by Geoffrey P. E. Clarkson

The object of this study is the investment of trust funds held by banks in the United States—funds that currently amount to nearly \$60 billions. The purpose of our model is to simulate the process employed in the investment of trust funds in common stocks. When making a decision a trust officer in a bank is confronted with a large assortment of information. Information abounds on the operation of firms and the market valuation of their stocks, and published reports make predictions about the future state of the general economy and stock market. When an investor acts in an agency or fiduciary capacity, legal restrictions and the desires of his client must also be considered. These factors, when evaluated and combined into an investment program, ultimately result in a decision to buy specific quantities of particular stocks and bonds. Thus, an investor choosing a portfolio is processing information: he sorts the useful from the irrelevant, and decides which parts of the total information flow are most important.

The investment process is a problem in decision-making under uncertainty. Our model, written as a computer program, simulates the procedures used in choosing investment policies for particular accounts, in evaluating the alternatives presented by the market, and in selecting the required portfolios. The analysis is based on the operations at a mediumsized national bank¹ and the decision-maker of our model is the trust investment officer.² We require our simulation model to select portfolios

¹ The trust assets of this bank are approximately equal to the average for all national banks.

^a It should be noted that our model reflects the behavior of one investor and hence

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using the same information that is available to the trust officer at the time his decisions are made.

Postulates and Data for the Model

Since our model is a theory of individual decision-making behavior, the method of analysis is based on the theory of human problem-solving (Newell, Shaw, and Simon, 1958a). In keeping with the postulates of this theory, the main postulates for the analysis of the investment decision process are that there exist:

1. A *memory* that contains lists of industries each of which has a list of companies associated with it. The memory also contains information associated with the general economy, industries, and individual companies.³

2. Search and selection procedures that perform the task of searching the lists of information stored in memory, selecting those bits that have the required attributes, regrouping the selected items of information into new lists, and performing algebraic operations when necessary. These procedures function in a manner similar to a clerk who prepares lists of stocks suitable for current investment by scanning a master list.

3. A set of rules or criteria that guide the decision-making process by stipulating when and how each decision process is to be used. The set of rules constitutes the structure of the decision processes for an individual investor. It might be compared to the "rules of thumb" of the traditional "expert," but there is an important difference—namely, the set of rules must be defined unambiguously.

In common with other problem-solving programs, the processes are used iteratively and recursively. Lists of industries and companies are searched for particular attributes; sublists are created, searched and divided again. For example, to obtain a high growth portfolio, the list of companies stored in memory is searched to obtain securities with the desired characteristics. Additional criteria are employed to narrow (or expand) this list. Further search and testing against desired criteria yields the specific selection of stocks to buy.

Like the investor it simulates, the program stores the final result (list)

may not describe the general case. The implications of this study for more general theories of investment are discussed in Clarkson (1962), chap. 8.

³ Investors categorize companies by industry. Not all investors may associate identical companies with a given industry, but the process of classification by industry remains invariant as the primary basis for listing companies in the memory. The information associated with each company also varies among investors, but each may be represented as having a list of attributes with their values stored in memory, *e.g.* growth rate, dividend rate, price earnings ratio, expected earnings, expected yield, etc.

for future use. If the same problem reoccurs, the entire process need not be repeated. The list may be judged by present criteria, accepted, adapted to meet new conditions, or completely rejected. In the latter event the program would renew search and selection activity until a new list had been formed.

To define a model of trust investment behavior within this general framework we require the basic rules (operations) used in making a decision to purchase particular securities. To obtain these data, trust departments of several local banks are studied by interviewing departmental officers and by observing behavior at committee meetings called to review past and future decisions. Attention was then focused on an investment officer who was chiefly responsible for all decisions relevant to the choice of portfolios within a particular bank. The history of several accounts were examined and naïve behavioral models were constructed to help uncover these decision processes that appeared to be invariant among accounts.

In an attempt to confirm or refute these hypotheses, the trust officer was asked to permit "protocols" to be made of his decision processes.⁴ These protocols recorded the trust officer's decision processes for accounts that arose in the course of his work. The decisions made during those problem sessions determined the particular securities that were purchased for those accounts.

