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Comparison of Methods for Equipment Replacement Decisions with Emphasis on the MAPI System

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To the Graduate Council:

I am submitting herewith a thesis written by Seetharama Lakshmi entitled "Comparison of Methods for Equipment Replacement Decisions with Emphasis on the MAPI System." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Industrial Engineering.

Howard P. Emerson, Major Professor

We have read this thesis and recommend its acceptance:

Howard L. Loveless, Robert M. LaForge

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Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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To the Graduate Council:

I am submitting herewith a thesis written by Seetharama Lakshmi Narasimhan entitled "Comparison of Methods for Equipment Replacement Decisions with Emphasis on the MAPI System." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Industrial Engineering.

Howard P. Emerson
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We have read this thesis and recommend its acceptance:

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COMPARISON OF METHODS FOR EQUIPMENT REPLACEMENT DECISIONS WITH EMPHASIS ON THE MAPI SYSTEM

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Seetharama Lakshmi Narasimhan

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CHAPTER I

INTRODUCTION

It has usually been the prime responsibility of the general managers of manufacturing plants to increase the rate of return. Once an investment is made, it is largely irreversible. So the formulation of an equipment purchase or replacement policy plays a major role in achieving their goal. Since all durable goods are not like the "wonderful one horse shay" -- which lasted exactly one hundred years to the day, and fell apart completely, all at once -- the problem of when to replace them is a critical one.

The management is interested in obtaining the best possible piece of equipment among the innumerable alternatives available in the market which satisfy their requirements. There is every likelihood that a wrong one may be selected, when all the aspects concerning the project are not considered. The proper selection of equipment is, therefore, one of the most important decisions of management. One of the most helpful tools, in formulating the replacement analysis is the Economic Cost Model which in many cases is simply an equation, or a few equations, that represent the relative merits of the equipments considered for replacement. If properly developed and used, it gives a picture of the many challenging alternatives. (16) Based upon the cost model, the management can make proper decisions.

REASONS FOR EQUIPMENT REPLACEMENT

There are many reasons why an equipment should be replaced in manufacturing industries. (5, p. 183) First, improved machines operating at lower costs may be available in the market for performing the same job. Second, the type and service requirement of the existing facility may vary or change. Third, the asset itself may be deteriorated due to wear, tear and lack of maintenance. Fourth, the public requirement may change and the equipment may not be able to produce a product to meet the needs. Last, causes such as fire, flood or accident may result in rapid deterioration of the equipment. All these factors contribute to the replacement of machines.

CONSEQUENCES OF BAD EQUIPMENT POLICY

The effects of failure to recognize the importance of replacement policy have been pointed out in history. Probably the best illustration is the case of Great Britain after World War II. It was generally believed that Britain would modernize its industries soon after the war but it did not; and ended up in a technological stagnation. The British Government sent several task forces into various industries to look into the existing facilities, organizations and operating facilities in order to increase productivity. A typical comment from "The Economist" (London) of March 10, is given below: (11, p. 8)

The public has in recent months waked up to the fact that the whole wealth-creating mechanism of British Community is badly in need of a drastic overhaul. Several of the basic industries--one is tempted to say most of them--are badly out-of-date in their productive equipment and methods. An hour of work in Great Britain produces less in material product, relatively to other countries, than it used to and less than it will have to if the British people are to keep their place among those with high standards of living.

The following report was published by the Report of the Working Party on Jewelry and Silverware:

It is necessary if the trade is to enjoy robust health, that firms should be ready and keen to rebuild, renovate, and re-equip at each stage of progress as soon as it becomes commercially practicable to do so; in our opinion, that a change of policy is overdue, and devote itself whole-heartedly to the fulfillment of a rebuilding and re-equipment plan such as would put the whole industry on a thoroughly modern basis. **(11, p. 10)**

METHODS OF DETERMINING RELATIVE MERITS OF ALTERNATIVES

In determining the relative economy of the potential investment, a measure of return for each of the alternatives should be calculated. For computing the relative rate of return on investments, various methods are in existence. Five major methods are considered in the present study for determining the relative merits of alternatives.

Accounting Method

The rate of return is calculated, in this method, by dividing the income by the book value of the asset at the beginning of the year.

Payback Method

This is based on the speed with which the invested funds are returned to the business. It is in a sense the reciprocal of the Accounting Method.

Annual Cost Method

This method provides a uniform annual cost of the asset during the service life of the equipment, by bringing all relevent costs into the present worth and then spreading their total uniformly through its life period.

Rate of Return Method

This method is also called the Discounted Cash Flow Method. This method can be used with either Present Worth or Annual Cost calculations. This method yields the exact rate of return on investment.

MAPI System

The MAPI System based on the use of various charts is designed to cover all types of Capital Budgeting Decisions, including Replacements of Equipment. It was developed by the Machinery and Allied Products Institute (MAPI), the pioneers who emphasized the need for systematic replacement studies.

The purpose of this study is to review and compare these systems, giving emphasis to the MAPI System. The following Chapter II, embodies the necessity of allowing for depreciation of

assets. All of Chapter III is devoted to the history, development, and practical application of the MAPI System. Chapter IV explains in brief, the other four methods of comparing alternatives. Chapter V evaluates the pros and cons of the MAPI System, compared to other systems.

CHAPTER II

DEPRECIATION AND OBSOLESCENCE

Depreciation

The word depreciation has different aspects. Considered in a wide sense, it also includes obsolescence. Generally, depreciation measures the amount by which the value of an asset declines through time. In some cases the decline in value can be prevented to a certain extent by continually re-investing in the asset to replace what is lost. Buildings and bridges can be kept usable for a long time in the same way. But most of the industries deteriorate in due course and portions of the asset may be consumed in process of use with the following results:

1. Physical yield may decline for the asset.
2. The asset may become more costly to operate because of the frequent breakdowns involved. Or to prevent such breakdowns, costs may be increased.

Obsolescence

The above mentioned considerations cover both depreciation and obsolescence. Obsolescence can be defined as the loss in value which is due to the competition of new inventions such as the automobile, which displaced the horse and buggy and likewise the inter-urban railways. In the case of machines, changes in design or improvement of the product demand a different machine. Due to these effects of obsolescence, the value of the present equipment

goes down considerably.

PURPOSE OF MEASURING DEPRECIATION

Depreciation is used for various purposes. J. L. Meij (8) indicates four different aspects:

1. In order to compute tax-liability.
2. To decide the value of the asset in the second hand market.
3. To decide the percentage of gross profit.
4. To fix the price of the product.

Tax Liability

More write-off in the initial period reduces the tax, and more return in the initial periods, increases the overall rate of return because the manufacturer gets to use his money longer before turning it over as taxes. It also allows for more working capital for the management, soon after the heavy investment is made.

Valuation of Assets

While considering the resale value of the asset, the difference between the original and the present measures the depreciated amount.

Calculating the Net Profit

During the use of the machine, parts of the machine are consumed by the products manufactured. It must be replaced by another

machine to continue the function, as soon as it becomes useless. So depreciation allowances are included while calculating the return on investment.

Price Policy

In the majority of cases prices are fixed by existing market conditions. In the case of articles with marginal profit the manufacturer is restricted in the amount for depreciation he can take, yet the amount should be shown on the books.

All these above-mentioned factors should be considered, along with obsolescence when the amount for depreciation is allotted.

CHAPTER III

MAPI SYSTEM - HISTORY AND DEVELOPMENT

The Machinery and Allied Products Institute (MAPI) was originated in 1933. Since then the organization has been interested in problems and policies concerning the capital goods industries such as depreciation policy, the impact of taxation, and the effect of technology on employment and living standards. The institute published about thirty papers in the series emphasizing the importance of these policies in industries.

The paper "Saving and Investment in American Enterprise System" presented before the Temporary National Economic Committee analyzed critically the theory of economic maturity. This paper attracted the attention of commercial organizations and capital goods industrialists. Meanwhile the paper gained educational value and was introduced in colleges. They produced great demand for pamphlets and the institute was not able to meet the unexpected demand. (11, p. v)

Soon after World War II the institute published a book named "The Bogey of Economic Maturity," with George Terborgh as research director. The book was followed by a series of bulletins and pamphlets, such as "Investment Earnings vs. Cost Savings in Machinery Replacement" and "Capital Goods Industries and Tax Reform." (11, p. viii) Another publication analyzing the industrial stagnation in Great Britain kindled the interest of many industrialists towards MAPI concepts.

