7-1-1978

The Effect Of Government Regulation On The Profitability Of Drug Manufactures

Thoman E. Thorenson

THE EFFECT OF GOVERNMENT REGULATION ON THE PROFITABILITY OF DRUG MANUFACTURERS

by

Thomas E. Thoreson

Bachelor of Arts, University of Montana, 1967

Master of Science, University of North Dakota, 1975

An Independent Study Submitted to the Graduate Faculty of the University of North Dakota in Partial Fulfillment of the Requirements for the Degree MASTER OF BUSINESS ADMINISTRATION

GRAND FORKS, NORTH DAKOTA

1978

THE EFFECT OF GOVERNMENT REGULATION ON THE PROFITABILITY OF DRUG MANUFACTURERS

by

Thomas E. Thoreson

Approved:

E. A. Christiansen, Ph.D. Date July 7, 1978
Major Professor

Table of Contents

List of Tables and Figures

Introduction

The ethical drug industry is a major component of the pharmaceutical industry. Ethical drug manufacturers produce drugs for which a physician's prescription is required, as opposed to over-the-counter drugs. This industry is characterized by competition based on innovation, with the development and marketing of new or improved drug products. Products are synthesized in the laboratories of the companies and tested prior to marketing. Relatively few products which are discovered and synthesized in the laboratory become marketable products. The reasons for this are varied. Often a company will patent a new chemical entity and prevent other companies from developing this same product. A drug may be shown to have little effect or may cause deleterious side effects. A major barrier to the development and marketing of new drug products is regulation by the government. The ethical drug industry has been regulated since 1938 by the Food and Drug Administration (FDA) under the provisions of the Food, Drug and Cosmetics Act. The function and primary mandate of this agency is to ensure the safety of medicines and all other products which are directly consumed by the public. To this end, the FDA requires extensive laboratory and clinical testing of all new drugs prior to their approval for general marketing. Following the thalidomide tragedies of the early 1960's and claims of ineffective or unsafe

drugs being released on the open market, drug testing requirements were intensified. The provisions of the 1962 Kefauver-Harris amendments to the Food, Drug and Cosmetics Act required not only safety testing but also proof of effectiveness and a summary of possible side effects. The testing process was made subject to FDA regulation. The companies were required to submit plans for clinical testing of each new product along with data from preclinical laboratory tests.

In addition to the preclinical and clinical testing of new products prior to approval by the FDA, drug safety amendments, proposed in 1977, would add yet another phase to the testing process. They would require the limiting of sales, after preliminary approval to a small control group before general marketing could begin. This group would be monitored for signs of adverse reactions.

It was suggested that increased government regulatory requirements have seriously injured the drug industry. Schwartzman charged that the FDA, by ignoring the economic impact of regulation, has hindered innovation by drug manufacturers (1). He calculated that the rate of return on Research and Development (R and D) investments declined from 12% in 1960 to a current rate of approximately 3.3%, after taxes. Sarett showed that the average development time for a new product rose from 2 years in 1960 to 6-8 years in 1968-72. Bailey stated that between the years of 1954-1961,

---

[1]Schwartzman, D.; Innovation in the Pharmaceutical Industry; 1976; Johns Hopkins Press, Baltimore & London.

224 new drugs were introduced whereas only 87 were introduced between 1962-1969, after the passage of the amendments (2).

The expenditures required to produce a new product also increased in the post-Kefauver period (Table I). In 1960 the cost

TABLE I

Annual Expenditure Required to Develop
a Constant Number of New Drugs
(Millions of 1957-59 Dollars)

N	Before 1962	After 1962
5	$12.95	$29.09
10	29.94	70.55
15	54.45	128.33
20	88.03	207.40
25	133.40	314.40
30	194.10	457.40

Source: Baily, M., J. Polit. Econ., 1972, v. 80, p. 78.

of development of a new drug was $1.3 million. This was compared with a cost of approximately $11.5 million in 1972 (3). While total R and D expenditures increased by 50% in the last five years, partially due to inflation, the development cost of a single drug rose over 200%. The result was that the industry cut back on research projects. The FDA argued that the sharp decline in innovation, as measured by the number of new drugs approved, was not a consequence of regulation but was a result of a depletion of new opportunities in biomedical knowledge. In the American Economic Review, Grabowski reported that R and D productivity declined six-fold

---

[2] Baily, M. J.; Polit. Econ.; 1972; v. 80, pp. 70-85.

[3] Sarett, L. H.; Research Mgmt.; 1974; v. 27, pp. 18-20.

in the U.S. between 1960 and 1971 while it declined only half as much in Great Britain during the same period (4). The difference was attributed to more strict regulatory procedures associated with the Kefauver amendments. Many drugs which were used successfully overseas for many years were prohibited in the U.S. as a result of FDA efforts.

