I. INTRODUCTION

Unquestionably, the capital budgeting process is of critical importance in helping firms achieve their various objectives. Hence, the more accurately capital budgeting models reflect the actual conditions faced by firms, the greater will be the assistance the models provide in reaching corporate goals. The past decade has seen a significant evolution of the methods utilized in capital budgeting. Payback and return on investment approaches have been recognized as inferior to the discounted cash flow models—net present value and internal rate of return. In addition, the importance of reflecting "risk" has become accepted because of the inadequacy of a single parameter (the expected value or mean) to incorporate all of the relevant underlying aspects of cash flow distributions. Therefore, measures of variation or dispersion are called upon to enrich the formulations. However, such extensions are not free of theoretical and applied difficulties. To further complicate matters, correlations among investment opportunities, multiperiod capital rationing, reinvestment of cash throwoffs, and financing decisions should also be reflected. An even more challenging task is at hand when the dimensionality of the problem is still further increased by considering the multinational setting. This necessitates the incorporation of foreign exchange rates, differential foreign tax treatment, and international economic, social, and political factors. Unfortunately, traditional approaches, as well as mathematical programming formulations, have been found wanting in their ability to precisely and robustly reflect the multidimensional setting while rendering a model which can be accurately solved within "reasonable" computer time and memory requirements. These shortcomings make it advantageous to consider Monte Carlo simulation as a natural resolution of the dilemma. Simulation can effectively be used to reflect diverse and complex interrelationships among stochastic variables over a series of years. Key decision variables can be ascertained. The sensitivity of results to changes in state and decision variables can also be determined. Various assumptions relative to the shape and parameter values of input variable distribution can be tested and their impact pinpointed. Hence, simulation proves to be a flexible and powerful approach to the multinational capital budgeting process.

This paper extends the Hertz (see Hertz [16] and [17]) simulation model to the multinational capital budgeting process. The critical areas discussed above are incorporated. The approach is flexible enough to utilize several criteria in the final investment selection process.

The next section surveys the traditional, mathematical programming, and simulation-based capital budgeting models developed to date. Section three investigates the important international variables and their estimation. It also includes an analysis of the parameters, exogenous and endogenous variables, and identities of the model. Section four presents the model's output and supplementary analysis effective in selecting profitable capital investments. Lastly, extensions of the model are discussed.

II. CAPITAL BUDGETING MODELS

To appreciate the great value of simulation techniques, a survey of the predominant capital budgeting models is necessary. For interested readers, various references are given. This part of the paper investigates briefly three groups of capital budgeting techniques: (1) traditional models; (2) mathematical programming models; and (3) simulation models.

Traditional Models

Model builders distinguish three areas of consideration concerning knowledge of the future: (1) "certainty"—where perfect knowledge is assumed; (2) "risk"—where only the parameters and shapes of the probability distributions of future occurrences can be specified; and (3) "uncertainty"—where neither all possible states of the world nor the probability of their occurrences can be specified. Due to the wider knowledge of the "certainty" techniques and the overwhelming difficulty of the "uncertainty" assumptions, the "risk" case will receive our greatest attention.

The traditional "certainty" capital budgeting models (payback, return on investment, net present value - NPV, and internal rate of return - IRR) only require a very brief comment. More and more firms are discarding the former two techniques in favor of one of the latter two. The major reasons for this switch to the NPV and IRR models are that: (1) they accurately reflect the time value of money (a dollar of cash inflow today is more beneficial than a dollar a year from now) which is ignored by the former two; and (2) they consider the importance of the financing decision relative to the investment under consideration. Thus, any sophisticated approach to the capital budgeting process should incorporate these two important aspects. For a discussion of these models see Johnson [19], Bierman and Smidt [1], or conventional finance texts as [31] and [33].

The "risk" case is generally treated through one of the following three approaches: the informal reflection of risk, the risk-adjusted discount rate, and the certainty equivalent. These three methods reflect the fact that future events are unknown but probability distributions can be used to specify the likelihood of various occurrences. The mean and standard deviation of these distributions are used to provide decision criteria.

The informal method subjectively evaluates the tradeoff between the riskiness of projects and their net present values. If two projects are similar in terms of their riskiness (i.e., the standard deviations of the discounted return distributions are approximately equal) the one with the higher mean NPV would be selected. Weston [33, Ch. 8] gives a good illustration of the application of this technique.

The risk adjusted rate of return model

classifies investment proposals according to their riskiness based on the standard deviation of the cash inflows over the life of the investment. Then, the cash inflows are discounted at a rate dependent upon the risk class that the proposal falls into—the riskier the project the higher the rate. The magnitude of the risk adjustment should reflect both the riskiness of the project per se and the firm's attitude toward risk taking.

In the certainty equivalent method, "risky" future cash flows are weighted by a coefficient reflecting the investment's degree of risk (the greater the risk the lower the coefficient). These figures are then discounted at a "risk free" rate (e.g., the rate of interest on U.S. Governmental Bonds). References discussing these latter two models would include Van Horne [31], Weston [33], and Robichek and Myers [27].

These three models are a step in the right direction in that they attempt to reflect the stochastic nature of future events. Needless to say, their major shortcoming is their simplicity —they fail to reflect many very relevant and vitally important aspects: interrelationships among investment opportunities and current operations, various contingencies over the life of the investment, and the capital rationing phenomenon. In addition, the multinational dimension necessitates the incorporation of new relevant variab[illegible]. To overcome these shortcomings, decidedly more robust mathematical programming models were necessitated. Such models were formulated; their major characteristics are now discussed.

<u>Mathematical Programming Models</u>

Four classes of mathematical programming models have been applied to the capital budgeting process under risk: quadratic programming, dynamic programming, stochastic linear programming, and chance constrained programming. Only a brief and general description of these approaches, and some of the major contributions made, will be undertaken.