The institute published the book "The Dynamic Equipment Policy" in 1949 which was concerned with the re-equipment policies in industries. The manual was followed by a general guide to applications called "The MAPI Replacement Manual." In 1954 the institute published the book "Realistic Depreciation Policy" which analyzed the purpose and amount of depreciation allowances to be allowed.

The short-comings of the book "Dynamic Equipment Policy" underwent vivid criticism by various authors. The result was the refinement and development of the formula. This in turn led to the publication of the book "The Business Investment Policy," in 1958.

Having briefly described the history and development of MAPI, the rest of this chapter is concerned with the practical application of the MAPI System. The following discussion deals with some of the terms often encountered in the study of the MAPI System.

MEANING OF THE TERMS USED

One More Year

Unlike other methods, the MAPI System measures the urgency of the project compared with going on without it for one more year. It derives the after-tax return on the net investment in the project, as compared to the alternative, for the coming year.

Capital Consumption

As an asset ages, its capital value decreases through deterioration, obsolescence, increased maintenance cost, and decreased

performance. The capital consumption is the decline in the present value of the asset. The capital consumption value for the first year is the difference between the value of the asset at the beginning of the first year and at the end of the first year. The capital value at the beginning of the year is its initial cost. The capital value at the end of the year is the initial cost plus the interest minus the earnings obtained from the project. Therefore the capital consumption can be obtained from the first year earnings after deducting the interest, taxes, and return on equity capital. This may also be stated as the cost of utilizing the machine for one year. The capital consumption allowance can be calculated by using the MAPI formula.

The formula concerns itself with the next year costs of the existing facilities and the proposed one. It also has built into its basic formation a compensation for the effect of future technological improvements. Obsolescence and deterioration reduced the estimated annual savings of the proposed equipment every year, over the life of the equipment.

In order to project a particular pattern of earnings for the purpose of determining the capital consumption of the asset, Terborgh has made the following assumptions:

1. The initial value of the asset as its cost.
2. The rate of discount at which the services are capitalized into their initial value.
3. Continuation of the assumed rate in the future.

The calculation of the capital consumption is dealt with later.

Obsolescence and Deterioration

As we have already discussed, it is hardly possible to predict the effect of obsolescence in the case of new assets. It is random in nature. Usually, the effect of obsolescence is more during the earlier part of its service life. In contrast, since deterioration is a function of the workability of the asset, it is less in initial cases and increases in due course. It is considerable in the latter part of the asset's life since the maintenance charges and spoiled work increase during this period. This counter-balances the effect of obsolescence.

Due to this reason, it is assumed by Terborgh (13, p. 69) that the combined effect of obsolescence and deterioration is constant during the service life of the asset.

Functional Downgrading

When a machine is new it is used to perform precisional work. As the machine gets older, accuracy is lost. It is finally allotted to work which require low grade services. In many cases it is possible to reduce the effect of obsolescence by utilizing the services of the machine in low grade work. It extends the service period of the equipment. In the absence of this downgrading, if we assume that the reduction in annual savings, (run off) would proceed at a constant rate, then the presence of which will produce a concavity in the projection patterns of earning.

Projection Patterns

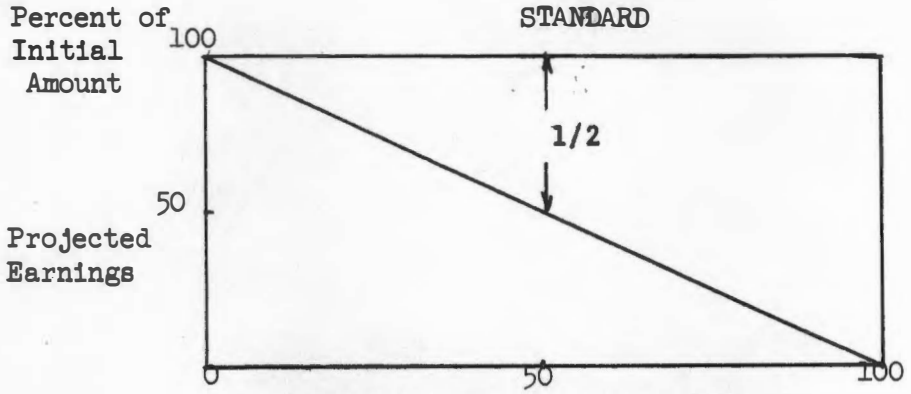
In order to determine the pattern of absolute earnings of depreciable assets in the future, Terborgh suggests three kinds of patterns. These patterns show the declining trend of earnings over the estimated life of the equipment. The earnings are measured as the proportion of the total life time run off of the asset. They are shown in the Figure 1, assuming the salvage of the equipment as zero.

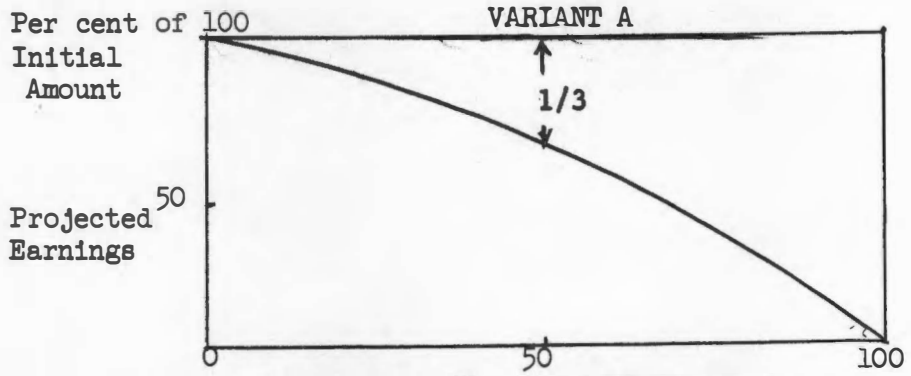
Standard. This type consumes exactly half of its life time run off capital, during one half of its life. It has a constant rate of run off accumulation of obsolescence and deterioration, as shown in the figure.

Variant A. This pattern consumes one-third of its life time run off, during the first half of its life.

Variant B. It consumes two-thirds of its life time run off, during the first half of its life.

In practice when the obsolescence and deterioration are the major factors of consideration, "Standard" type is used. If the effect of obsolescence is predicted to be slow in early life but will speed up as time goes on, "Variant A" is adopted. If the effect of which is predicted to be rapid in early years with a subsequent slow up in later period "Variant B" is taken. Also when-





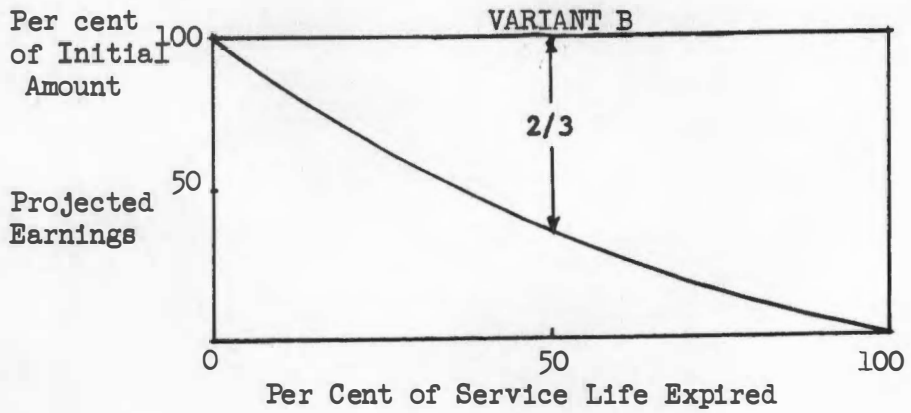


FIGURE 1

MAPI Formula Earnings Projections Assuming Zero Terminal Salvage

ever the effect of functional downgrading is foreseen, "Variant B" is adopted. If the pattern for a particular equipment can be predicted in advance, anyone of the suitable patterns can be proposed.