Spending for R and D on new drugs gradually shifted overseas during the past five years. Domestic expenditures over this period increased 2.3% per year while expenditures by U.S. companies abroad increased at a rate of 19%, adjusted for inflation.

There has also been a shift in the output of research efforts as far as the number of companies involved in R and D. This output has become more concentrated in a few large companies as a result of the higher costs and tighter budgeting. Grabowski showed that between 1957 and 1961 the four largest companies share of research output was 24%. Between 1967 and 1971 this share was 48.7% (Table II). Since Schwartzman showed that the pharmaceutical industry accounted for 91% of all new drug research between 1960 and 1969, it was seen that the output of the four largest companies was a major source of innovation. There seemed to be a consensus that these shifts in R and D spending were adaptive measures by the industry to the adverse regulatory climate in the U.S. In the long run the lower rates of return coupled with sharply increased costs for research and development and the increased time lag for realization of profits from R and D investment, caused in part by

---

[4] Grabowski, H. G. and Vernon, J. M.; American Econ. Review; 1977; v. 67, No. 1; pp. 354-371.

TABLE II

Decline in Number of New Chemical Entity (NCE) Introductions in Post- Amendment Period and Concentration of Innovative Output by U.S. Ethical Drug Industry

	Periods		
	1957-61	1962-66	1967-71
1. Total # NCE's	233	93	76
2. # Firms having NCE's	51	34	23
3. Sales of NCE's in first three years after introduction	$1220.3	$738.6	$726.8
4. Four largest Firm's share of innovational output	24%	25%	48.7%
5. Four largest Firm's share of sales	26.5%	24%	26.1%

Source: Grabowski, G. A. and Vernon, J. M., American Econ. 1977, v. 67, no. 1, p. 365.

FDA regulation, indicated a declining research commitment by the companies. Many projects which would normally have been undertaken in the past are no longer economically feasible.

Steiner considered the government to be a key external environmental force affecting and influencing the business firm. He stated that in its dealings with business, government was quite capable of lodging unexpected burdens on particular industries and companies (5).

The main problem defined in this study is that there are several

---

[5] Steiner, G. A. and Miner, J. B.; Management Policy and Review; 1977; MacMillan; New York and London.

areas of the firms' operations which could be affected by regulatory policies and which would therefore be of concern to management. These range from the expected profitability of new drug research projects to the general attitude of the investment community and the public toward the securities of companies which were so heavily regulated. Of primary concern would be the expected profitability of R and D projects under various regulatory climates. The profitability of a research project could be affected by an increased time required to test market a drug to a small control group before general marketing could begin. This would increase the time over which development costs would be incurred and delay the realization of revenues and profits from the investment in R and D for the new product. If the increased time and monetary costs were excessive, then the profitability, as measured by capital budgeting techniques such as the profitability index or net present value analysis, would be lowered, possibly to the point where the project could not be justified on the basis of the expected monetary benefits to be derived. If a large number of such projects were rejected as too unprofitable, the amount of innovation in the firm would decrease. Therefore, the purpose of this study was to determine the effect of government-related changes in the profitability of R and D projects on the decisions by management to invest in further R and D spending. Information on rates of return for R and D investment and the length of time for cash inflows from sales of the products were used to calculate the expected profitability of R and D projects. The various capital budgeting techniques, which used the time value of money,

were evaluated for their use in decision making for R and D projects under marketing restrictions imposed by the government. Present value calculations, using the cost and income figures of other authors in the field, were used to determine if the projects which led to the development of new drug products would have been profitable using the acceptance criteria for present value analysis.

Literature Survey

Net Present Value analysis techniques have been used by other authors to determine the expected rate of return and the profitability of R and D investment. Their contributions were reviewed in this chapter. Additional information related to risk, development times and development costs was also presented.

Of the thousands of chemical compounds that are synthesized in pharmaceutical laboratories only a small percentage ever become marketable drug products. An even smaller percentage are highly successful and profitable. In 1970, according to the Pharmaceutical Manufacturers Association, 126,060 compounds were extracted or synthesized and over 700,000 were tested pharmacologically. Of these, 1,013 reached the final testing stage and only 16 were successful in passing all tests and obtaining FDA approval for marketing. Wardell and Lasagna surveyed fifteen major drug companies and reported on the number of Investigational New Drug Applications which eventually became approved New Drug Applications. Their results showed that, by April 1974, only 7.1 percent of all Investigational New Drug Applications filed from 1963 through 1967 had resulted in approved New Drug Applications (1). The data

---

[1] Wardell, W. and Lasagna, L.; Conference on Drug Development and Marketing; American Enterprise Institute for Public Policy Research; 1974; Washington, D.C.

indicated only a .07 probability of a clinically tested new chemical entity being marketed. Therefore, a company that is considering a large investment in R and D faces a high level of uncertainty as to whether the investment will be profitable. This uncertainty must be considered in any capital budgeting decisions made by management.