Quadratic programming is a technique used to optimize a non-linear objective function subject to linear constraints. One of the pioneering works in this area was by Farrer [10]. He reflected uncertainty in the objective function by using both the mean and variance of the net present value distributions of the investment proposals under consideration. This technique also enables the incorporation of project interdependences through the use of the variance-covariance matrix. Cohen and Elton [6] used this approach in the QP model they formulated. They generated an "efficient set" of achievable risk-return tradeoffs given the feasible combinations of investment alternatives. Unfortunately, as the number of projects grows, difficulties in the solution of the problem escalate quickly.

From a conceptual point of view, a very powerful way of handling uncertainty in mathematical programming models is dynamic programming. This technique optimizes a recursive functional describing a sequential, multi-stage decision-making process where some of the variables are stochastic. Unfortunately, as the number of variables and/or the number of constraints on the problem increase (as is certainly the case with even a small real world problem) the "curse of dimensionality" prohibits efficient solution of the model within realistic computer time and memory requirements. Some advances have been made by Weingartner and Ness [26], Glover [13], and Nemhauser [25] to improve the strengths of computer solution algorithms.

Stochastic linear programming is an approach used to solve problems where the parameters of the model are uncertain but their distributions can be specified. The method involves generating an empirical distribution for the optimum value of the objective function. This is done by allowing the parameters of the system to vary according to their probability distributions and resolving the problem. Cohen and Elton [6] and Byrne, Charnes, Cooper and Kortanek [2] have applied this technique to the capital budgeting area.

Chance constrained programming optimizes an objective function with stochastic variables, and constraints which are only required to hold with some probability less than unity. In this area, four major uninational capital budgeting contributions have been made: Nasland [22], Byrne [3], [4], and Hillier [18]. In addition, Merville [21] has formulated a chance-constrained programming model for the multinational firm's capital budgeting process. However, the lack of efficient solution algorithms for realistic size problems limits the utility of this approach at the present time.

After this brief review, it is possible to show how simulation techniques can be of superior practicality and applicability. Indeed, all of the mathematical models suffer from one or more of the following serious limitations:

1. The model itself is not sufficiently robust to reflect all of the relevant variables and interrelationships in practical sized problems. This is especially true of stochastic linear programming and chance constrained programming, and to a lesser degree of quadratic programming.
2. The model has conceptual weaknesses which jeopardize the validity of the results obtained. Here again, stochastic linear programming and chance constrained programming are the most faulty.
3. The complexities of the model make the accurate solution of realistic problems difficult at best and infeasible at worst. Dynamic programming under uncertainty and chance constrained programming are weakest in this regard.

Due to these significant shortcomings, simulation approaches offer desirable advantages over mathematical models.

Simulation Models

The pioneering work applying Monte Carlo simulation to capital budgeting was undertaken by Hertz [16] in 1964. His approach considered nine variables: market size, selling prices, market growth rate, share of market, original investment required, residual value, operating costs, fixed costs, and useful life of facilities. The decision maker is asked to provide estimates of the expected values and measures of dispersion for the distributions of each of the nine input variables. The output consists of an empirical distribution of return on investment (ROI). However, this initial work was embedded with three major limitations:

1. Cash flows were not discounted, and hence the timing of flows was not taken into account;
2. No consideration was given to the financing decision for the new investment proposal;
3. Project interrelationships and environmental factors were not taken into account.

In his 1968 article Hertz [17] overcomes the first shortcoming by providing three empirical distributions based on the simulation: the payback criterion, the ROI, and the discounted ROI.

In 1968, Salazar and Sen [28] developed a simulation utilizing Weingartner's basic horizon model and built his constraints for interrelated projects into their formulation. Their simulation reflects two types of uncertainties: (1) environmental uncertainty based on what future economic, social, and competitive conditions may be, and (2) cash flow uncertainties where the mean and standard deviation of the cash flows are considered. The results are analyzed by ranking various portfolios of projects as a function of differing environmental conditions and/or management preferences toward risk and return.

In spite of its increasing importance, the subject of international capital budgeting does not seem to attract financial model builders. This fact is very unfortunate because the rise of the multinational corporation necessitates sophisticated tools of analysis. Simulation is certainly a very adequate technique for handling the complex multinational set-up. It demonstrates the interdependence of variables in the decision process and makes it possible to visualize the dynamics in business decisions. Furthermore, risk (particularly international risk) can be introduced very efficiently into the capital investment activity which can thus be rendered very realistic. As of now, evidently only one simulation formulation has been applied to this field [5]. However, this model does not reflect the crucial multinational variables involved, and consequently is still constructed in an uninational set up.

The proposed simulation utilizes the strengths of the models developed to date. In addition it reflects the critical international variables and the impact of social, economic, and political factors in the multinational arena of the capital budgeting process.

III. NATURE OF INTERNATIONAL CAPITAL BUDGETING

The somewhat complicated evaluation of investment opportunities in an uninational setting is rendered extremely complex in less familiar environments. Indeed, new financial systems and attitudes, new variables such as exchange rates, tax and interest differentials between countries, joint ventures, etc., necessitate a solid framework of analysis. As mentioned above, the usual mathematical programming techniques of capital budgeting lack the flexibility and generality necessary to handle the complex international problems. Conversely, simulation procedures constitute a powerful approach to incorporate stochastic variables and interrelationships. Simulation is now just coming of age, thus gaining wider acceptance in the business community. Hence the model formulated here should prove beneficial to the management of multinational firms.

