or 4, due to differential inflation. In 1981 the inflation rate was about 10% and the rate of return on investment commonly used by industry was 15%. On the other hand the tax credit for investment had been increased to 10%. These changes increased the TCRR in cost calculation from 2.51 to 5.09 or by a factor of 2. (Different companies use slightly different methods but the overall result remains approximately a factor of 2). This means that the capital charge that appears in the cost calculation increased by a factor of 7 to 8 (3.5 for the direct construction cost multiplied by a factor of 2 for the increase in capital cost).

The inflation which started in the early 70's has introduced a step function in capital cost which is expressed by the increase in the rate of return required. This step increase has a tremendous impact on all capital intensive industries and on the way we run the economy. This imbalance is a continuing force pressing for higher inflation. Luckily, a large part of our production comes from old plants, and most investments in chemical industry in recent years deal only with a small part of the total production change, thus reducing the impact on a specific product. But while the full impact is not yet felt in product prices, it reduces industrial growth and prevents many essential investments. Companies now look only for totally new products which do not compete with old products, and therefore can be priced higher. This change has introduced some new boundary conditions to capital intensive industry. It is considered almost impossible to replace a plant by a newer, more efficient process achieved by process development, which is a severe problem in the steel industry. Process development has, therefore, changed from that of the development of new processes and plants to improvement only in the operation of existing plants.

Congress has tried to encourage investment by decreasing taxes from 48% to 46%, by giving an investment credit of 10%, and accelerating depreciation. The combined effect of this is illustrated by some examples in Table 4. Consider, for example, a base year of 1967 in which the TCRR at 7% ROR and the tax laws current in that year was 2.51. With no change in the tax laws, the required TCRR at 15% ROR (10% inflation compared to 2%) increases to

Table 20 THE EFFECT OF THE CHANGE IN THE INCOME TAX LAW AND THE ROR ON THE TCRR

ROR	DEPRECIABLE LIFE (YEARS)	INCOME TAX RATE	INVESTMENT TAX CREDIT	TCRR
7%	13	48%	7%	2.51
15%	13	48%	7%	5.98
10%	5	48%	10%	3.12
15%	5	46%	10%	5.09
20%	5	46%	10%	8.16

Plant Life — 20 years

Depreciation — Sum of the year digits

5.98. The recent changes in the tax law (5 year depreciation instead of 13, 10% investment tax credit) would decrease this to 5.2, still much higher than in 1967. However, simultaneously with the improvement in tax laws, interest rates increased above inflation to 15%, increasing the required ROR to 18-20%. This increases the TCRR to 8.2. The increase in interest rate, due to fiscal policy measures, has more than nullified the attractiveness of the tax incentives legislated by Congress.

Increasing production capacity by new capital investment will, therefore, introduce a step increase of the cost in new plants due to inflation and high interest rates, which will push prices up far more than the average inflation would indicate. This example illustrates what we mean by self-acceleration. If the inflation rate jumps from one level to another, the capital cost increases much more than inflation. Increasing inflation from 2 to 10% more than doubles the capital charges. This increase in capital cost due to increased interest is in addition to the increase in investment and operating cost caused by the inflation itself, and provides a driving force for further inflation. In capital intensive industries capital costs comprise more than 60% of final cost and in order for new industries to become attractive, the short term increase in prices has to be more than 70%, (0.6x1.1x2+0.4x1.1).

There is one feature of Fig. 9 that merits special interest. The curves are convex and the increase accelerates at high ROR, which is equivalent to higher inflation rates. This worrisome nonlinear feature is made worse by the income tax for companies, which increases the required return.

The calculations in the previous sections have been based on the standard method used by most industries for computing costs in a new plant based on an equity investment. A considerable fraction of the investment capital for new industry is raised by loans. The cost of capital is, in most cases, based on bank loans. Inflation in this case has a very similar effect, though taxes have less effect as interest payments are a permissible expense for tax computation. Table 21 gives the effect of interest on capital charges for a 20 year loan. A good base case would be a 5% interest (2% inflation) and one can then compute the incremental effect of inflation simply by assuming that the prime rate will be 3% over inflation. An increase in the inflation rate from 2% to 10% again doubles the cost of capital.