As a measure of risk, Clymer used the attrition rate of compounds entering the development process (2). He says that the attrition rate has increased as a result of increased requirements and interpretive regulations brought about by the 1962 Drug Amendments. From 1965 to 1968 the ratio of FDA rejections to investigational new drug applications filings increased from 32% to 53%. The level of investigational new drug applications filled during this period remained fairly constant.

The time required for research and development and for approval of a new product has also increased since 1962. Sarett showed that the development times for new drugs increased from 2 years in the 1958-1962 period, to 5½ - 8 years in the period from 1968 to 1972. Development time tripled during the decade from 1962 to 1972. The average regulatory approval times in the U.S. and overseas also increased, as shown:

	1962	1969	1972
U.S.	6 mo.	40 mo.	variable
Overseas	6 mo.	9 mo.	16 mo.

[2]Clymer, H. A.; The Changing Costs and Risks of Pharmaceutical Innovation, Economics of Drug Innovation; 1970; J.D. Cooper, ed.; pp. 109-124.

Adding approval times to development time, the total time required to market a new drug product, from innovation to public availability, is 7.5 to 15 years. Schwartzman used 10 years for the estimated R and D period because he felt that this value represented an average of Sarett's and Clymer's estimates.

Sarett showed that the cost of developing a new drug rose from $1.2 million in 1962 to $11.5 million in 1973. He attributed a large portion of this increase to changes in FDA regulations. Peltzman and Baily estimated that increased regulatory stringency from the passage of the 1962 drug amendments increased the cost of R and D for a new chemical entity by 136%. Schwartzman estimated the R and D cost per new chemical entity in 1960 to be $1.02 million. In 1973 this value increased by 1,015% to $10.35 million. Mund showed that while total development costs for ethical products rose from $50 million in 1951 to $472 million in 1968, the number of new chemical entities produced by the R and D effort declined from 42 to 1956 to just 11 in 1968 (Table III) (3).

An analysis of the cost data from Table III showed that from 1951 to 1962, costs rose at an annual rate of approximately $17 million while from 1962 to 1968, the annual increase was $33 million. This indicates that after 1962, when the FDA amendments were passed, the annual R and D expenditure rate increased at a faster rate.

A major criterion for evaluating the effect of public policy,

---

[3] Mund, V. A.; The Return on Investment in the Innovative Pharmaceutical Firm; Economics of Drug Innovation; 1970; J.D. Cooper, ed.; pp. 125-138.

TABLE III

Industry New Product Performance.
Company Financed R and D Expenditures
and New Chemical Entities (NCE)
1951-1968

Midpoint Year
in 10 Year Cycle

Yr	R & D Exp. (mill)	Yr	New NCE's
1951	$ 50	1956	42
1952	63	1957	51
1953	67	1958	44
1954	78	1959	63
1955	91	1959	63
1956	105	1960	45
1957	127	1961	39
1958	170	1962	27
1959	197	1963	16
1960	206	1964	17
1961	227	1965	23
1962	238	1966	12
1963	267	1967	25
1964	278	1968	11
1965	329		
1966	374		
1967	412		
1968	472		

Source: Mund, V.A., Econ. of Drug Innovation, 1970, p. 129.

such as government regulation, on investment decisions, including R and D, has been the impact of policy on the expected rate of return (4). If a proposed policy reduced the expected rate of return on investment in R and D below the level available from alternative investments, then the amount of investment in R and D would be reduced. Both Mund and Schwartzman calculated rates of return on R and D investment. They used capital budgeting