The proposed simulation has been made as general as possible while not sacrificing ease of understanding and use. In order to provide adequate information and a flexible analysis, a two stage capital budgeting simulation is recommended. First, the investment is evaluated as a uninational opportunity by the subsidiary proposing it. Then, it must be analyzed from the parent's point of view. This joint evaluation is of paramount importance. Indeed, a plant built in a foreign country can be a very profitable investment in itself, but currency devaluations, tax differentials and/or quantitative controls can make it worthless to the parent company. The proposed model handles both the case where the parent is considering a joint venture as well as a 100% participation. Furthermore, the model allows for simultaneous investigation of several investments.

Because of the unquestioned significance of the international variables in the model's development, a discussion of these inputs and their estimation is now undertaken.

International Variables and Their Estimation

Model generality is obtained by considering all the necessary inputs without breaking them down into their specific components. By so doing, the sophistication of the formulation is enhanced without unbearable complexity in its use.

The following relevant international variables are incorporated:

1. Foreign exchange rate risks
2. Inflation risks
3. Expropriation risks
4. Risks of war
5. Foreign taxation and differential tax treatments between countries
6. Duties, embargos, and quantitative controls

The first four risks are represented by stochastic inputs. The last two international variables can be considered deterministic and known a priori by management. Sensitivity analyses allow considerable testing of the adequacy and relative importance of each input. A range of values and a probability distribution must be specified for each parameter. The following discussion considers the type of information which will enhance the quality of each estimate. Of course, the more accurate the data inputs, the more precise and reliable will be the results.

1. Foreign exchange rate risks:

Changes in foreign exchange rates, and particularly devaluations, can affect considerably a project's worthiness. Without question, the dollar equivalent of profits is decreased when a devaluation occurs in the host country of a subsidiary. Therefore, a careful prediction of foreign exchange rates must be made. Various events contributing to changes in foreign exchange rates must be examined:

a. Direct causes:
   - -import surplus crises;
   - -government spending abroad;
   - -withdrawal of foreign balances;
   - -over exporting of long term capital

b. Indirect causes:
   - -inflation, particularly relative inflation;
   - -political conditions;
   - -structural changes within the country;
   - -national demoralization;
   - -policies of foreign countries on investments

An analysis of these variables should lead to adequate forecasts of foreign exchange rates. For more details the reader is referred to [9] and [34].

2. Inflation risks:

Inflation has a great influence on asset valuation, profits, and credit availability. Consequently, this risk must also be studied by management.

Inflation is often associated with immoderate creation of money. A close look at the changes in the money stock is therefore of crucial importance. Other factors to be examined are government spending and changed restrictions of imported goods (through the balance of payments). A good analysis of inflation in the multinational environment can be found in [14].

3. Expropriation risks:

Obviously, expropriations of the foreign investment are of overriding importance. Therefore, a careful evaluation of the characteristics of nations and their propensity to expropriate must be established. Also, the features of the firms more subject to expropriation must be examined.

a. Country characteristics:
   - -GNP per capita: measures the level of development and can be expanded to a ranking of nations according to their propensity to expropriate [15].

- Ideology of the industrial elite: [8] gives a ranking of the elite depending on its willingness to expropriate.
- Public sector-private sector mix: the lower the weight put to the value of private ownership, the higher the propensity to expropriate [29], [30].
- Political stability: a major variable in the assessment of expropriation [11] establishes a rating scale for stability which can be used to determine the risk of expropriation.
- Balance of payments: the worse the balance of payments the more likely it is that the country perceives the repatriation of profits as a threat, which may lead to expropriation.
- Other variables such as the level of the domestic entrepreneurial sector [30], colonial heritage, etc.

b. Firm characteristics:

- Nature of economic activity: from the highest propensity to expropriate to the lowest, investments are classified as follows:
  1. service.
  2. extracting.
  3. public utilities.
  4. agriculture.
  5. manufacturing.
- Importance of the firm in the country's economic system: this factor renders the investment more or less vulnerable.
- Foreign exchange activity of the firm: depending on the contributions to the balance of payments the investment is more or less subject to expropriation.
- Nationality of the firm: for cultural reasons some nationalities are more accepted than others.
- Ownership characteristics: joint ventures are less vulnerable than a branch or a 100% owned subsidiary [12].
- Tactical vulnerability of the firm: product, skills, management style, etc. also influence expropriation.

4. Risk of war:

Whereas expropriation does not necessarily mean complete loss of the value of the assets (because of indemnity from governments), the outbreak of a war can impose a complete loss. Therefore, as elusive as this variable is, an estimate of war possibilities should be made by management. A very useful rating scheme for such an evaluation is made in [8].

5. & 6. Tax treatments, quantitative controls, duties, and embargos:

Tax treatments, quantitative controls, duties, and embargos can be considered as known with certainty even if some changes can occur over the life of the investment. However, the simulation allows probabilistic evaluation of these inputs.

The taxation of funds shifted from a foreign country to the U.S. is a very complex subject, and should be studied carefully for each specific investment. However, it can be stated that a double taxation problem will often occur: funds are taxed by the country or region and possibly taxed again by the IRS. Fortunately, the US has taxation agreements with numerous countries so as to eliminate unfair taxation (for example, profits, even if not repatriated will be taxed at about the same rate as if obtained in the U.S.). Therefore, the taxation of dividends, profits, and royalties and fees is one of the model's inputs both for the subsidiary and the parent.

All the other inputs necessary for the determination of cash flows are straightforward enough and do not create special problems of estimation. Even if the predictions of the international variables discussed above seem somewhat complex, they only require careful evaluation and analysis of available information. Furthermore, such requirements should motivate managers to investigate the international environment and help them understand better the multiple interrelationships inherent to multinational investments. This procedure, in conjunction with the decision maker's judgement, leads to very realistic estimates of the crucial uncertainty profiles.