Calculating Capital Consumption

The three projection patterns presented are mathematical curves which make it feasible to calculate capital consumption, if the following stipulations are furnished. (13, p. 71)

1. The projection pattern
2. The estimated service life
3. The estimated terminal salvage, as a percentage of the cost of the asset
4. The assumed income-tax rate
5. Depreciation method used for income tax purposes
6. The debt ratio (ratio of the debt to total investment)
7. The interest rate on borrowed capital
8. The after-tax return on equity capital

Terborgh has derived formulas for calculating the capital consumption as a ratio to the first cost of the asset. (13, pp. 221-232) He has calculated a series of values assuming different years of service life and terminal salvage ratio. He has presented them in chart form for each of the three projection patterns of earning. The charts are built for a debt ratio of 25 per cent, interest rate of 3 per cent on borrowed capital and after-tax return of 10 per cent

on equity capital. There are two sets of curves in each chart, one for straight line tax depreciation method and another for sum-of-digits or double-rate declining-balance method. These charts give the "capital consumption allowance" of the equipment for the next year. The reason why it is indicated as capital consumption allowance instead of capital consumption is explained under the heading 'The MAPI Charts."

Since these charts have assumed in their calculations the Items 6 to 8 in the above mentioned list, only the first five items are necessary for calculating the capital consumption allowance. An example is illustrated for finding the same for an asset--given the following stipulations:

The projection pattern	Variant A
The estimated service life	Ten years
The estimated terminal salvage	20 per cent
Income-tax rate	50 per cent
Depreciation method	Sum-of-digits method

The Figure 2 is drawn for the assumptions given there itself, for an income-tax rate of 50 per cent. Therefore, from the Figure 2, the capital consumption allowance as a percentage ratio to the first cost of the asset is 3.1.

ASSUMPTIONS MADE IN BUILDING THE MAPI CHARTS

It is important to keep in mind that these charts have assumed

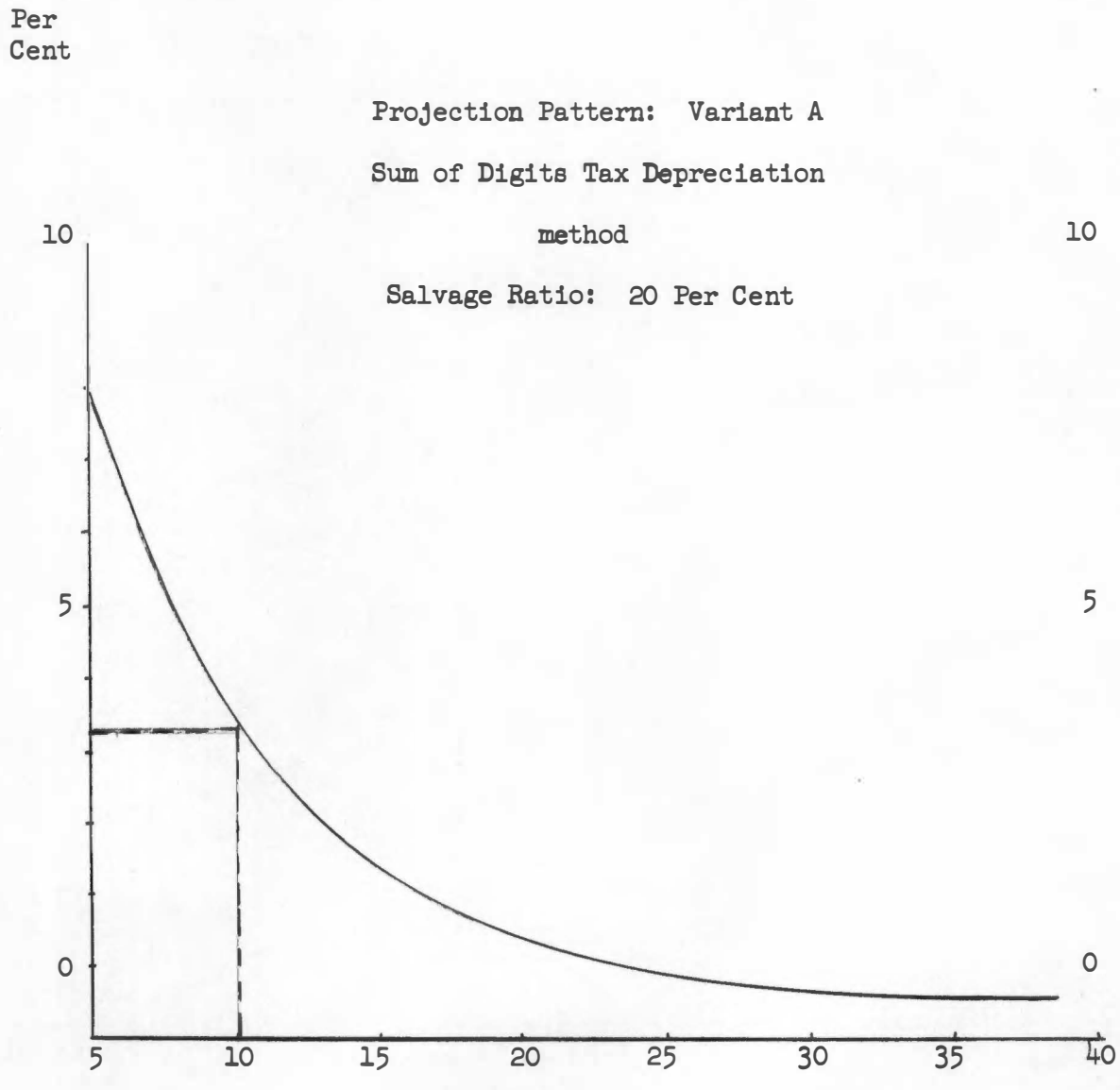


FIGURE 2

MAPI CHART

in their basic formation, a debt ratio of 25 per cent, a debt interest rate of 3 per cent and after-tax equity return of 10 per cent. (13, p. 78) This combination yields a capitalization rate of 8.25 per cent (.75 x 10 + .25 x 3).

Since most of the companies fall under the catagory of 50 per cent income tax, the charts are built for 50 per cent income tax rate. For any other income tax percentage adjustments can easily be made by following the directions given in the charts. (13, pp. 121-125)

The same curve is used for both sum-of-digits and declining-balance methods, in calculating the percentage ratio of capital consumption allowance. Terborgh has proved in Appendix H (13, pp. 242-243) that the error produced in making this assumption is negligible.

The following discussion deals with the simplified application of the MAPI Form (Table 1, Page 35) as presented in the book, Business Investment Policy. The items which are self-explanatory are excluded from discussion. A problem is also illustrated at the end of this chapter using the MAPI Method.

I. REQUIRED INVESTMENT

Installed Cost (Item 1)

In addition to the cost of the equipment, installation and transportation costs should be added. If the existing facilities were also affected by the installation of the new item, then the

expenditure involved should also be included here.

Disposal Value of Assets to be Retired by Project (Item 2)

A reasonable value of the salvage for the retired assets should be entered here.

Capital Additions Required in Absence of the Project (Item 3)

Line 2 covers the investment released by the project, whereas Line 3 concerns investment avoided by it. The new building might have prevented the rebuilding of the existing equipment. These items should be added here. "If you have an entry on this line, be sure the operational analysis of Section II reflects the benefit of the assumed capital additions to operation in the absence of the project." (13, p. 107)

The capital additions may replace certain facilities. In that case the cost of down-time, etc., should also be considered and added to the cost of addition themselves.

ESTIMATING THE ANNUAL OPERATING ADVANTAGE

In calculating the annual operating advantage of an equipment, all relevent factors should be taken into account, giving careful consideration to all irreducible and intangible items. Converting everything into dollar figures enables one to figure out and compare the relative merits of alternatives. For doing this a systematic approach is essential. As a convenient way to serve this pur-

pose, though the form may vary according to the project for which it is being used, Terborgh has suggested a Summary of Analysis Form which, hereafter, will be called the MAPI Form.

II. NEXT-YEAR ADVANTAGE FROM PROJECT

A. OPERATING ADVANTAGE

Assumed Operating Rate of Project (Item 6)

Careful consideration should be given to this item. It is the estimated operating rate of the project to be installed. It should not be confused with the operating rate of the plant. In doing so, all works that can be advantageously done by the new machine must be taken into consideration so as to yield maximum beneficial use to the project.

When the operating rate of the project is very close to that of the plant, it can be taken as the plant's rate itself. For example, suppose the plant rate of the project is two thousand hours per year. If the estimated future relation of the project hours to plant hours is 75 per cent, the plant rate is then fifteen hundred hours. When the operation rate of the plant and the project rate vary considerably, the lower one is taken for calculation purposes.

The following analysis, "Effect of Project on Revenue" is intended to figure out the effect of project on revenue as distinguished from its costs. Items 7 and 8 deal with the estimated decrease or increase in sales. In this case, the expansion of sales by the pro-

ject should also be taken into account.