---

4 Schwartzman, D.; Innovation in the Pharmaceutical Industry; 1976; The Johns Hopkins Press; Baltimore and London.

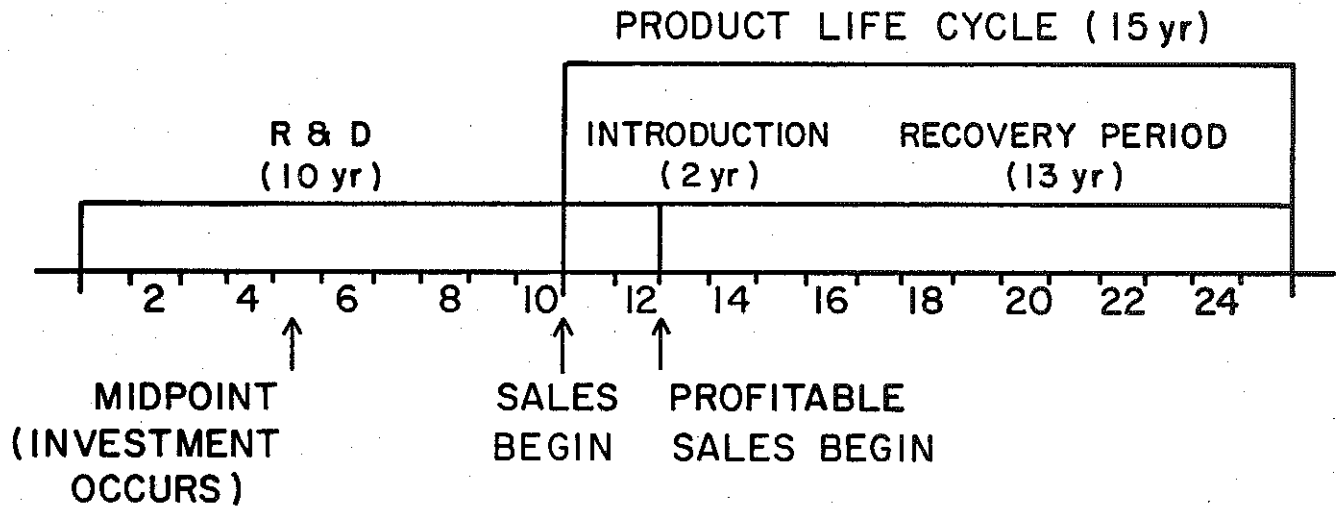
techniques which took into account the time value of money.

Mund estimated the time periods for the complete cycle of drug development, from basic research through introduction of the product to the recovery period for the investment (Fig. 1). He stated that profitability analysis in the pharmaceutical industry could be misleading, since it was usually based on the analysis of financial statements and generally accepted accounting principles. Under the matching system for balancing costs against revenues to determine profit, expenditures must either be expensed in the current year or carried forward as assets to be written off against revenue in future years. Unless it can be readily seen how certain expenditures will benefit future sales, these expenditures must be written off as current expenses. In the pharmaceutical industry it is difficult to estimate future sales, since there is a high degree of uncertainty associated with undeveloped, unproven and nonapproved drugs. As a result of this difficulty, it is necessary to use an analytical technique considering the time value of money. Mund estimated $15 million to be a realistic average of the development cost of a typical new drug product. R and D costs were deductible, so at a 50% tax rate, this amount would actually cost the company only $7.5 million. This value was used as a net after-tax cash outlay. A 10 year development period was assumed, as was a 15 year sales period (see Fig. 1).

He used a value of 13% as the average after-tax return, since it was the average earned by all industry. This value was the discount rate used in the calculations. He found the $7.5 million

Fig. 1

FLOW CHART SHOWING TIME PERIODS FROM SPECIFIC RESEARCH TO MARKETING A NEW PRODUCT



principal invested in year one increased to $17.65 million in year 8 at 13%. As annual cash inflow of $2.9 million started a year 8 and continued for 13 years to recover the investment principal.

The necessary annual sales to generate an after-tax profit of $2.9 million (the amount necessary to recover the investment, was as follows:

After-tax operating margin (%)	Annual Sales Required (Millions)
15	19.2
20	14.4
25	11.5

It could be seen that annual sales of $19.2 million were required to recover this investment within its 20 year life at an after-tax operating margin of 15%. In 1967 only 34 products of the hundreds on the market achieved an annual sales level of $10 million and only 12 achieved a $20 million level. Therefore, few drug products would yield the 13% rate of return. This would be a concern to management in the decision making process considering investment in R and D.

Schwartzman calculated the expected rate of return on R and D projects currently (1973) and for 1960. He used the formula:

$$\frac{C_1}{(1+i)} + \frac{C_2}{(1+i)^2} + \ldots + \frac{C_n}{(1+i)^n} + \frac{Y_{n+1}}{(1+i)^{n+1}}$$

$$\frac{Y_{n+2}}{(1+i)^{n+2}} + \ldots + \frac{Y_{n+m}}{(1+i)^{n+m}} = 0$$

where c = annual cost of research, Y = annual net income, i = discount rate, and n,m = number of years. This equation represents a stream of discounted expenditures subtracted from a stream of discounted income earned from the expenditures. The equation determined the rate of return from the projected streams of expenditures and income. The estimated cost of R and D for a new drug was $24.4 million, or $12.2 million after taxes. The annual rate, over a 10 year development time was 12.2/10 = $1.22. Income was estimated by adding profits and R and D expenditures and subtracting the cost of financing working capital and fixed assets, with adjustments for taxes.