Project Related Variables and Their Estimation

In addition to the critical international variables, the following inputs are also required in order to ascertain the project's cash flows:

1. Initial Outlay;
2. Financing Costs (for the parent and the subsidiary including principal and interest);
3. Working Capital needs for the project;
4. Market size for product generated by the investment proposal;
5. Market growth rate over the life of the project;
6. Selling prices and demand relationships;
7. Market share achieved by firm;
8. Variable costs per unit;
9. Fixed costs per year;
10. Transportation costs;
11. Useful life and salvage value of the project as well as depreciation method selected;
12. Host country tax on profits generated by the project.

Variables one, two, and twelve have very little uncertainty associated with them; thus, the dispersion in their distributions is small. All of the others are more uncertain and take on distributions of varying shapes and dispersion. Because of widespread knowledge of the meaning and impact of the above variables plus their adequate treatment elsewhere in the literature (see Hertz [16], [17]), further discussion is not felt necessary.

Subsidiary Simulation of the Investment Proposal

As mentioned previously, the nature of multinational capital budgeting decisions necessitates careful evaluation of projects both from the subsidiary's and the parent's point of view. Thus, we will discuss in depth how the simulation proceeds in each of these analyses.

The subsidiary's evaluation of a given investment proposal utilizes mainly the direct project costs and revenues discussed above. The analysis uses a uninational framework and considers the parent mainly as a source of funds to finance accepted projects.

The technical details of this stage of the simulation are presented in three illustrations. Table 1 lists the relevant cash inflows and outflows for the subsidiary.

TABLE 1

SUBSIDIARY CASH FLOWS

Inflows	Outflows
Revenue from Sales	Initial Outlay
Salvage Value	Financing Costs
	Host Country Taxes
	Operating Costs

Table 2 defines the variables (both exogenous and endogenous) and formulates the identities of the simulation model. Figure 1 shows a flow chart of this part of the simulation. Of course, the main results produced by the simulation are the empirical values of net income after host country taxes, and the yearly net cash inflows over the life of the investment. Based on these values, the desirability of the project can be determined using the discounted rate of return, net present value, and the payback criteria. The subsidiary will then either recommend that the project be accepted or rejected based on the empirical distributions of the various criteria mentioned. This decision is made by considering the subsidiary's cost of capital (which can be different from the world-wide cost of capital of the total corporation).

Parent Company's Simulation of the Capital Investment Process

The parent company takes a more global view in its evaluation of potential projects. It utilizes the empirical data relative to the project per se, but also incorporates the critical international variables associated with the transfer of funds. The additional risks and uncertainties discussed above are built into the framework so that the parent can adequately assess the situation before it commits funds to a given project in a specific country.

Table 3 shows the cash flows from the parent's point of view.

TABLE 2

VARIABLES OF THE SUBSIDIARY SIMULATION MODEL

PARAMETERS:

SP_t = Selling price per unit in year t KS = The subsidiary cost of capital

DR_t = Depreciation rate for year t selected by user

MAX = Total number of simulation runs to be considered

EXOGENOUS VARIABLES:

Stochastic variables with known probability distributions:

MG_t = Market growth rate for each year t

MS_i = Initial market size in number of units

SM_t = Share of the market for each year t

INV = Initial Investment required by the proposal

N = Useful life of investment

FC_t = Total operating fixed costs in year t

VC_t = Variable Operating Costs per unit in year t

IC_t = Interest costs associated with the project in year t

OC_t = Other project related costs in year t

WC_t = Working Capital Needs of the project in year t

TR_t = Tax rate for host country tax on project returns in year t

IR_t = Rate of inflation in year t

WAR_t = The probability that a war will break out in the host country during year t

$LWAR_t$ = The % of loss suffered by the firm if a war occurs in year t

EX_t = The probability that expropriation will take place in host country in year t

LEX_t = The loss suffered by the firm if expropriation takes place in host country during year t

ENDOGENOUS VARIABLES:

$USAL_t$ = Unit sales generated by the proposal in year t

REV_t = Total revenue generated by the proposal in year t

TC_t = Total costs associated with the project in year t

TAX_t = Host country tax on taxable income generated by project in year t

$NIAT_t$ = Net Income after host country tax generated by project in year t

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TABLE 2 - CONTINUED

NCI_t = Net Cash inflow generated by project in year t

BV_t = Book value of the project in year t

SV_t = Salvage value of the project in year t

$TINF_n$ = Terminal Inflow if expropriation or war occurs

$PAYB_m$ = Payback period for the investment on the m^{th} simulation run

NPV_m = Net Present value for the investment on the m^{th} simulation run

IRR_m = Discounted rate of return for the investment on the m^{th} simulation run

<u>IDENTITIES</u>:

$BV_0 = INV$

$BV_t = INV - (DR_t)(BV_{t-1})$

$MS_t = (MS_{t-1})(1+MG_{t-1})$ $\quad t=2,3,\ldots,N$

$USAL_t = (MS_t)(SM_t)$ $\quad t=1,2,\ldots,N$

$REV_t = (SP_t)(USAL_t)$ " "

$TVC_t = (VC_t)(USAL_t)$ " "

$DEP_t = (DR_t)(BV_t)$ " "

$TC_t = TVC_t + FC_t + OC_t + DEP_t$ $\quad t=1,2,\ldots,N$

$TAX_t = (TR_t)(REV_t - TC_t)$ " "

$NIAT_t = REV_t - TC_t - TAX_t$ " "

$NCI_t = NIAT_t + DEP_t - WC_t$ " "

$$SV_n = \sum_{t=1}^{n} (INV - DEP_t)(1 + IR_t)$$

If expropriation (EX_n) occurs in year n, determine loss suffered (LEX_n), then

$TINF_n = (1 - LEX_n)(SV_n + NCI_n)$

If war (WAR_n) occurs in year n, determine loss suffered ($LWAR_n$), then

$TINF_n = (1 - LWAR_n)(SV_n + NCI_n)$

$PAYB_m$ = The period i such that: $INV - \sum_{t=1}^{i} (NCI_t + IC_t) = 0$

$$NPV_m = \sum_{t=1}^{n} \frac{NCI_t}{(1+KS)^t} - INV$$

IRR_m = The discount rate r such that: $\sum_{t=1}^{N} \frac{NCI_t}{(1+r)^t} - INV = 0$