9.2 Inflation-adjusted Cost Accounting

The standard method (which is given in Table A-1 for cost analysis fails to include inflation in the product price. In a paper (9) a claim was made that

Table 21 TCRR FOR INVESTMENT FINANCED BY A LOAN

ROR	TCRR
5	1.60
7	1.89
10	2.35
13	2.85
15	3.16
20	4.09

this method overestimates capital costs, since such computations include inflation in the expected rate of return but do not include inflation in the product price. Hence, the product price is inflated the first year to the value needed to generate the increased rate of return. By inflating the product cost each year, one could get the same overall rate of return, which will initially give a lower required product cost. In the absence of any income tax this would totally nullify the self-accelerating effect of inflation on capital cost. The only remaining effect would be the effect of inflation on construction cost itself. With present tax laws there is still a very significant effect as depreciation is not inflation adjusted. Table 22 gives some examples for the effect of inflation on adjusted capital cost if the procedure for cost estimating recommended by (9) is adopted. It can be seen that even with the the present (1981) change in the rate of depreciation, inflation adjusted accounting cannot overcome the self-accelerating effect of inflation. The rise in capital expense for 10% inflation is 40% even if one uses inflation adjusted accounting. This is lower than the 80% increase for standard accounting, but is still a strong inflationary force.

However, inflation adjusted accounting only applies to cases where the capital is self-generated in the company or raised as equity capital. It is hard to use it for a loan as the project would have insufficient cash flow in the early years to cover the payments.

Furthermore, in times of inflation there is a justification to raise the actual inflation adjusted required rate of return above that required in terms of low inflation. Inflation is often differential. Thus, different cost elements and prices may increase out of phase with each other. This makes capital recovery more uncertain and difficult. The rate of return in a new plant or venture always contains compensation for risk. Some of the risk is technological, others deal with an uncertain market. Inflation increases the latter risk considerably and therefore justifies an increase in the real return hoped for. It is true that inflation also can cause much higher profits. Real estate increased more than inflation, and 15 years ago interest rates were lower than inflation in recent years. Anybody who invested on borrowed money, 15 years ago, made a significant profit due to inflation if the project itself was sound.

The actual self-accelerating effect of inflation should therefore be lower than computed in Table 19, but higher than in Table 20. Most companies probably use a policy inbetween. However, one has to realize that in a free market the perceived cost of investment

Table 22 TCRR FOR DIFFERENT INFLATION RATES USING THE INFLATION ADJUSTED METHOD

				TCRR	
CASE		INFLATION RATE	ROR	WITHOUT INFLATION ADJUSTED	WITH INFLATION ADJUSTED
D.L. = 13 years	I.T. = 50%	0%	5%	2.23	(2.23)
D.L. = 13 years	I.T. = 50%	5%	10%	4.12	(2.64)
D.L. = 13 years	I.T. = 50%	10%	15%	6.73	(3.17)
D.L. = 10 years	I.T. = 50%	0%	5%	2.16	(2.16)
D.L. = 10 years	I.T. = 50%	5%	10%	3.91	(2.55)
D.L. = 10 years	I.T. = 50%	10%	15%	6.54	(3.05)
D.L. = 5 years	I.T. = 46%	0%	5%	2.00	(2.00)
D.L. = 5 years	I.T. = 46%	5%	10%	3.55	(2.32)
D.L. = 55 years	I.T. = 46%	10%	15%	5.77	(2.74)

controls investment decisions and as long as industrial practice for accounting and venture analysis does not change, the self-accelerating effects of inflation are going to be very strong.

10. Summary and Discussion

Inflation, especially a change in the rate of inflation, has a strong self-accelerating effect similar to autocatalysis. The feedback circuit is via the increase in interest rate caused by inflation.

In 1965 it was claimed that for gasoline from coal to be attractive, the price of oil has to increase by a factor of 2 - from $3.00 to $7.50 per bbl (2 cents to 5 cents/L). Nevertheless, synthetic fuels have not become attractive when the price of oil has gone up by a factor of 8. Due to inflation, the cost of synthetic fuels has also gone up by a factor of 8 and environmental concerns have raised the factor to 10 (1,000% since 1965). If we discount the general inflation (250%), the increase beyond inflation is still a factor of 4. We have, therefore, discarded the plans for synthetic fuels. But the problem is not just synthetic fuels but the future of our industry in general, as all share the same problem.

Shortsighted management and an emphasis of American industry on short-term results may have made the problem worse than it really has to be (4, 11). But there are also deep underlying problems caused by inflation and high interest rates, which are beyond the capability of individial companies to solve.

Our society cannot prosper solely by manufacturing computers or becoming a service economy. Heavy basic industry was and is a mainstay of our real wealth. Economists have a mystical belief in a self-adjusting society. Very few of them have heard of multiple steady states or catastrophe theory. In view of the autocatalytic feedback circuitry by which high interest rates amplify inflation, it is very disturbing that many economists recommend high interest rates to fight inflation.