Change in Product Quality (Item 7)

The effect on sales due to the change in product quality resulting from the project, should be noted here. In most cases the project will result in increased sales. Occasionally, due to economic production runs, it may also decrease.

Increased Output (Item 8)

The resultant benefit to sales, due to the effect of the new project, should be entered. Obviously it is the net change in sales from all such shifts in the volume and composition of output. If this project increases the sales of some other projects, it should also be noted.

The following section, "Effect of Project on Operating Costs," deals with the calculation of the total effect of the project on operating costs. If the project is a part of the existing business, it is necessary to include its indirect effects, in addition to the direct effects.

For example, the project may divert or free a part of the time of the existing facilities. Then the estimated savings must be taken into account. In addition to this, savings concerning the direct and indirect labor costs should be estimated, by studying the representative sample of operations, and the expected pattern of mix of work in the future. Effect of each of the items should be calculated and totalled even though they may be rough estimates

sometimes.

Direct Labor (Item 10)

All payroll costs such as overtime shift premiums and bonuses should be included. Since the estimate covers an entire year, the cost of paid holidays and vacations should also be added to it.

Indirect Labor (Item 11)

This line calls for every labor expense except the direct labor involved. If the particular project affects the labor cost of general administration, sales or purchase, the amount should be entered here. Item by item estimates of the actual gain or loss incurred must be calculated. The application of accounting burden rates to the changes of direct costs should not be used.

Fringe Benefits (Item 12)

The effect of the project on all employment costs which are not covered in the Lines 10 and 11, such as social security pensions, insurance, profit sharing, etc., should be considered here.

Maintenance (Item 13)

This item represents the ordinary maintenance only. Costs such as rebuilds and reworks should not be included here. It may occur irregularly in the life time of the equipment and therefore difficult to predict. Generally the new machines require a routine preventive maintenance charge only. The old machines will be worn and the maintenance cost will be considerable.

Tooling (Item 14)

The total expenditures for tools, jigs and fixtures are uneven. An average amount of requirement should be estimated from past experience. Tools that last longer can be taken as future capital additions.

Supplies (Item 15)

If there is any difference in the consumption of supplies, such as oil, saw blades, etc., the total value should be entered here.

Scrap and Rework (Item 16)

All the spoiled work should be considered here. If rework can be done, the cost of which should be estimated. If it is to be condemned, "take the cost of replacement, less scrap value." (13, p. 99)

Downtime (Item 17)

This relates only the cost of interrupted production. In some cases, the effect of an outrage can be minimized to a certain extent by moving the substitute material to the spot immediately. When a substitute is not possible, it may be very costly. The best method is, to estimate this expenditure, to count them in terms of annual cost of risk or hazard.

Power (Item 18)

The difference between the next year power requirements of the project with the new equipments and without them should be con-

sidered; it should be converted in terms of dollars.

Floor Space (Item 19)

This is quite a common item, whenever projects are installed. This item should be taken into consideration only when the released space is used for some other purpose.

Property Taxes and Insurance (Item 20)

The increase or decrease in property taxes due to the new project should be entered here. Adjustments should not be made for income tax purposes here. The MAPI Form does it later.

Subcontracting (Item 21)

The increase or decrease in income due to subcontracting should be entered here. Incidental costs for subcontracting such as supervision, inspection, transportation and return expenses should also be included.

Inventory Costs (Item 22)

The decrease or increase in the inventory limits due to the new project should be credited or debited accordingly. Operating costs such as storage, handling, recording, etc., should also be entered. If any of the items were already taken into account, double counting should be avoided.

Safety (Item 23)

A reasonable estimate of the benefit due to the increased

safety of the new project should be estimated.

Flexibility (Item 24)

This is another item often disregarded. An approximate estimate of increased or decreased flexibility should be made and converted into dollar value.

Other (Item 25)

This is a catch-all for items not listed. "Take a good look around before you pass it up." (13, p. 100)

B. NON-OPERATING ADVANTAGE

Decline of Disposal Value During the Year (Item 30 A)

A reasonable amount by which the disposal value of the existing equipment will decline during the next year should be estimated. No attempt should be made to adjust for tax effects in this line. It is done later by the MAPI Form.

Next Year Allocation of Capital Additions (Item 30 B)

The capital additions of Item 3 should be divided by the estimated service life of the asset replaced. For example, if the life is estimated to be three years, one-third of the amount of the Item 3 should be entered here.

III. COMPUTATION OF MAPI URGENCY RATING

Total Next Year Advantage After Income Tax (Item 32)

This item is self-explanatory. For example, if the Item 31 shows six thousand dollars and if the applicable tax rate is 50 per cent, then the entry in this line is (6000 - 0.5 x 6000) $3,000.

MAPI Chart Allowance for Project (Item 33)

This item is also self-explanatory. It is the figure in the column "F" of the table following the MAPI Form.

Amount Available for Return on Investment (Item 34)

This is the difference between the Items 32 and 33. It is the amount available as return on investment.

MAPI Urgency Rating (Item 35)

It measures the urgency of the project as compared with going on with out the new project for one more year. The urgency rating derives the next year after-tax return on the net investment. In considering the net investment required for the project, it deducts the salvage value of the old asset as well as the next year capital consumptions avoided by the new project, from the total investment required to install the project. It can also be called the next-year relative return on net investment. The next year relative return can be calculated from the following stipulations.

A - Net investment

B - Next year Operating Advantage

C - Next year Capital Consumption Avoided

D - Next year Capital Consumption Incurred

E - Next year Income Tax Adjustment

$$\text{Next year Relative Return} = \frac{B + C - D - E}{A}$$

This can be best illustrated with the example followed.

Example of Next Year Relative Return

A project costing eleven thousand dollars makes it possible for the disposal of the old equipment of worth three thousand dollars. The estimated next year operating advantage is five thousand dollars, and the expected decline in disposal value of the asset (old) is one thousand dollars. The salvage of the project after one year is estimated as nine thousand five hundred dollars. Assume debt ratio is 25 per cent, interest rate on borrowed capital is 3 per cent, life of the project ten years, salvage value of the new equipment 10 per cent, income tax rate 50 per cent, and sum of digits tax depreciation method for this problem.

B - $5,000 C - $1,000

A - $8,000 D - $5,000

E - Next year income tax adjustment

An operating advantage of five thousand dollars will increase the income tax by $\left(\frac{50}{100} \times 5{,}000\right) = \$2{,}500$. The disposal of the existing asset will reduce the capital consumption deduction by one thousand dollars and the interest deduction by $(.03 \times 3{,}000 \times \frac{25}{100}) = \$22.50$.

This combination increases the tax by $0.5 \times (1{,}000 + 22.5) = \$511$.

The proposed project will bring new deprecation deductions of

$(11,000 \times \frac{10}{55}) = \$2,000$ (first year sum of digits depreciation) and new interest deductions of $(0.03 \times 11,000 \times \frac{25}{100}) = \$82.5$, with a combined tax savings of $0.5 \times (2,000 + 82.5) = \$1,041$. This can be summarized as follows:

	Tax Increase	Tax Decrease
From the operating advantage	\$2,500	
From disposal	511	
From aquisition of new project		\$1,041
Total	\$3,011	\$1,041
Net Increase	1,970	

Therefore the after-tax

relative rate of return $= \frac{5,000 + 1,000 - 1,500 - 1,970}{8,000}$

$= 31.625$ Per Cent

Interpretation of Results

By the additional capital of eight thousand dollars it obtains an operational advantage of five thousand dollars. It avoids capital consumption of the old equipment by one thousand five hundred dollars and results with an increase of one thousand nine hundred and seventy dollars. Substituting this value in the formula, it yields the next year relative return as 31.625 per cent.

So if all the five items of information were given, the next year relative return can be calculated. The next year capital consumption is difficult to find. This amount can be calculated from

the MAPI Formula, as indicated already.

How the Calculations are Accommodated in the MAPI Form

It should be clearly understood that the MAPI Form does not exactly follow the equation but it arrives at the same answer by simplified computations. A, B, and C can be obtained from the MAPI Form; Lines 5, 29 and 30, respectively. D and E are not shown in the form. The following discussion is concerned about the MAPI Charts.

MAPI Charts

As previously discussed under the heading "Next Year Income Tax Adjustment," the net change in income occurs due to the following two reasons:

1. Next year operating advantage and avoidance of next year capital consumption.
2. Tax savings from the next year deductions added by the project.