Figure 1

FLOWCHART OF SUBSIDIARY SIMULATION

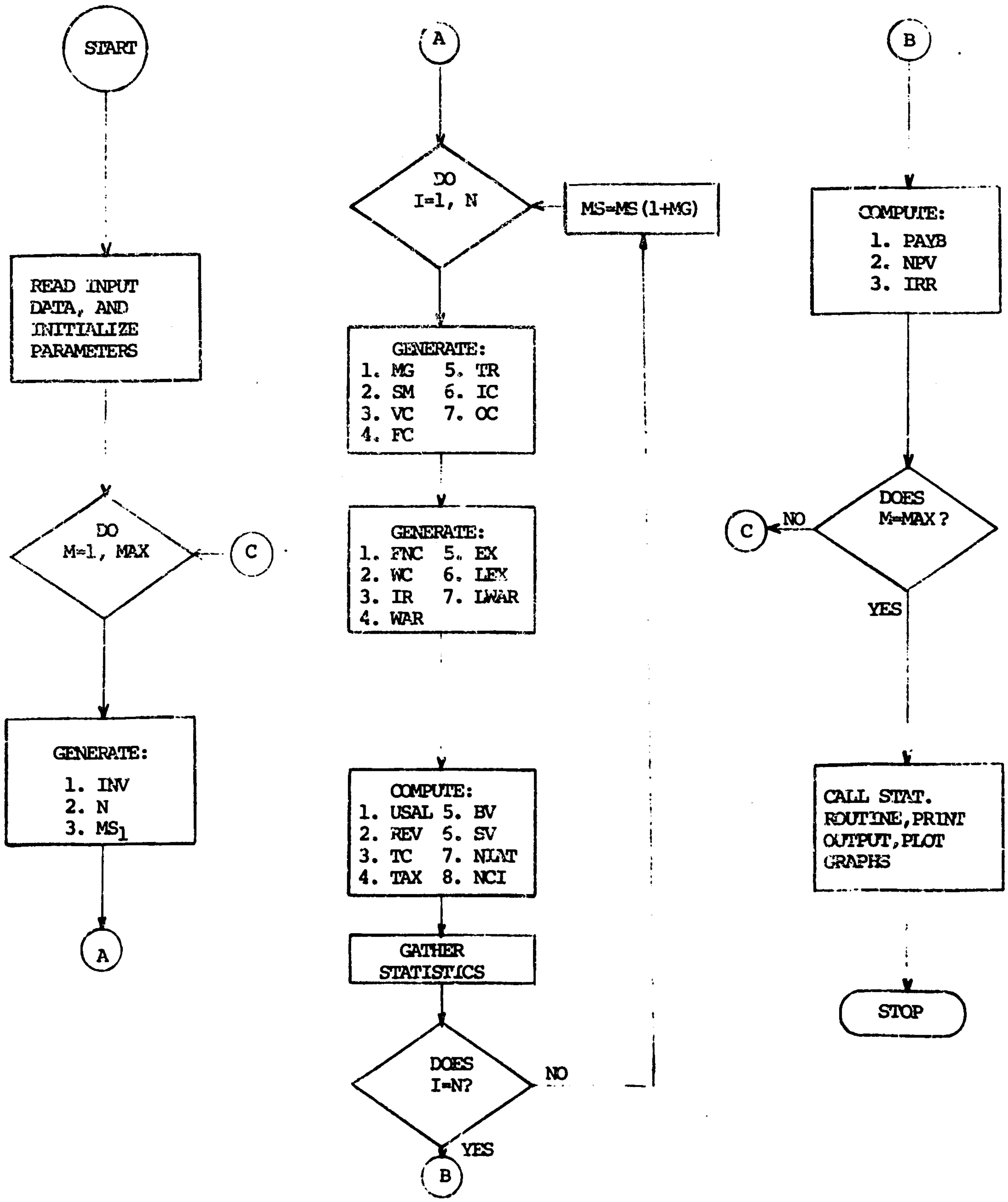


TABLE 3

PARENT COMPANY CASH FLOWS

Inflows	Outflows
Direct savings generated by the project	Equity funds provided
Profit repatriated	Loans provided
Dividends	Labor, material, and other costs
Royalties and fees	Transportation costs
Interest and loan repayments	Taxes paid on dividends, royalties, and profits repatriated

Table 4 represents the new variables and identities of importance here. Figure 2 presents the flowchart of the parent's analysis. The same outputs as before--internal rate of return, net present value, and payback--provide the criteria in the parent's evaluation of the worth of the project. The decision is made by using a world-wide cost of capital and any additional qualitative factors.

Mechanics of the Simulation

As noted above, the simulation is designed to be flexible and complete yet not overdemanding on the user relative to necessary data inputs. However, it was also pointed out that the more precise the input specifications are, the more exact and helpful will be the results generated by the simulation. Thus, balancing these tradeoffs, the decision-maker is asked to specify the various variables as accurately as he can for as many years in the future as possible. It is realized, of course, that the farther into the future a user must estimate distributions, the greater the degree of uncertainty. Offsetting this shortcoming are two countermeasures: (1) the discounting process which weights more distant years less heavily, and (2) the fact that sensitivity analysis can be used to determine the impact of changes in the input variables on the decision criteria. In order to make the variable estimation process as painless as possible, the user is given many alternatives as to the method of specifying inputs: (1) he can provide the pessimistic, optimistic, and most likely estimates; (2) the parameters of well known distributions (e.g., Binomial, Uniform, Normal, Beta, etc.) can be specified; (3) he can input any discrete distribution that he feels is appropriate; or (4) he can specify that the distribution is a composite of various distributions. The user is asked to input parameters and distributions for as many years in the future as he feels confident of. However, some variables will incur only minor changes over time, and the distributions can be unchanged for several years.