Schwartzman used 8% as the interest rate for financing. The formula for finding y was:

$$y = .5 \overline{/(\text{Profits before taxes} + \text{R and D} + \frac{.08 \text{ debt}}{\text{debt} + \text{equity}}}$$

$$\overline{(\text{Working Capital} + \text{Net Plant}) - .08 (\text{Working Capital} + \text{Net Plant})/}$$

where .5 was the 50% tax rate. Net profit after taxes was 15.4% of sales. To adjust this rate to reflect the cost of financing the required investment, 2.5% was subtracted to give a profit margin of 12.8% of sales as the return on investment in R and D. He used $11 million as the estimated average level of international sales per drug product. To find annual net profits per drug, sales were multipled by the profit margin to give a $1.4 million value. In the introductory period and in the declining period of the product life cycle, the profits were lower to reflect the costs of introduction

and the decrease in profits associated with the decline stage. The costs and income were shown in Table IV. The product life cycle was

TABLE IV

Stream of R & D Costs and
Net Income for an Average
New Chemical Entity (Millions)

Year	R & D Cost (C)	Net Income (Y)
1	-1.22	
2	-1.22	
3	-1.22	
4	-1.22	
5	-1.22	
6	-1.22	
7	-1.22	
8	-1.22	
9	-1.22	
10	-1.22	
11		.47
12		.94
13		1.40
14		1.40
15		1.40
16		1.40
17		1.40
18		1.40
19		1.40
20		1.40
21		1.40
22		1.40
23		1.40
24		.94
25		.47

Source: Schwartzman, D., Innovation in the Pharmaceutical Industry, 1976, p. 143.

estimated to be 15 years. This life cycle increased since 1960, when it was 5 years. This increase was thought to be due to a decrease in the number of new drugs introduced each year. The decline was ascribed to increased difficulty in obtaining FDA

approval and in discovering and developing new drugs.

The expected rate of return was found by solving Schwartzman's equation for i. The value obtained was 3.3% when a 15.4% gross margin figure and a 15 year commercial life were used (Table V).

TABLE V

Expected Rates of Return on R & D Investments in 1973 and 1960

Yr.	Commerical Life (Yr)	Gross Margins (%) 15.4	17.5	20.0
1973	15	3.3	4.6	6.0
	20	5.1	6.3	7.5
1960	5	11.4	14.9	18.4

Source: Schwartzman, D., Innovation in the Pharmaceutical Industry, 1976, p. 144 & 151.

The gross margin figure was based on the reported figures from six large pharmaceutical companies.

The expected rate of return in 1973, which was used as a current estimate, was compared with the value for 1960. The large investments in R and D in the late 50's and early 60's were made because the rate of return was higher. In 1960, the cost of developing a new product was $650,000, after-taxes, spread over a development period of only 5 years. Some estimates of the R and D period during this time were even shorter. The same equation was used to calculate the present value of the stream of costs and income. The c values were the cost, $650,000 divided by 5 to yield $130,000 per year. The y value for a three year plateau within the 5 year product life cycle

was estimated at $280,000 per year per product. The stream of costs and income was then: (millions)

Year	c	y
1	-.13	
2	-.13	
3	-.13	
4	-.13	
5	-.13	
6		.14
7		.28
8		.28
9		.28
10		.14

Solving this equation for i gave a value of 11.4% for the expected rate of return, based on a 15.4% gross margin (see Table V).

Schwartzman noted that the decrease in the rate of return occurred sharply, immediately after the passage of the 1962 drug amendments, rather than gradually and informly over the thirteen year period. The evidence suggested a correlation between the declining expected rate of return and more stringent FDA regulation requirements since the early 1960's.

The Health Research Group of the FDA is currently considering proposals which, if accepted, would require an additional toxicity testing and would consequently delay further the development and marketing of new drug products. These proposals would also increase the costs of R and D dramatically. The restrictiveness of FDA regulations has resulted in a downward trend in the average effective patent life of new drug products. The Best Judgment Estimates of the average effective patent life of drugs approved in

1966-1969 compared with those approved in 1970-1973 dropped from 13.9 years to 12.4 years. Since this average covered all classes of drug products, the decline suggested that greater FDA restrictiveness was responsible, rather than a depletion of research opportunities. A depletion of research opportunities would be expected to affect only a few therapeutic classes of drugs. Also, the average regulatory period for drugs marketed in 1970-1973 was 5.6 years, which was 1.6 years longer than the 4.0 years in the 1966-1969 period. The new HRG proposals would increase the research period by an estimated twelve to eighteen months. In addition, the regulatory period would be lengthened so that the total R and D period would be extended by up to 2-2.5 years. This increased R and D time would likely be at the expense of the marketable life of the product. The rate of return would also expected to be reduced even further under these proposals.