The first deduction takes place in the Line 32 of the form. The second deduction takes place in the Line 33. So it is clear from the above discussion the MAPI Charts are designed to yield the excess of the next year capital consumption over the income tax savings from the next year deductions added by the asset, for depreciation and interest. Thus Terborgh has simplified enormous amount of calculations with the help of the MAPI Charts.

AUTOMATIC SCREW MACHINE PROBLEM

A proposal is made by the equipment analyst to purchase four Jack & Jack Screw Machines similar to the present equipment except that they have an automatic attachment. It is believe that the proposed system should be able to meet the future requirements fully. The maufacturer has quoted a price of fifty-five thousand two hundred and twenty-three dollars for the cap, slides, rear drill and burr attachments. Shipping and installation charges are estimated at eight hundred and forty-three dollars and four hundred dollars respectively. The present after-tax disposal of the old equipment is five thousand dollars.

Before selecting the project, the analyst investigated the possibility of rebuilding the present equipment. The cost of new automatics was obtained as twenty-three thousand six hundred dollars from some reliable sources. Because of its specialized character, the old equipment will have zero salvage at the end of its life; the benefit of faster RPM is not obtained in this case.

Stipulations

Project Operating Rate of sixteen hours per day for two hundred and forty days of four machines	15,360 hours
Projection Pattern	Standard
Service Life	15 years
Terminal Salvage Rate	50 per cent

Tax Depreciation Method	Straight-line
Tax Rate	50 per cent

Installed Cost of the Project

Price of the machine	$55,923
Freight cost	843
Installation cost	400
	$57,166

Direct Labor

The decrease in labor cost is obtained two ways:

1. Due to increased efficiency of the machines alone
2. Overall efficiency of the department

In the past, each operator was looking after an average of four lathes. Now it has been estimated that an operator can look after five new machines. This amounts to a labor savings of 25 per cent.

1. Based on the information of the representative, the productivity of the new machine is increased to 150 per cent. The products now being run on six machines can be run on four machines. This saves one-half operator per shift per day, or two one-half operator per day of two shifts. The savings can be calculated as follows:

Base rate		$2.40 per hour
Savings for a year	=	240 x 16 x 1/2
	=	1920 hours
Amount saved per year	=	1920 x 2.40

= $4,608.00

2. In addition, for the past six months an average of four and one-half persons were working in the department. An increase in labor productivity of 25 per cent, will relieve one full person, at two dollars and forty cents per hour, resulting in the following labor savings:

Total number of hours saved	= 1920
Amount saved	= 1920 x 2.40
	= $4,608.00
Total direct labor savings	= $4,608 + 4,608
	= $9,216.00

Indirect Labor

For the first six months of the year, an average of five set-up men were working in the department. Based on three set-ups per shift per man, there were fifteen set-ups on twenty-one machines. This amounts to 15/21 or seven-tenths set-ups per machine day.

The new machines are expected to work at 150 per cent rate of the old machine. Therefore, set-ups required per day machine

= 1.5 x .7 = 1.05.

It is also estimated that new machines will reduce the set-up time by 25 per cent. On the basis of a set-up time of 2.67 hours for old machine, the set-up time for the new machine is two hours.

Set-up hours per day for six old machines = 6x.7x2.67 = 11.2 hrs.

Set-up hours per day for four new machines = 4x1x2 = 8.0 hrs.

Savings in set-up hours per day = 11.2-8.0 = 3.2 hrs.

Amount saved for a year at $2.40 per hour labor = 2.65x3.2x240 = $2,035

Maintenance

The maintenance cost for the first six months of the year was:

Labor	$4,325
Material	4,481
Total	$8,806

Annual maintenance cost = 2 x 8806 = $17,612

Seventy-five per cent of the total maintenance cost was spent for this department of twenty-one machines,

$$\text{Maintenance cost per machine} = \frac{.75 \times 17,612}{21}$$

$$= \$630$$

The new machines require only a preventive maintenance sum of fifty dollars per machine for the first year. Based on the calculations, savings can be figured as follows:

For old machines	= 6 x 630	= $3,780
For new machines	= 4 x 50	= 200
Annual savings		$3,580

Scrap and Rework

During the first six months of this year, the scrap and rework averaged three hundred dollars for each machine. An estimated savings of 50 per cent will yield an amount as follows:

Cost of rework in old machines = 300 x 6 = $1,800

Cost of rework in new machine = 150 x 4 = $ 600

Net savings in rework = 1800-600= $1,200

Fringe Benefits

Twenty-three per cent of labor is spent on fringe benefits.

Direct Labor	$9,216
Indirect Labor	2,035
Maintenance Labor	1,790
Rework Labor	1,200
	$14,241
Savings = .23 x 14,241 =	2,266

Results of Analysis

Installed Cost (Line 1)	$57,166
Net Investment Required, (Line 5)	28,566
Next-Year Operating Advantage	18,297
MAPI Urgency Rating	37 Per Cent

TABLE I

MAPI FORM

(SUMMARY OF ANALYSIS)

I. REQUIRED INVESTMENT

1.	Installed Cost of Project	$57,166
2.	Disposal Value of Assets to be Retired by Project	$ 5,000
3.	Capital Additions Required in Absence of Project	$23,600
4.	Investment Released or Avoided by Project (2+3)	$28,600
5.	Net Investment Required (1-4)	$28,566

II. NEXT-YEAR ADVANTAGE FROM PROJECT

A. OPERATING ADVANTAGE

(USE FIRST YEAR OF PROJECT OPERATION)

6.	Assumed Operating Rate of Project (Hrs. per Yr.)	Hrs.15,360	
	Effect of Project on Revenue	**Increase**	**Decrease**
7.	From Change in Quality of Products	$	$
8.	From Change in Volume of Output	$ A	$ B
9.	Total		
	Effect of Project on Operating Costs		
10.	Direct Labor		$ 9,216
11.	Indirect Labor		2,035
12.	Fringe Benefits		2,266
13.	Maintenance		3,580
14.	Tooling		
15.	Supplies		
16.	Scrap and Rework		1,200
17.	Down Time		
18.	Power		
19.	Floor Space		
20.	Property Taxes and Insurance		

TABLE I (continued)

Effect of Project on Operating Costs

		Increase	Decrease
21.	Subcontracting		
22.	Inventory		
23.	Safety		
24.	Flexibility		
25.	Other		
26.	Total		$18,297
27.	Net Increase in Revenue (9A-9B)		
28.	Net Decrease in Operating Cost (26B-26A)		$18,297
29.	Next-Year Operating A vantage (27+28)		$18,297

B. NON-OPERATING ADVANTAGE

(USE ONLY IF THERE IS AN ENTRY IN LINE 4)

30.	Next-Year Capital Consumption Avoided by Project:	
	A Decline of Disposal Value During the Year	
	B Next-Year Allocation of Capital Additions	$ 4,750
	Total	$ 4,750

C. TOTAL ADVANTAGE

31.	Total Next-Year Advantage From Project (29+30)	$23,047

TABLE I (continued)

III. COMPUTATION OF MAPI URGENCY RATING

32. Total Next-Year Advantage After Income Tax (31-Tax) $11,523

33. MAPI CHART ALLOWANCE FOR PROJECT
(Total of Column F, Below) $ 990

(Enter Depreciable Assets Only)

Item or Group	Installed Cost of Item or Group A	Estimated Service Life (Years) B	Estimated Terminal Salvage (Percent of Cost) C	MAPI Chart Number D	Chart Percentage E	Chart Percentage x Cost (E x A) F
1	$58,080	15	50 Per Cent	1	1.70	$990.00
				TOTAL		$990.00

34. Amount Available For Return On Investment
(32-33) $10,533.

35. MAPI URGENCY RATING (34 ÷5). 100 % 37

Comment and Recommendation. It is imperative that this new equipment should be purchased or the old one should be rebuilt. The purchase of the new equipment facilitates many more advantages than the old equipment. Thirty-seven per cent return on investment more than justifies the purchase of the equipment.

CHAPTER IV

COMPARISON OF ALTERNATIVES BY VARIOUS METHODS

In order to compare the rate of return obtained from the MAPI System with the other methods of obtaining the rate of return, the example illustrated in the previous chapter for the MAPI System is chosen. The data for all the examples are given in the Table II, page 40. The assumptions made are given in each case and the results are shown in the Table VIII, page 50.