Close inspection of the protocols revealed that many of the decisions pertaining to the formulation of expectations, and the evaluation of industries, companies and stocks were made before the selection of a particular portfolio began. In an attempt to discover how these prior decisions were made a new approach was taken. The trust officer was asked to read articles from financial journals and analysts' reports, to which he subscribed, and comment on the ideas, forecasts, facts, etc., presented in the articles. Protocols of these thought processes were more successful in that they revealed many of the decision processes subsumed in the earlier transcripts

On the basis of these data and analytic techniques, a model was con structed. The model considers the problem of investing the funds of new accounts in common stocks. It does not directly consider the problem of allocating the funds among bonds, preferreds, and common stocks. The trust investment model is stated in terms of a computer model and is presented in the next section.⁵

⁴A "protocol" is a transcript of the verbalized thought and actions of a subject when the subject has been instructed to think or problem-solve aloud. Thus, the transcript is a record of the subject's thought processes while engaged in making a decision. Since a protocol is a detailed description of what a person does it avoids some of the problems inherent in interview and questionnaire techniques that ask the subject to state his reasons for behaving as he does. For further discussion see Newell, Shaw, Simon (1958*a*).

"The program is written in Information Processing Language V (Newell, 1961e).

The trust investment process can be divided into three parts: (a) the analysis and selection of a list of stocks suitable for current investment—the "A" List, (b) the formulation of an investment policy, and (c) the selection of a portfolio. Each of these sections can be also broken down into a number of subsections (see Fig. 1).

The process of selecting a current list of stocks [step (a)] entails an analysis of individual companies as well as an appreciation of the factors affecting their respective industries and the economy as a whole. The problem of formulating an investment policy [step (b)] involves a process that translates the information on the beneficiary or client into an investment goal that will yield the desired combination of income and/or appreciation. This process requires the trust investor to consider such things as the effect of taxes on the stream of income generated by the portfolio as well as the stability of that stream. The actual selection of a portfolio [step (c)] follows directly from steps (a) and (b). While the selection



Figure 1. Structure of decision process.

procedure contains rules on diversification and on how to determine the size of participations, the essence of the process lies in carrying the prior analysis to its logical conclusion.

In presenting this model of trust investment behavior, we shall follow the outline of the process given in Fig. 1 so that each subsection as well as the interrelations can stand by themselves for critical appraisal.

Having outlined the investment process and the method of analysis used in constructing the model, the only question that needs to be examined before proceeding with a description of the model is the effect of the organization and the fiduciary relation on the trust investment process.⁴

Since banks are responsible for all investments made in their name, elaborate procedures are set up to review and approve all investment decisions." Also, the necessity of being able to justify their investment decisions in a court of law has led trust investors to create a set of criteria with which to judge the quality of any given portfolio or investment. For all practical purposes these criteria can be reduced essentially to one maxim: A security is of investment quality if and only if it is being bought or is being held by other leading trust institutions.⁸ Clearly, this maxim is circular in nature and if strictly true would preclude change. However, the smaller the bank the truer the maxim, which implies that innovations must come from the larger banks acting by themselves or in small groups. If innovations do not occur very frequently, the maxim then asserts that the general list of stocks that are considered suitable for trust investment will remain fairly stable over time. The addition of a further observation, namely, that trust investors eschew taking losses, *i.e.*, selling stocks whose prices have fallen below the purchase price, allows an even stronger prediction to be made. The basic list of stocks-the "B" List-that are considered to be suitable for trust investment by a particular bank will remain fairly stable over time, any changes being in the form of additions. Thus, for any given trust investor, the basic list of stocks from which he can choose is given to him by the historical record. At any particular point in time an investor selects stocks from a subset of his basic list. This subset

⁶ As we are principally concerned with the investment of trust funds for individual accounts, the important constraints are those that are imposed on the investor by the banking institution and the fiduciary relation with the client.