It is important to describe more precisely how the international aspect of the simulation is handled. The risks of expropriation and war are obtained through a Monte Carlo determination. When the simulation establishes that expropriation or war occurred, it determines, from the input distribution, the associated loss. This result is used to derive the terminal inflow as a proportion of salvage value and the yearly cash inflow.

TABLE 4

VARIABLES OF THE PARENT COMPANY SIMULATION MODEL

PARAMETERS:

DET_0 = The debt funds committed to the project by the parent in year 0

EQY_0 = The equity funds committed to the project by the parent in year 0

DIV_t = The dividend rate as a percent of earnings generated by the project in year t

REP_t = The percent of profits repatriated in year t

KP = The parent company's cost of capital

EXOGENOUS VARIABLES:

Stochastic variables with known probability distributions:

FER_t = The Foreign Exchange Rate in year t

ROY_t = The amount of royalties and fees to be paid to the parent in year t

SAV_t = The direct savings generated by the project in year t

LMC_t = The labor, material, and other costs paid by the parent for production of the product by sub in year t

$TRAN_t$ = The transportation costs associated with importing the product in year t

$PITR_t$ = The weighted "international" tax rate on dividends, royalties and profits repatriated

$PHTR_t$ = Parent home tax rate

INT_t = The interest payments received by the parent in year t

$PRIN_t$ = The principal payments received by the parent in year t

$REQY_t$ = Equity funds retired in year t

ENDOGENOUS VARIABLES:

$PREV_t$ = The before "international" tax total foreign revenue for the parent generated by project in year t

PTC_t = The total cost for the parent generated by project in year t

$PTAX_t$ = The total tax paid by the parent in year t

PITAX = The amount of "international" tax paid by the parent

PHTAX = The amount of home tax paid by the parent

TABLE 4 - CONTINUED

$PNIAT_t$ = The parent's net income after all taxes

$PNCI_t$ = The parent's net cash inflow in year t

$PPAYB_m$ = The parent's payback for simulation run m

$PNPV_m$ = The parent's net present value for simulation run m

$PIRR_m$ = The parent's internal rate of return for simulation run m

IDENTITIES:

$PREV_t = (FER_t)[(DIV_t + REP_t)(NIAT_t) + ROY_t + INT_t]$

$PTC_t = IMC_t + TRAN_t$

$PITAX_t = (PREV_t)(PITR_t)$

$PHTAX_t = (SAV_t - PTC_t)(PHTR_t)$

$PTAX_t = PITAX_t + PHTAX_t$

$PNIAT_t = PREV_t + SAV_t - PTC_t - PTAX_t$

$PNCI_t = PNIAT_t + PRIN_t + REQY_t$

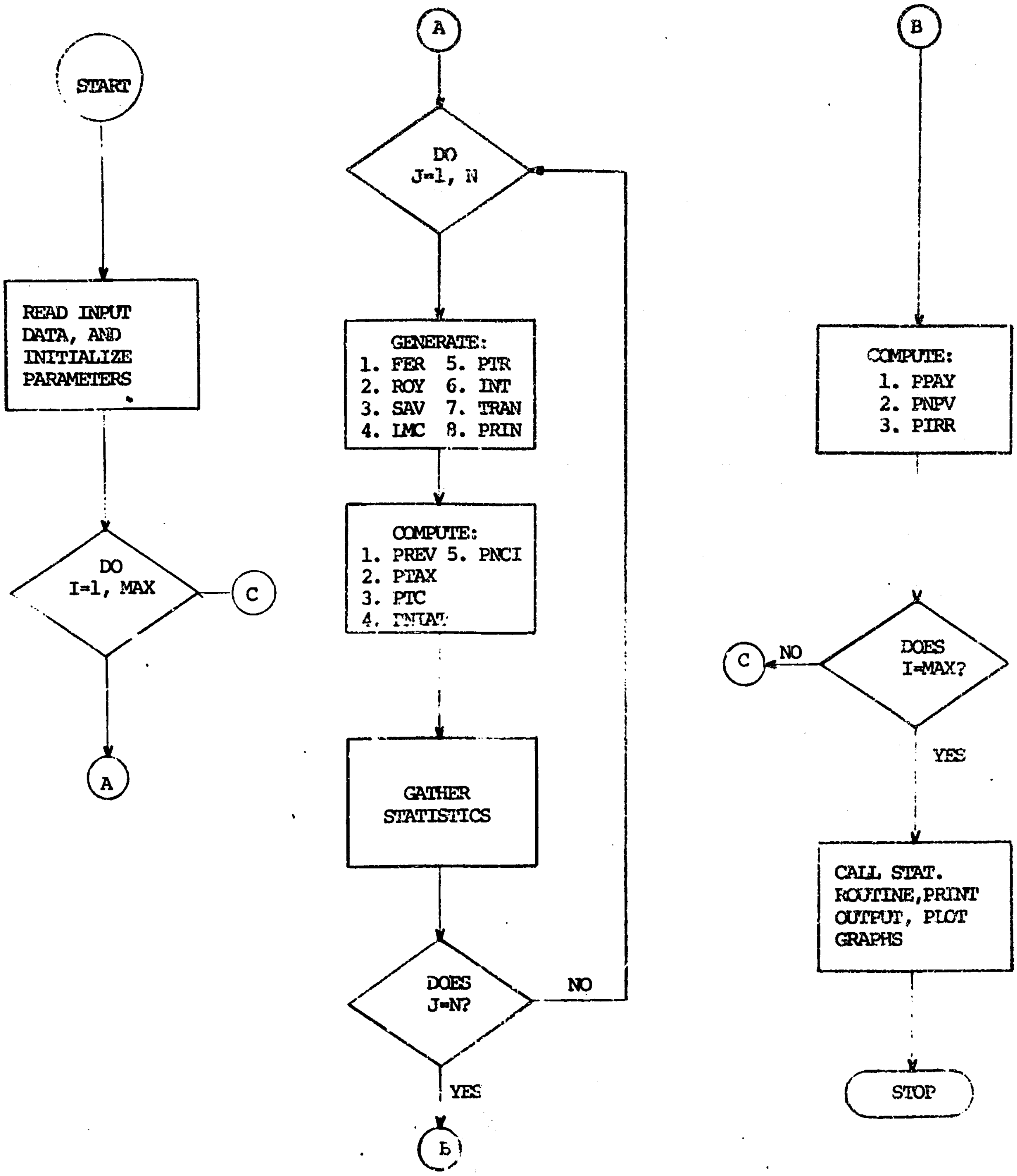
$PPAYB_m$ = The period i such that $(DET_0 + EQY_0) - \sum_{t=0}^{i} PNCI_t = 0$