ACCOUNTING METHOD

This method has been in practice a long time. The rate of return is calculated by dividing the after-tax savings by the investment required to install the project. This method gives the same weight to cash receipts in the last year as in the first year. This method does not take into consideration the time value of money. Because it ignores interest rates and considers the distant earnings equal to their present worth, (30) the rate of return obtained from this method is not exact. This is also called the apparent rate of return.

Assuming the data given in the Table II, page 40, the rate of return is calculated in the Table III, page 41 by dividing the annual savings of seven thousand three hundred and one dollars by the required investment of fifty-seven thousand one hundred and sixty-six dollars. This calculation yields a rate of return of

TABLE II

DATA FOR ALL CASES

Details			Present Equipment	Proposed Equipment
Present value (P)			$5,000	$57,166
Life in years (n)			5	15
Salvage value (L)			0	$28,583
Corporate income-tax rate			50%	50%
Before tax annual savings* obtained by installing the new machine				
Direct labor	$9,216			
Indirect labor	2,035			
Fringe benefits	2,266			
Maintenance	3,500			
Scrap and rework	1,200			
Total		$18,297		

*These savings decrease at $800 per year due to increases in scrap, rework, maintenance, and fringe benefits.

TABLE III

ACCOUNTING METHOD PROBLEM

Description		Calculations		Amount
Investment required (P)			=	$57,166
Salvage value (L)			=	28,583
Average annual savings				
Annual savings in the first year	=	$18,297		
Annual savings in fifteenth year	=	7,097		
Average annual savings			=	12,697
Life of the equipment (n)	=	15 years		
Straight-line depreciation $\frac{P-L}{n}$	=	$\frac{28,583}{15}$	=	1,906
Average taxable income	=	$12,697-1,906	=	10,791
Tax at 50 per cent		.50x10,791	=	5,396
Average after tax annual savings (R)	=	$12,697-5,396	=	7,301
Rate of return R/P	=	$\frac{7,301}{57,166}$=0.128	=	12.8%

12.8 per cent, favoring the replacement of the old machine, (the minimum attractive return of the company being 10 per cent).

PAYBACK METHOD

The Payback Method figures out the period of years within which the investment would be repaid. (30) It is obtained by dividing the investment required to install the project by the after-tax savings from the project. This method does not yield the rate of return. This is the reciprocal of the Accounting Method. The Payback Method also does not take into consideration the time value of money.

According to the data given in Table II, page 40, and Table III, page 41, the payback years are calculated in the Table IV, page 43 by dividing the investment of fifty-seven thousand one hundred and sixty-six dollars by the annual savings of seven thousand three hundred and one dollars. This calculation yields the payback of the investment in 7.8 years.

ANNUAL COST METHOD

The disadvantage of the above mentioned methods is rectified in the uniform Annual Cost Method. In this method, all values which are not already in the form of annual payments and receipts are brought to the present worth and their sums are then spread throughout the life of the equipment in uniform annual payments. Costs such as maintenance, taxes and insurance are already in the

TABLE IV

PAYBACK METHOD PROBLEM

Description		Amount
Investment required	=	$57,166
After-tax return (obtained from Table III)	=	7,301
Payback years		
$\frac{\text{Investment}}{\text{Average annual savings}}$	= $\frac{57,166}{7,301}$	= 7.8 Years

form of uniform annual cost terms and can be added to the other costs after the latter have been converted to uniform annual costs.

The depreciation amount is determined by taking into consideration both the useful life of the equipment and the desired interest rate, with the help of interest tables. (17) It consists of an uniform annual amount which is deposited to earn compound interest so that the deposit and the interest together will accumulate sufficient funds at the end of the service life of the equipment. The annual cost of operating both the old and the new equipment is calculated, and the one which operates at a lesser expenditure is considered the better one.

According to the data given in the Table II, and assuming an interest rate of 8 per cent on the capital, the before-tax annual savings are calculated in the Table V, page 45 as nine thousand four hundred and fifty-two dollars. These savings are reduced by the income tax of four thousand seven hundred and twenty-six dollars, (50 per cent of nine thousand four hundred and fifty-two dollars). On this basis, the new machine should result in an annual savings of four thousand seven hundred and twenty-six dollars, favoring the replacement of the old machine.

RATE OF RETURN METHOD

Another type of Cost Model is the Rate of Return Method. Though this type of calculation has been used in mathematics of

TABLE V

ANNUAL COST METHOD PROBLEM

Source of Expense	Present Machine		Proposed Machine	
Sinking fund deposit (P-L) (sff-i-n) at 8 per cent interest	(5000-0) (sff-.08-5) 5000 x 0.17046	= $ 852	(57,166-28,583) (sff-.08-15) 28,583 x 0.03683	= $1,052
Return on investment P x i (money tied up in the machine or in the sinking fund)	5000 x 0.08	= 400	57,166 x 0.08	= 4,573
Equivalent annual savings by installing the new machine or the relative cost for the old machine		13,825		---
Total annual costs		$15,077		$5,625
Before tax annual savings by installing the new machine				= $9,452

finance for a long time, it has been used increasingly in industry only since 1950. This method possesses various names such as the Discounted Cash Flow Method, Investor's Method and Profitability Index. (5, p. 118)

In stipulating the required calculations, this method requires the total investment, the annual benefit from the project, the useful life of the equipment and the income-tax rate. The model is set up using all income (positive) and disbursements (negative), and reducing the total of their present worth to zero. Since the interest or rate of return is to be found, the corresponding factors are introduced in the formula as unknowns. After the equation has been established, the exact interest rate is calculated by trial and error prodedure. When an interest rate makes the equation equal to zero, it represents the interest rate or the rate of return on investment. If a particular interest rate lies between two interest rates, straight-line interpolation is satisfactory.

According to the data given in the Table II, page 40, the Table VI, page 47, shows the total cash inflow and outflow for the invested amount. An amount of fifty-seven thousand one hundred and sixty-six dollars is invested in the beginning of the first year or at zero year. The straight-line depreciation amount is obtained from the Table III, page 41. The exact rate of return can be calculated by interpolating between the present worth interest rates

TABLE VI

CALCULATION OF RATE OF RETURN

Years	Savings before Income-tax	Depre-ciation	Taxable Income	Income-tax at 50%	Total cash Flow-back After-tax	Trial Interest Rates			
						pwf'	Present worth	pwf'	Present worth
	A	B	C A - B	D -0.50.C	E A - D	F @ 10%	E x F	G @ 12%	E x G
0	-57,166				-57,166	1.000	-57,166	1.000	-57,166
1	18,297	-1,906	16,391	-8,196	10,101	.9091	9,182	.8929	9,091
2	17,497	-1,906	15,591	-7,796	9,701	.8264	8,016	.7972	7,733
3	16,697	-1,906	14,791	-7,396	9,301	.7513	6,988	.7118	6,620
4	15,897	-1,906	13,991	-6,996	8,901	.6830	6,079	.6355	5,657
5	15,087	-1,906	13,191	-6,596	8,501	.6209	5,278	.5674	4,823
6	14,297	-1,906	12,391	-6,196	8,101	.5645	4,573	.5066	4,104
7	13,497	-1,906	11,591	-5,796	7,701	.5132	3,952	.4523	3,483
8	12,697	-1,906	10,791	-5,396	7,301	.4665	3,406	.4039	2,949
9	11,897	-1,906	9,991	-4,996	6,901	.4241	2,927	.3606	2,488
10	11,097	-1,906	9,191	-4,596	6,501	.3855	2,506	.3220	2,094
11	10,297	-1,906	8,391	-4,196	6,101	.3505	2,138	.2875	1,754
12	9,497	-1,906	7,591	-3,796	5,701	.3186	1,816	.2567	1,463
13	8,697	-1,906	6,791	-3,396	5,301	.2897	1,536	.2292	1,215
14	7,897	-1,906	5,991	-2,996	4,901	.2633	1,290	.2046	1,003
15	7,097	-1,906	5,191	-2,596	4,501	.2394	1,078	.1827	822
Total							$3,599		-1,939

TABLE VII

CASH-FLOW OF AMOUNT IN RATE OF RETURN METHOD

End of Year	A Interest Due (11.26% of money owed at start of year)	B Total Money Owed Before Year-End Payment	C Year-End Payment	D Money Owed After Year-End Payment
	Previous D x.1126	Previous D+A		B - C
0				57,166
1	6,440	63,606	10,101	53,505
2	6,030	59,535	9,701	49,834
3	5,620	55,454	9,301	46,153
4	5,200	51,353	8,901	42,452
5	4,780	47,232	8,501	38,731
6	4,365	43,096	8,101	34,995
7	3,940	38,935	7,701	31,234
8	3,515	34,749	7,301	27,448
9	3,090	30,538	6,901	23,637
10	2,660	26,297	6,501	19,796
11	2,225	22,021	6,101	15,920
12	1,790	17,710	5,701	12,009
13	1,350	13,359	5,301	8,058
14	897	8,955	4,901	4,054
15	447	4,501	4,501	----

to find the discount rate that causes the cash flow back to equal fifty-seven thousand one hundred and sixty-six dollars.