^{*} "All investments of trust funds shall be made, retained or disposed of only with the approval of the Trust Committee. . . . The Trust Committee shall, at least once during each period of twelve months, review all the assets held in or for each fiduciary account to determine their safety and current value and the advisability of retaining or disposing of them." Excerpt from the *Trust Manual* of a National Bank.

It is interesting to note that this Trust Committee is appointed by the Board of Directors and is composed of the President, the Vice-President in charge of investments, the Vice-President in charge of trusts, and other officials.

⁸ By a simple substitution of words this maxim can roughly be applied to the composition of portfolios, *i.e.* the ratio of common stock to bonds and preferred stocks.

is a proper subset of the "B" List and is defined by a concept of relative valuation. As expectations, prices, yields, and other metrics change with time, so does the content of this subset which is called the "A" List.

Hence, institutional constraints reduce the problem of determining the list of stocks from which, at a given point in time, an investor actually chooses—the "A" List—to one of "stocks" and "flows." Since the "stocks" change slowly with time the model assumes them to be given and takes as part of its goal the analysis and prediction of the "flows."

1. Selection of the Current List of Stocks—The "A" List

In this section we shall present the data and the mechanisms that the model uses to evaluate and select the stocks for the "A" List. Unlike the model's processes for steps (b) and (c), the mechanisms described in this section are not intended to be a reproduction of the analytic procedures used by the trust officer each time he selects a new portfolio. To reproduce



Figure 2. Selecting the "A" List.

only those procedures would require us to ignore all the data on each company that he has collected and processed in preceding years. To take the historical data into account, the model must employ a set of mechanisms that generate the same sorts of measures and comparative data that the trust officer actually employs when he is selecting a portfolio. Clearly, the trust investor (unlike the model) does not evaluate all companies at one time. But, our object is to use that set of mechanisms that yield the right kind of data and measures of performance. Thus, the processes described in this section should not be viewed as a complete simulation of what the trust officer does prior to each portfolio selection, but rather as an approximation of the processes he has used over the years in order to build up a set of measures by which the performance of a company can be judged. Our success in this respect will be tested later on.

In order to describe the processes that are involved in the selection of the "A" List it is necessary, at first, to treat some of the mechanisms as though they were independent of each other. While this is not in fact the case, the ways in which they are interrelated will be discussed after the data processing mechanisms have been described. To facilitate this explication a flow chart of the selection procedure is presented in Fig. 2.

1A. PROCESSING THE RAW INFORMATION

Although the information used to derive the current list of stocks is classified into three main categories, e.g., general economy, industry, and company, the processes by which the information is handled are roughly the same. Differences occur in the content of the information processed and the manner in which interrelations are formed, but the basic structure of the sorting and evaluating processes remains the same.

For each category there is a set of attributes that correspond to the important variables in that category. For example, for all companies the set of attributes consists of sales, earnings, cash flow per share, profit margin, working capital, price earnings ratio, dividend payout ratio, dividends per share, dividend yield, and prices. The values of these attributes are their numerical values, and these are determined by the information which is fed into the model. Since the values will reflect the changes that occur in economy, industry and company variables those that change frequently are readily distinguished from those that do not. Those that change infrequently with time reflect the general trend of the economy, industry, or company, while the others indicate those attributes that are more sensitive to short-run fluctuations. The mechanisms that derive these values are the same in all cases, and it is to these processes that attention is now directed. 1A1. Determination of Attributes and Their Values. All information, except that dealing with economy or industry forecasts, is fed into the model in numerical form. These data consist of the historical values of each

attribute in the system for the last ten years.⁹ The data are entered in the form of lists, and from these basic lists the model generates, for each attribute, three additional lists. The first of these lists contains the mean of the ten historical values. The second contains a set of nine values which record the rate of increase (or decrease) of each value in the historical record over the value immediately proceeding it. The third of these lists contains the average rate of change of the values for the entire ten year period. For each attribute, then, the model contains the four following lists of information:

(i) *Current Value*. This list contains the last ten annual values of each attribute arranged chronologically so that the most recent is at the head of the list.