$$PNPV_m = \sum_{t=0}^{N} \frac{PNCI_t}{(1+KP)^t} - (DET_0 + EQY_0)$$

$PIRR_m$ = The discount rate r such that $\sum_{t=0}^{n} \frac{PNCI_t}{(1+r)^t} - (DET_0 + EQY_0) = 0$

Figure 2

FLOWCHART OF PARENT COMPANY SIMULATION



Inflation is dealt with in two ways. First, it can be taken into consideration in the estimation of the exogenous variables by the user's specifying a different distribution for each year of the anticipated useful life of the project. Second, the distribution can be shifted to the right, every year, by the expected percent inflation which can be done for selling price, variable cost, etc. If a single distribution is specified for all periods, the inflation factor is built into the simulation and taken into consideration in the yearly revision of the distributions for the exogenous variables.

It is also important to outline that the model handles dependency among the random variables. Some relationships can be easily taken care of in the estimation of the different distributions. For example, a high rate of inflation in a given year must be associated with larger expected changes in foreign exchange rates for that year, and the corresponding distributions must be so built. However, some dependencies are contingent on the value of the random variables generated by the simulation and can only be handled by the model. An example will make things clearer. It is reasonable to assume that, generally, a high level of fixed cost is associated with a lower variable cost per unit. Consequently, the model takes this fact into consideration and generates low values of variable cost whenever high fixed costs are selected from its distribution. The same type of treatment is established between other interrelated variables.

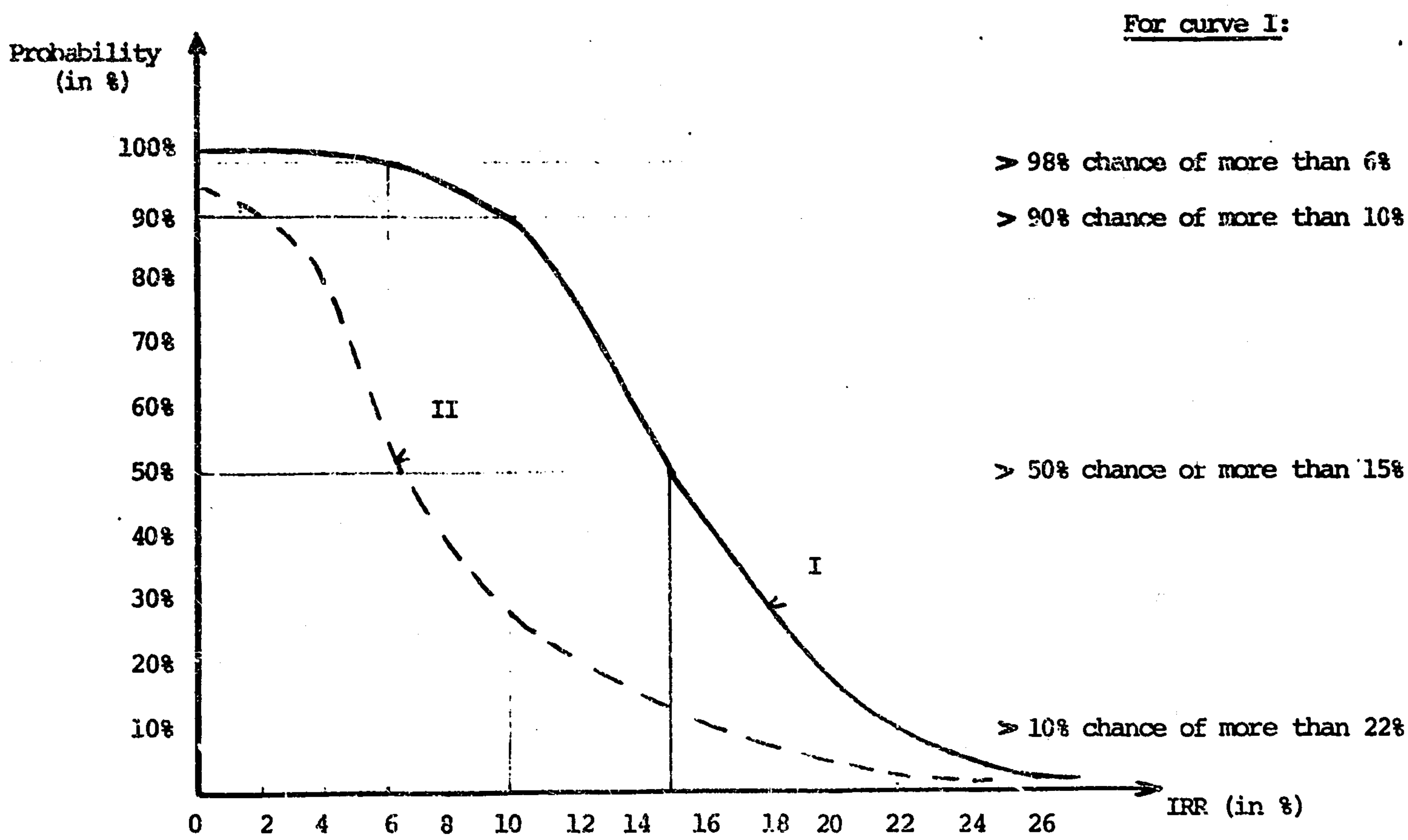
One final detail should be mentioned. Because of the two stage analysis of the investment proposals--first by the subsidiary and then by the parent--two different costs of capital are used. The subsidiary uses its own cost of capital in order to determine whether the investment is desirable from its viewpoint, and if the project should be recommended to the parent for acquisition. In a similar vein, the parent uses a world wide cost of capital figure which it considers relevant (given the risk posture of the investment and the economic, social, and political factors present in the host country) to determine whether it should commit funds to the project. Such an approach gives a double, somewhat independent, more stringent screening of proposals. They must survive both cut off points in order to be adopted by the multinational firm.