Therefore, the rate of return $= 10 + \frac{3399}{5530} \times 2$

$= 11.26$ per cent

Table VII, page 48, shows that at 11.26 per cent rate of return, the total cash inflow and outflow is equal to zero.

TABLE VIII

RESULTS OBTAINED BY ALL METHODS

S. No.	Method	Result	
1	Accounting Method	Rate of Return	= 12.8%
2	Payback Method	Years to recover investment	= 7.8
3	Annual Cost Method	Annual Savings	= $4,726
4	Rate of Return Method	Rate of Return	= 11.26%
5	MAPI Method	Urgency Rating	= 37%

CHAPTER V

DISCUSSION OF RESULTS

The tabulated results at the end of the previous chapter (Table VIII, page 50) would lead to a decision to install the new machine in all the cases if the company's marginal return were 10 per cent. The table did not present the same answers for the various methods, even though the same problem was carried out in all cases. This chapter evaluates the pros and cons of each of the methods considered in this thesis.

Accounting Method and Payback Method

The Accounting Method showed a slightly higher rate of return than the Rate of Return Method. In spite of the fact that the method was easy to follow and calculate, it lacked in many aspects. It neglected the time value of money and treated equally the earnings in the first year's life of the equipment as well as the earnings at the end of the fifteen years. The results obtained by this method were, therefore, not accurate for even though the answer they gave was near that of the Rate of Return Method, the proximity is coincidental. Since the Payback Method also suffered the same sort of discrepency, it did not yield a reliable result either.

Annual Cost Method

The Annual Cost Method presented only the annual cost of

maintaining each alternative. The result did not provide a definite measure of benefit obtained from the project.

In this method, either the salvage value of the old machine can be deducted from the investment made or it can be dealt with separately. (5, p. 379)

In either way, the difference between the annual costs will be the same. However, the analyst should be careful not to count the salvage value of the old machine twice. This method is sensitive to changes in the assumed rate of return. It occasionally happens in this method that when the rate of retun is changed, the decision also changes.

Rate of Return Method

This method was able to accommodate all types of depreciation methods, earnings patterns, and obsolescence. This method yields the same rate of return regardless of the debt/equity ratio; no provision is made for this ratio. These factors compel the analyst to predict the exact future earnings. While comparing more than two alternatives, the analyst may be misguided if he has not performed all relevent calculations. When the rate of return on extra investment is calculated, the answer obtained should exceed the minimum return to warrant affirmative decision. (5, pp. 216-217)

MAPI Method

The MAPI Method may be considered as a variation of the Annual Cost Method. The formula assumes the cost of money. It calculates an Urgency Rating by dividing the first year after tax

annual savings by the net investment required by the project. These calculations relate to the incremental analysis since the return is calculated on the extra investment (Net Investment). The Urgency Rating is not equivalent to the rate of return, but it is a number representing the degree of urgency of the new project. The MAPI Method also guides the analyst with suitable charts and tables. In spite of its advantages, it is restricted in its applications because of the standardized forms and charts with the built in assumptions such as fixed debt/equity ratio, interest rate on borrowed capital, etc. The depreciation methods provided may not cover all cases.

From the above discussion it may hardly be possible to decide which one is the better method. Because of the inherent shortcomings involved in the Accounting Method and in the Payback Method, which are not competent to provide a reliable answer. The other three methods are theoretically correct for the assumption made and will be evaluated in the remaining part of the discussion.

The characteristics of a method for making good decisions are grouped in Appendix A, page 64 and the relative merits of each of the groups listed is rated there. The Annual Cost Method, the Rate of Return Method and the MAPI Method are compared individually with the characteristics. The extent to which they meet the requirements is also evaluated in Appendix A, page 64. The method

which scores the maximum number of points will be considered the better one. The Table IX, page 55 shows the summary of evaluation performed. The MAPI Method scores the maximum number of points.

The following discussion deals with some of the assumptions made in calculating the return.

Deducting the Salvage Value of the Present Equipment from the Investment Required for the Proposed Project

Deducting the salvage value from the net investment does not make any difference in comparing the annual cost of alternatives. (5, p. 379) While calculating the return, the value of the denominator in the formula given below, decreases. This decrease causes an increase in the rate of return and hence the urgency of the project leads to the early replacment of the old equipment. In addition to this, Terborgh deducts the capital additions required for the old project in absence of the new project, (from the investment required for installing the new project). He includes the capital consumptions avoided by the project while calculating the annual savings. These assumptions have the effect of increasing the numerator and decreasing the denominator in the formula,

$$\text{Return} = \frac{\text{Annual Savings}}{\text{Investment}}$$

and recommend the early replacement of the equipment. This concept is illustrated by examples in Appendix B, page 77.

TABLE IX

SUMMARY OF RATINGS

	Item	Annual Cost Method	Rate of Return Method	MAPI Method
A.	Flexibility	29	31	29
B.	Simple and Reliable	20	20	23
C.	Account for All Costs	20	20	20
D.	Value of Money	12	13	14
E.	Nature of Earnings	8	8	8
	Totals	89	92	94

Calculation of the Next-Year Return MAPI Method

Once the replacement is made, it is ordinarily not necessary to check the rate of return every year. Whenever the analyst feels the necessity for checking, he can do so. One more realistic point should be noted here. The rate of return calculated in the other methods was the same throughout the life of the equipment. Since the rate of return depends on many factors, it is more realistic to consider it year by year. Calculating the rate of return every year enables the analyst to write off any amount whenever necessary. Otherwise, the analyst may regret his neglect after it is too late to remedy the situation.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

From the above discussion it may be concluded that the MAPI Method is better than the other methods. This study evaluated the methods assuming the characteristics of a good formula. From Table IX, page 55, it is clear that there is little difference between the scores of the MAPI Method and that of the Rate of Return Method. The MAPI Method was superior in its simplicity and guidance to the analyst, whereas the Rate of Return Method was superior in its flexibility. In evaluating solutions to non-formula problems, Terborgh has also followed the same principle of rate of return. Since the Annual Cost Method did not present the exact measure of benefit, there was difficulty in making decisions.

However, if the merit ratings of the five characteristics were changed, one might reach some other conclusion because of the close tie between the scores of the MAPI Method and the Rate of Return Method. The ratings were also done strictly according to the author's opinion.

It is suggested that a complete book should be published on the Rate of Return Method, systematically describing all the steps to be performed in replacement analysis, with convenient charts, forms and tables. In such a book, the author of this study believes that the Rate of Return Method would prove to be very useful to industry.

Recommendations

The following recommendations for more flexibility and usefulness of the MAPI Method grew out of this study:

1. Two more projection patterns might be increased as follows.
   a. One fourth run off during the first half of the life of the equipment.
   b. Three-fourths run off during the first half of the life of the equipment.
2. Sinking fund tax depreciation might also be incorporated in the charts.
3. The interest rate on debt might be increased.
4. A separate line might be provided to meet the inflation effects.
5. In the MAPI Charts, for calculating the capital consumption allowances, two more curves might be added with salvage ratios 60 and 70 per cent.
6. The assumptions made in the method might be exhibited near the MAPI Charts or in some place more significant to the reader.

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APPENDIXES

APPENDIX A

For evaluating the three methods, five characteristics of a good formula or method for making decisions are listed below:

I. The method must be able to accommodate various types of earnings patterns, such as those listed in Table XVII.

II. The method should be flexible and suitable for various types of problems, such as those mentioned in Table XIII.

III. The method should take into account the value of money as indicated in Table XVI.

IV. The method should be simple and reliable so as to satisfy the conditions listed in Table XIV.

V. The method should account for all costs such as those shown in Table XV.

These criteria were entered in the Evaluation Work Sheet, Table X, and there also relative ranking was recorded. If the criteria at the row was considered as better than at the column, a (X) sign entered to the corresponding square. Otherwise (O) sign was recorded in the corresponding square. The total number of points scored by each criteria were listed and ranked as A, B, C, D and E as shown

I. O----------E

II. 2----------C

III. 1----------D

IV. 3----------B

V. 4----------A

Table XI shows the merit of two or more combined criteria in relation to the merit of a single criteria. The appropriate marks were made, as shown: greater merit (yes), lesser merit (no), or equal merit (equal).