(ii) *Ten-year Average*. Each time a new value is added to (i) a new average of the ten values is placed on this list. Thus, this list contains a ten year moving average of the values in (i).

(iii) Recent Changes. This list contains the rate of increase (or decrease) of each value in the Current Value List over the value immediately below it. Thus, if the values of the Current Value List are called x_i , where $i = 1, 2, \ldots, 10$, then the Recent Change List will have nine entries whose values will equal:

$$\frac{x_i - x_{i+1}}{x_{i+1}}$$
 where $i = 1, 2, \ldots, 9$

(iv) Average Rate of Change. This list contains the average rate of change of the values on list (i) for the entire ten year period. Like list (ii), this is revised every time there is a new entry on the Current Value List.

Hence, the basic information which is given to the model is processed so that it is expressed in terms of rates of change and/or ratios which are directly comparable throughout the system.

1A2. The Formation of Expectations. Information on forecasts is fed into the model in two different forms. Forecasts for economy and industry attributes are converted for input into a three-valued scale "above," "below," or "equal to." The entry is based on the published predictions that the value for a given attribute is going to rise, fall, or stay the same over the next interval of time. Numerical data is not used in an attempt to avoid the chaos of averaging the array of forecasts found in financial literature.

For the analysis of company performance, however, numerical forecasts

[•] The attributes themselves are taken as given. They were derived by an analysis of trust investors' decision processes and by observing which variables are considered important by investment services.

The data for economy and industry attributes was taken from *Moody's Industrials*, *Review of Current Business*, and *Statistical Abstracts*, while data for company attributes was taken from the Value Line Investment Survey.

are needed, and in a further effort to avoid conflicting opinions all forecasts for company attributes are taken from the Value Line Investment Survey.

All forecast attributes have the current forecasts as their only value. Previous forecasts are not kept and the model takes each forecast at face value without making any attempt to judge its "goodness" or "record of success." This procedure may not be too realistic as it ignores the effects of personal preferences on perception. But, the model is not equipped to handle "second guessing" and other judgmental modifications and the information is assumed to be reliable. Before discussing the role of expectations in our model, it is necessary to mention some further behavioral characteristics of trust investors.

By and large, trust investment is long-term investment. As previously noted, trust investors do not engage in trading stocks for their clients, but look to the long-term growth of the economy and the market to justify their investments. This is not to say that they remain aloof from daily, monthly, or yearly fluctuations, but rather that their emphasis is on the analysis of industries and their respective companies. Their basic belief is that the market will eventually recognize a company's "true value." Hence, in general, trust investors analyze companies and not the market.

Clearly changes in the market do affect investor behavior, but the effects are more in keeping with a feedback mechanism than one where the investor acts on the basis of his own market forecasts. Thus, attributes containing forecasted information are included in this model, but they receive different amounts of attention depending on whether the attributes belong to the economy, industries, or specific companies. Since the content of the Expectation Lists varies as well as the form, these lists are described in turn.

(i) Economy and Industry Expectation Lists. For each attribute in both of these categories the Expectation Lists contain two entries. The first is the forecasted value for that attribute converted into the input form of "above," "below," or "equal to." The second is the first value on the Recent Change List—namely, the rate of change of that attribute for last year—converted into the same three-valued scale.¹⁰ Hence Economy and Industry Expectation Lists contain pairs of "aboves," "belows," or "equals to" which under two possible sets of conditions will form a pattern of only "aboves" or "belows."

(ii) Company Expectation Lists. Expectation Lists exist for five of the ten company attributes.¹¹ These Expectation Lists contain one or two entries all of which are in numerical form. These entries are derived from

¹⁰ In this case the three-valued scale is recording whether the rate of change for this attribute last year was positive, negative or zero.

¹¹ The five attributes which have forecasted values are: sales, earnings per share, cash flow per share, profit margin, and dividends per share.

the twelve-month and three- to five-year forecasts recorded in the model for these attributes. The first entry is on all Expectation Lists and is obtained by converting the twelve-month forecast into an expected rate of change. The second entry exists only for sales and earnings per share Expectation Lists and is obtained by converting the three- to five-year forecast into an expected average rate of change.