IV. VALIDATION AND ANALYSIS OF THE MODEL'S OUTPUT

The simulation not only permits managers to evaluate and compare the performance of different potential investments, but also presents an analytical approach to determine relationships among investment variables and international factors.

The main output consists in the two profiles of Net Present Value (NPV) and Internal Rate of Return (IRR) for the parent company and for the subsidiary. As explained previously, the return to the parent is not the same as to the subsidiary in the country of the investment.

Figure 3



Therefore, a double evaluation of each investment is highly recommended, even in the case of a 100% financing by the parent.

Figure 3 gives an example of the main output. Curve I represents the IRR profile for the subsidiary whereas II is for the parent. As can be quickly noticed in this specific case, the IRR for the parent is everywhere lower than the subsidiary's IRR. However, this need not always be the case (it would depend on the influence of foreign exchange rates, tax differentials, etc.). The purpose of these two profiles is to make sure that the worthiness of the investment can be evaluated by all the groups of the organizations (parent's managers and possible partners in the country of the investment) with their possibly different aspirations. Therefore, an investment is worth having only if these two groups' criteria of acceptability are met.

How are these profiles used? As demonstrated by curve I of Figure 3, there is a 98% chance that an IRR $\geq$ 6% can be obtained, a 90% chance of more than 10%, a 50% chance of more than 15%, and a 10% chance of an IRR $\geq$ 22%. We know that the investment will be worthwhile (from the point of view of the subsidiary) if the IRR is at least equal to its cost of capital.

if we assume a subsidiary's cost of capital of 10%, the chance of having an IRR $\geq$ 10% are 90 out of 100. The decision makers will have to decide whether they are ready to take the risk implied: 90 chances out of 100 of having a profitable investment, but 10 out of 100 of losing money. The same analysis needs to be done with curve II from the point of view of the parent (we wish to remind the reader that the cost of capital for the parent and the subsidiary can be different).

The analysis of the output data is rendered more sophisticated than merely evaluating the graphical output by the following elaborations. A statistical analysis subroutine using a multiple ranking criteria discussed by Kleijnen, Naylor, and Seaks [20] analyzes and determines the order of the project desirability and whether statistically significant differences exist among the ranked projects. This analysis is performed by each subsidiary and by the parent for all projects considered by the multinational firm. Such results are invaluable where the firms are faced with capital rationing and multiple, competing opportunities and risks.

In addition, because of the importance of extremes, the simulation could be rerun at least two other times to evaluate the impact of all the inputs having very optimistic distributions and very pessimistic ones. Thus, each investment would have three profiles for each of the criteria. This more complete information can provide valuable insights relative to the investment's overall attractiveness.

Payback criteria are also given as an output of the model through the same type of profiles. This ratio tells the decision maker the number of years required to recover the initial cash investment. This method of investment evaluation should only be used as a secondary criterion, i.e., to differentiate between mutually exclusive projects which have about the same IRR or NPV profiles. However, even if the payback criterion is not a measure of profitability (it does not take into account the cash flows after the payback period) it can be important for international investments. Indeed, the shorter the payback period the smaller the risk of loss due to expropriation, war, or unfavorable foreign exchange rate fluctuations. Therefore, managers can consider this measure as an important aspect of the multinational investment process.

Another significant benefit from the simulation approach is the sensitivity analysis that can be performed. Indeed, decision makers can change the distribution of each variable one at a time, and have a good understanding of the importance each variable has on the value of the investment. It allows an increased comprehension of the relationships among variables and their impact on the decision process. This information is extremely valuable especially for the evaluation of the international variables, particularly for foreign exchange rates which are difficult enough to forecast. If, for example, the final results are found very little affected by changes in currency values, it is clear that the uncertainty of the investment is greatly reduced. On the contrary, high sensitivity to foreign exchange rates would warn the decision maker to give special forecasting attention to this variable.

V. CONCLUSION AND EXTENSIONS

The major emphases of the simulation proposed in this paper were: (1) the extension of capital budgeting analysis to include both project related and international variables relevant to the multinational firm; and (2) the flexibility of a two-stage screening process where first subsidiaries evaluate investment proposals, and then the parent company supplements the analysis by considering the project's desirability from its point of view.

The dual goals of the simulation design were to provide a robust and flexible model and to require only those information inputs that could be relatively accurately estimated. It is because of this second goal that the model does not extensively treat the interrelationships among current proposals and ongoing operations, as well as among the proposals themselves. However, an extension of the current formulation could be made by formally reflecting these portfolio effects. As information systems become more sophisticated, these improvements will certainly become more feasible.

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