Results

Problem Statement

The main problem addressed in this study was whether or not increased regulatory restrictions imposed by the government have led to a decrease in the number of new products introduced by the drug companies within the industry. The FDA has been tightening its restrictions in both the safety testing and marketing areas since the passage of the 1962 amendments. This increased regulation has affected the development times and costs and the profitability of R and D projects to such an extent that managers in firms in the industry must be more critical of projects which are being considered for investment.

Since few products survive the stringent approval process, each project must be analyzed thoroughly for potential profitability. Each must meet the required rate of return set down by management and the acceptance criteria used for determining satisfactory investments.

Capital budgeting methods, which consider the time value of money, are one way of determining the acceptability of investments. These methods have been used in one form or another by various authors in the field of economics to determine expected rates of return, over time, of R and D investments and the level of sales required to return certain rates of return on investment by the pharmaceutical

industry. These authors have not directly addressed the question of whether or not the investments have met traditional acceptance criteria for decision making by management.

Therefore, to determine if the R and D projects alluded to by these authors would be acceptable to management, the analysis presented in this study addressed the acceptability question directly. Using the capital budgeting techniques which were detailed in the methodology section, the acceptability of the R and D projects presented by Mund and Schwartzman was evaluated.

Methodology

Capital budgeting (capital-expenditure planning) is the allocation of capital among alternative investment opportunities (1). It is regarded as one of the most important functions of management in the firm. It takes into account the time value of money. According to Weston, the objective is to develop an optimum capital budget, i.e., the level of investment that maximizes the present value of the firm (2). This budget is simultaneously determined by the interaction of supply and demand forces under conditions of uncertainty. Supply forces refer to the firm's cost of capital. Demand is related to the investment opportunities open to the firm or the stream of revenues resulting from an investment decision. Uncertainty must be a part of the decision since it is impossible.

---

[1] Haynes, N. W., and Henry, W. R.; Managerial Economics: Analysis and Cases; 3rd ed.; 1974; Business Publications, Inc.; Dallas.

[2] Weston, J. F. and Brigham, E. F.; Managerial Finance, 5th ed.; 1975; Dryden Press; Hinsdale, Illinois.

to know exactly what the project will cost or what revenues will be gained. The external forces and influences affecting the firm, including government regulations and restrictions, must be considered as part of the uncertainty surrounding any investment decision. Van Horne stated that an investment proposal should be judged in relation to whether it could provide a return equal to or greater than that required by potential investors (3).

This required rate of return relates the affect of the investment decision to the share price and is thus an important consideration in maintaining the attractive investment image of the firm. A project which would not meet this level of return would not be acceptable for the investment of large amounts of funds.

For large firms investing large sums of money in research and development projects with a high degree of uncertainty, both internal and external, sophisticated techniques must be used to determine the best possible allocation of these funds. Some of the techniques commonly employed by these firms in their capital budgeting decision-making processes include net present value analysis, the internal rate of return method and the profitability index. Certain firms have used variations of each method which have resulted in highly complex, specifically tailored techniques to reflect individual acceptance criteria. A simplified explanation of each technique was presented in this section.

---

[3] Van Horne, J. C.; Financial Management and Policy; 2nd ed.; 1971; Prentice Hall; Englewood Cliffs, New Jersey.

I. Net Present Value Method

This method is one of the most widely used discounted cash flow techniques. The present value of the expected net cash flows, usually discounted at the cost of capital, is found and the initial cash outlay is subtracted to yield the net present value. If the net present value is positive the project is acceptable while if it is negative the project is not acceptable. For two mutually exclusive projects, the one with the higher net present value should be chosen. The formula for the Net Present Value is:

$$NPV = \sum_{t=1}^{N} \frac{R_t}{(1 + k)^t} - C$$

In this formula, R represents the net cash flows, such as those realized from the investment, k is the cost of capital, C is the initial cash outlay and N is the number of periods, or the time, over which cash inflows will be received. The marginal cost of capital, k could also be defined as the required rate of return since the firm must at least recover its invested funds at a rate equal to or greater than that which it must pay for those funds.

II. Internal Rate of Return Method

This method defines an interest rate that equates the present value of the expected future cash flows with the initial cash outlay. The formula is:

$$\sum_{t=1}^{N} \frac{R_t}{(1 + r)^t} - C = 0$$

where the discount rate, r, is defined as the internal rate of return. Its value is usually found by trial and error. The normal acceptance criterion used with the Internal Rate of Return method is the comparison of the internal rate of return with the required, or hurdle, rate of return. If the internal rate of return exceeds the required rate, the investment is acceptance, if not, it normally should be rejected.