Based on these assumptions made in Table XI, relative merit ratings were performed in Table XII. Column C shows the adjusted importance ratings of each criteria. Each criteria contains a number of facts. The relative merit of each fact was calculated. The extent to which each method meets the requirement was evaluated and points were allotted accordingly for each fact. The points were added and found the total score for each criteria, for each method. These scores were summarized in Table IX.

The items compared in these Tables and the point ratings for each are those of the author. The comments do not cover all factors considered in making the ratings.

TABLE X

EVALUATION WORK SHEET

	I	II	III	IV	V
I	---	x	x	x	x
II	---	---	0	x	x
III	---	---	---	x	x
IV	---	---	---	---	x
V	---	---	---	---	---

TABLE XI

CRITERIA COMPARISON SHEET

Decision Number	Comperison	Decision		
		Yes	No	Equal
1	A > (B+C)		x	
2	A > (B+D)		x	
3	A > (B+E)	x		
4	A > (C+D)			x
5	A > (C+E)	x		
6	A > (B+C+D)		x	
7	A > (C+D)		x	
8	B > (C+E)		x	
9	B > (D+E)	x		
10	C > (D+E)			x

TABLE XII

CRITERIA DEVELOPMENT SHEET

	Criteria	A Initial Important Ratings	B Importance Rating Revision 1	2	3	C Adjusted Importance ratings
A	Flexibility	60	65	65	80	33
B	Simple & Reliable	40	40	40	60	25
C	Costs	30	30	35	50	20
D	Value of Money	25	20	30	30	13
E	Earnings	20	15	20	20	9

TABLE XIII

EVALUATION OF METHODS FLEXIBILITY

Description	Annual Cost Method	Pts.	Rate of Return Method	Pts.	MAPI Method	Pts.
(Each item counts 3 points)						
Equipment replace decisions	Can be done	3	Can be done	3	Can be done	3
Post-audit of projects	Can not be made	3	Can be made	3	Can be made	3
Lease vs. purchase	Can be done	3	Can be done	3	Can be done	3
Costly equipment with low maintenance cost vs. cheap equipment with high maintenance cost.	Can be considered	3	Can be considered	3	Can be considered	3
Comparing various alternatives at the same time	Can be done	3	When comparing more than two alternatives the analyst should be careful	3	Can be done	3

TABLE XIII (continued)

Description	Annual Cost Method	Pts.	Rate of Return Method	Pts.	MAPI Method	Pts.
Allowing for capital additions and deductions at any time	Can be done	3	Interest rate must be assumed and capital changes brought to the zero year	2	Method is suggested, neglecting the interest rate	2
Considering wide range of salvage values	Any value can be considered	3	Any range can be considered	3	Restricted between zero to 50 per cent salvage ratio	2
Considering wide range of life of the project in years.	Any value can be considered	3	Any range can be considered	3	Restricted; only up to fifty years can be considered	2
Various combinations of debt/equity ratios	Can be considered	3	Can be made	3	Fixed 25 per cent debt ratio	2
Giving answer whether it pays to postpone the project for some time	Left to the analyst	2	Left to the analyst	2	Can give the answer	3
Consideration of increment analysis	Not considered	3	Can be considered	3	The method itself yields the incremental return	3
Total		29		31		29

TABLE XIV

EVALUATION OF METHODS: SIMPLE AND RELIABLE

Description	Annual Cost Method	Pts.	Rate of Return Method	Pts.	MAPI Method	Pts.
(Each item counts 4 points)						
Clearly stated assumptions	There are not many assumptions	4	Assumptions are stated	4	Assumptions are stated	4
Consistancy in ranking projects	When the interest rate sometimes is changed the decision may change	3	Ranks consistantly	4	Ranks consistantly	4
Guidance to the analyst	No guidance to the analyst; it is left to the analyst to find	2	No guidance for evaluating intangibles	3	MAPI form serves this purpose	4
Tables and charts in the method easy to use	Interest tables can be used - Ready made charts are not provided	3	Interest tables can be used - No ready made charts are given	3	Charts are given	4

TABLE XIV (Continued)

Description	Annual Cost Method	Pts.	Rate of Return Method	Pts.	MAPI Method	Pts.
Decisions related to management policies	It does not give the true measure of advantage as rate of return	4	It gives the rate of return	4	It gives only relative rate of return	4
Easy to understand and calculate results	Easy to calculate and follow	4	Lot of calculations are involved -Computer can help here	2	Easy to calculate - Difficult to understand the theory	3
Total		20		20		23

TABLE XV

EVALUATION OF METHODS: ACCOUNTING ALL COSTS

Description	Annual Cost Method	Pts.	Rate of Return Method	Pts.	MAPI Method	Pts.
(Each item counts 4 points)						
Depreciation methods	Any method can be used	4	Any method can be used	4	Only three methods can be used	4
Obsolescences possible	Can be predicted by the analyst and incorporated in calculations	4	Can be accommodated	4	Are accommodated	4
Deterioration, wear and tear	Can be taken care of	4	Can be accommodated	4	Are taken care	4
Maintenance cost	Can be included	4	Can be included	4	Can be included	4
Direct and indirect labor costs	Can be included	4	Can be included	4	Can be included	4
Total		20		20		20

TABLE XVI

EVALUATION OF METHODS: VALUE OF MONEY

Description	Annual Cost Method	Pts.	Rate of Return Method	Pts.	MAPI Method	Pts.
(Each item counts 2 points)						
Present and proposed investments	Considered	2	Considered	2	Considered	2
Proposed salvages	Considered	2	Considered	2	Considered	2
Interest rate paid on borrowed capital	Any value can be assumed	2	Any value can be assumed	1	3% is assumed in building the formula	2
Income and property taxes, and insurance charges	Considered	2	Considered	2	Considered	2
Required return on investment	Any value can be assumed	2	The method yields the rate of return	2	8.25% capitalization rate is assumed	2

TABLE XVI (continued)

Description	Annual Cost Method	Pts.	Rate of Return Method	Pts.	MAPI Method	Pts.
Effect of inflation on the capital invested	Left to the analyst	1	Left to the analyst; it can be taken into account	2	Considered in special problems	2
Effect of break in period and lead times	Not considered; analyst can assume if it is needed	1	Solution is suggested	2	Solution is suggested	2
Total		12		13		14

TABLE XVII

EVALUATION OF METHODS: EARNING PATTERNS

Description	Annual Cost Method	Pts.	Rate of Return Method	Pts.	MAPI Method	Pts.
(Each item counts 2 points)						
Increase in earnings	Can be accommodated	2	Can be accommodated	2	Can be accommodated	2
Decrease in earnings	Can be accommodated	2	Can be accommodated	2	Can be accommodated	2
Irregular earnings	Can be accommodated	2	Can be accommodated	2	Can be accommodated	2
Earnings in the form of probability statements	Left to analyst	0	Nothing is suggested	0	Nothing is suggested	0
Mixed sources of income	Can be accommodated	2	Can be accommodated	2	Can be accommodated	2
Total		8		8		8

APPENDIX B

The same problem is done in various methods in order to compare the answers with the MAPI Method. These problems explain step by step how the rate of return is increased in each case. (See Table II)

1. Considering the first year annual savings alone, the first year percentage return from the project can be calculated.

The first year savings	=	$10,101
Investment	=	57,166
The first year return	=	17.8%
	=	$\frac{10,101}{57,166} = .178$

2. Considering the salvage value of the present equipment also, the return on net investment can be calculated for the next year.

The first year savings	=	$10,101
Net investment	=	52,166
Investment - $57,166		
Salvage 5,000		
$52,166		
The first year return	=	19.4%
	=	$\frac{10,101}{52,166} = .194$

3. In addition to the salvage value the capital additions required in absence of the project can also be taken into consideration and the next year return can be calculated.

The first year savings			= $10,101
Net investment			= 28,566
Investment	= 57,166		
Salvage		$5,000	
Capital additions required		23,600	
	$57,166	28,600	
Net investment	$28,566		
The first year return			= 35.5%
			$= \frac{10,101}{28,566} = .355$