The present high interest rates are not just an effect of inflation but also a result of intentional economic policy of the Federal Reserves. There is no question that interest rates much higher than inflation will reduce inflation by causing a recession. But just like in a chemical reactor, changing an input may have multiple effects. While high interest rates reduce inflation via a recession, they also prevent a recovery by increasing the underlying inflationary pressures, which is especially dangerous due to the autocatalytic nature of this relation. The policy also prevents the U.S. from dealing effectively with some of the underlying causes of inflation which are the imbalance of payments due to the import of oil, and the ability to compete effectively in the international market.

We need to look for alternative and more effective policies and here industrial management and engineering societies could make a significant contribution.

What is needed is imaginative thinking as to how to reduce the effect of high interest rates caused by inflation, and increase the productivity of the labor that dominates capital cost. Both may be critical to the continuing health of the chemical industry, and probably to the helath of the overall economy.

Conclusions

It has been shown in this work that an historical rate of return of a company can be computed with considerable accuracy. The method used is given in chapter two and makes use of financial data which are reported in the companies' annual reports. The method is found to be highly reliable for companies with a steady performance and steady growth. A sensitive analysis, which is given in chapter 5, indicates that the method yields reasonable boundaries to the estimated rate of return for all companies investigated.

It was found that the rates of return on capital investment in the American basic industry over the last thirty years was 3-7%. These rates of return are considerably lower than the investment criteria possibly used by companies. Published evaluations presently use rates of return of 15-20%.

The average rate of return of basic industry declined over the last 15 years. The decline of the profitability of corporations is found throughout different basic industries (steel, aluminum, chemical and glass) with the exception of the oil industry. The decline in the performance of those companies during the last fifteen years, cannot be detected in those companies' financial reports as measured by returns on assets, since inflation was increasing at that period of time. Inflation due to accounting rules will artificially produce an overestimated return on assets.

The performance experienced by different companies in other industries such as automative, computers, communication, consumer products, revealed similar conclusions: 1) a decline in the companies' profitability over the last 15 years. 2) the average rate of return over the last 30 years for these companies was 3-10% which is considerably lower than the rate of return employed by the companies as their investment criteria (hurdle rate).

In the last two years, the inflation adjusted interest rate has become, for the first time, higher than the rate the companies have earned back on their investment. These high interest rates, together with the companies' investment criteria, which are too high, could cause a cessation of new investments with disastrous, long term results.

In the second part of this work, it has been shown that inflation, especially a change in the rate of that inflation, will have a strong self-accelerating effect similar to autocatalysis. It was shown that the feedback circuit works via the increase in interest rate caused by inflation. This has a destructive effect on any new plant or investment. An increase in the inflation rate has therefore a severe effect on basic industry which is, by its nature, capital intensive. The cost of synthetic fuels in a new plant was found to have increased beyond inflation by a factor of four since 1965. This illustrates the problem of the entire basic industry.

It was found that the latest 1981 changes in tax laws helped cut costs for companies; however, the simultaneous increase in the interest rate nullified that advantage.

Appendix A ESTIMATION OF CAPITAL COST IN STANDARD COST ANALYSIS

PLANT CAPACITY – N ($/Year)
TOTAL INVESTMENT – T ($)
INTEREST ON WORKING CAPITAL – K ($)
DEPRECIABLE LIFE – 13 YEARS (Sum of the Year Digits)
D_i – DEPRECIABLE AMOUNT FOR THE INCOME TAX AT YEAR i
PLANT LIFE – 20 YEARS
INCOME TAX – 50%
ROR RATE – i
S – COST (Per Year) OF DEPRECIATION, AFTER TAX PROFIT WHICH ASSURES A CERTAIN RETURN ON INVESTMENT AND TAXES TO BE PAID
SHOULD BE CALCULATED THROUGH THE FOLLOWING EQUATION:

$$T = \sum_{n-1}^{20} \frac{(S+D_i)}{2} \cdot \frac{1}{(1+i)^n}$$

IT'S SOLUTION FOR: $T = 245.\cdot 10^6$ \$
$K = 1 \cdot 10^6$ \$
$i = 12\%$

is $S = 47.3 \times 10^6$ \$
for $N = 10.\,10^6$ UNIT/YEAR WE GET:

$$\text{CAPITAL CHARGE/UNIT} = \frac{1.10^6 + 47.3 \times 10^6}{10.10^6} = 4.83\ \$$$

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