Commenting on which method is the most appropriate one to use, Weston stated that if management was trying to maximize the value of the firm, it should chose the project with the highest net present value. Therefore, he concluded that firms should, in general, use the net present value method for evaluating investment proposals.

III. Profitability Index Method

The profitability index, on benefit-cost ratio, was defined by Van Horne as the present value of future net cash flows over the initial cash outlay. It is expressed as:

$$PI = \frac{\sum_{t=1}^{N} \frac{R_t}{(1+k)^t}}{R_o}$$

where R_t is the cash flow, N is the number of periods, k is the required rate of return and R_o is the initial cost. The index shows the relative profitability, or present value of benefits, per dollar of cost. A ratio of 1.0 or greater indicates that the

project is profitable and acceptable. The profitability index and the net present value always give the same accept-reject decisions but these methods can give different project rankings, depending on whether the projects being considered are mutually exclusive.

In applying capital budgeting methods to the evaluation of research projects in the pharmaceutical industry, several influences on the net present value of such projects were determined. The number of periods (years, quarters, etc.) in which cash flow were expected, the required rate of return and the initial research and administrative costs were estimated. The patent life of a drug product was used as an estimate of the number of periods in which an inflow of revenues could be expected since the products highest sales could be expected under patent protection. If, however, government restrictions on the marketing of the product were to occur, the level of revenues during the pre-marketing period would be lower than under general marketing. These uneven cash inflows in the first few periods would affect the overall net present value of the investment and result in the entire project being less profitable than it would be without marketing restrictions. Influences on the required rate of return could arise from the uncertainty involving the final approval of new products for general marketing after both safety and effectiveness testing and pre-marketing has taken place. With the possibility of fewer R and D projects surviving the increased scutiny; the firm's required rate of return on the surviving projects would be higher than before.

Therefore, proposed investments would be required to generate a higher rate of return than under less stringent government requirements for testing. Whether such products could do this successfully could not be assured. Higher initial costs incurred in starting research programs leading to a new product would be due to more elaborate animal and volunteer testing to ensure both safety and effectiveness with a minimum of side effects. More highly trained personnel and larger facilities in which to perform testing and analysis could also add to labor and overhead costs and to investment in fixed assets by the company.

Analysis

The calculations of Mund and Schwartzman were used as a basis for calculating the net present value of the investment in R and D which management would have to consider in making decisions on whether or not to proceed with projects. Since the sums of money would be quite large, this analysis and the results obtained would have considerable impact on the firm's future level of innovative activity.

To find the net present value of Mund's example, the annual cash inflows of $2.9 million would were multipled by their present value coefficients from years 8-20 to find the annual present values. The total present value obtained was then subtracted from $7.5 million to obtain the net present value of the investment. The net present value thus obtained was $7,468,788 - $7,500,000 = $31,212. The profitability index was $\frac{\$7,468,788}{\$7,500,000} = .9958$. The internal rate of return was slightly over 13% (Table VI).

TABLE VI

Applications of Capital Budgeting
Methods to R and D Investment

	Yr.		PV
	8		$1,084,093
	9		959,360
	10		849,008
	11		751,337
	12		664,906
	13		558,389
	14		520,719
	15		460,227
	16		407,803
	17		360,884
	18		319,354
	19		282,608
	20		250,099
TOTAL	PV	=	$7,468,783
	NPV	=	$7,468,783 - 7,500,000 = -$31,212
	PI	=	$\frac{7,468,783}{7,500,000}$ = .9958
	IRR	=	13%

g previously established acceptance criteria, this investment
not acceptable since NPV was negative and PI was less than one.
ied with the doubtful level of sales ($19.2 million) required
rn 13%, this investment appeared to be highly risky unless there
non-monetary factors or benefits which would make it more
active.

To calculate the net present value and profitability index
chwartzman's example, a discount rate of 10% was arbitrarily
en, since this rate was close to the overall rate of return
ired by industry in general (4). At 10%, the calculations

4 Schwartzman, D.; Innovation in the Pharmaceutical Industry;
; The Johns Hopkins Univ. Press; Baltimore and London.

he net present value was negative and the profitability

s than .5 (Table VII).

TABLE VII

NPV and PI of Average NCE
(Millions)

Annual Present Value	Total Present Value
-1,109,090	
-1,008,245	
- 916,599	
- 833,272	
- 757,522	
- 688,653	
- 626,055	
- 569,142	
- 517,402	
- 470,359	-7,496,339
164,730	
299,512	
405,524	
368,662	
335,146	
304,682	
276,976	
251,804	
228,914	
208,096	
189,182	
171,990	
156,352	
95,438	
43,381	3,500,389
NET PRESENT VALUE:	- 3,995,950

PROFITABILITY INDEX = .4669

Discussion and Conclusions

drug industry relies so heavily on R and D innovation
of products which in turn provide it with its income,
ce with or restrictions on this R and D process would
ct the income producing ability of the industry. If
turn on R and D investment was not comparable to that
e and was not adequate to sustain an R and D program,
n would eventually decline. Investors in the
these companies would not be encouraged to continue
e companies which were in such a "no-win" situation.
caught in this dilemma would be encouraged to shift
efforts to a less restrictive regulatory climate,
presently found overseas. As a result, the U.S.
receive less advanced medical health care products
ost than even before, since the products that were
e U.S. would be at a greater cost per product and would
make a high rate of return. Management in the
l be under greater pressure to make investment
the heightened degree of uncertainty regarding the
products and would be more cautious to commit
and D projects with uncertain outcomes. Capital
iques would have to be highly sophisticated to
tential costs and the effects of possible time delays

earch or regulatory periods.

tments once thought attractive would have to be re-
and possibly discontinued because of regulatory
ns.

capital budgeting methods, such as those used by
to evaluate investment decisions were applied to the
esented by Mund, the acceptance criteria indicated that
e investment in R and D was not acceptable on a purely
asis. The Schwartzman calculations indicated that the
turn on R and D investment declined almost three-fold over
ecade. The sharpest drop was seen immediately following
e of the 1962 Kefauver amendments to the Food, Drug and
Act. The average ten year development period could be
and the patent life shortened as much as two years under
roposed additional testing restrictions. The 3.3%
ate of return on R and D investment which was found by
n was less than the rate used by other industries as a
riterion, which has been approximately 10% after taxes.
e pharmaceutical industry was discouraged completely
cipating in innovative research programs to develop new
only remaining source of these programs would be non-profit
or academic facilities. Since it was pointed out that
resently accounts for approximately 90% of all new drug
search, the void to be filled by government would be
le. Since the source of operating funds for government
is tax revenue, it is conceivable that any sizeable
D program would require a large tax-financed budget.

ouragement by R and D in private industry would
overnment participation and control of health care
S.

capital budgeting techniques and acceptance
ed as the sole basis for evaluating R and D
was also uncertain. Perhaps, if a company was
relation to other firms within the same industry,
return on investment would not be as important
to other R and D investment proposals. For
could continue in the research venture as long
its marginal costs and fully utilizing its
nary pressures, which have increased the
a single drug product by 50% over the last
t the industry and have made cost figures appear
fluence has affected every sector of business,
, however, and for the purposes of this discussion
a constant.

ld be argued successfully that increased regulatory
nefited the public through safer and more
consensus of most authors in the field of
e FDA, by concentrating solely on safety and
nd ignoring the economic impacts of regulation,
eutical industry. Unless the industry is allowed
onable profit with a rate of return on R and D
sufficient to recover its costs, innovative
anies will decline. If this happens the U.S.

ace ever-increasing health care costs in the form

axation and control of another major aspect of

Bibliography

D Costs and Returns: The U.S. Pharmaceutical
ournal of Political Economy; The University of
ss; Chicago; 1972; v. 80; pp. 70-85.

he Changing Costs and Risks of Pharmaceutical
Economics of Drug Innovation; J. D. Cooper, ed.;
n University; Washington, D.C.; 1970; pp. 109-124.

and Vernon, J. M.; Consumer Protection Regulation
Drugs; American Economic Review; Banta; Menasha,
1977; v. 67, No. 1; pp. 354-371.

d Henry, W. R.; Managerial Economics: Analysis
3rd ed.; Business Publications, Inc.; Dallas; 1974.

Return on Investment in the Innovative Pharmaceutical
mics of Drug Innovation; J. D. Cooper, etc.; The
iversity; Washington, D.C.; 1970; pp. 125-138.

DA Regulations and their Influence on Future R and D;
nagement; Interscience; New York, London and Sydney;
; pp. 18-20.

Innovation in the Pharmaceutical Industry; Johns
versity Press; Baltimore and London; 1976.

ıd Miner, J. B.; Management Policy and Review;
New York and London; 1977.

; Financial Management and Policy, 2nd ed.; Prentice-
vood Cliffs, New Jersey; 1971.

Lasagna, L.; Conference on Drug Development and
American Enterprise Institute for Public Policy
ashington, D.C.; 1974.

l Brigham, E. F.; Managerial Finance, 5th ed.;
s, Hinsdale, Illinois; 1975.