1B. EVALUATING THE DATA

Logically this section should contain all the procedures of evaluation used in this model. However, in order to simplify the problem of describing the actual mechanisms, the processes of evaluation have been divided into two parts. Those that pertain to the information within each major category, *i.e.*, economy, industry, and company, are examined here; those that involve the interrelations between these sections are discussed in Sec. 1c.

The model evaluates the data by creating two main lists: the Relative Performance List, and the Relative Value List. As these processes are described in some detail it is worth pausing for a moment to make a list of the information already gathered for each attribute of each company:

- (i) A list of the last ten values of the attribute
- (ii) The mean of these ten values
- (iii) A list of the rates of change of these values
- (iv) The mean of these rates of change

(v) For relevant attributes an Expectation List that contains the expected rate of change for the coming year and, in the case of the sales and the earnings per share attributes, the expected average rate of change for the next three to five years

Attention has been drawn to this information as the processes of evaluation use these data as inputs.

1B1. The Relative Performance List. In order to determine the relative performance of each company within its given industry a list is made for each of the basic lists for each attribute of the mean for that attribute for each company. Hence, for each attribute there is now a list of means each of which belongs to a particular company within a given industry. The average of this list of means is taken so that we now have a distribution of means for a given attribute, plus the mean of that distribution. The deviation of each mean from the distribution mean is calculated as a percentage deviation and is then converted into the three-valued scale "above," "below," or "equal to." These per cent deviations from the distribution mean are recorded on the Relative Performance List of each attribute.

To classify this process further let a_{ij} represent the class of all company attribute means where:

 $i = 1, 2, \ldots, n$ represents the number of attributes for each company $j = 1, 2, \ldots, m$ represents the number of companies for each industry

Then the matrix
$$A_{n,m} = \begin{vmatrix} a_{11} & a_{12} & \cdots & a_{1m} \\ a_{21} & a_{22} & \cdots & a_{2m} \\ \vdots & & & \\ a_{n1} & a_{n2} & \cdots & a_{nm} \end{vmatrix}$$

is the row-by-row array of means for each attribute, for all companies within a given industry. The mean of the distribution of means for attribute i is given by:

$$\bar{a}_i = \frac{1}{m} \sum_{j=1}^m a_{ij}$$

The list of all such means forms the vector

$$\bar{A}_n = \begin{bmatrix} \bar{a}_1 \\ \bar{a}_2 \\ \vdots \\ \vdots \\ \bar{a}_n \end{bmatrix}$$

To determine the deviations of each a_{ij} from its respective mean \bar{a}_i the model takes the difference $(a_{ij} - \bar{a}_i)$ as a per cent of \bar{a}_i . Hence, the deviations for each attribute for all companies are given by the row-by-row array:

$$\begin{bmatrix} \frac{a_{11} - \bar{a}_1}{\bar{a}_1}, \frac{a_{12} - \bar{a}_1}{\bar{a}_1}, \dots, \frac{a_{1m} - \bar{a}_1}{\bar{a}_1} \\ \frac{a_{21} - \bar{a}_2}{\bar{a}_2}, \frac{a_{22} - \bar{a}_2}{\bar{a}_2}, \dots, \frac{a_{2m} - \bar{a}_2}{\bar{a}_2} \\ \vdots \\ \vdots \\ \frac{a_{n1} - \bar{a}_n}{\bar{a}_n}, \frac{a_{n2} - \bar{a}_n}{\bar{a}_n}, \dots, \frac{a_{nm} - \bar{a}_n}{\bar{a}_n} \end{bmatrix}$$

These percentage deviations are then converted into the three-valued scale "above," "below," or "equal to" where the base for the comparison is given by a five per cent boundary level either side of the distribution mean \tilde{a}_i . Thus for the relevant¹² attribute there is a Relative Performance List on which is recorded:

¹³ All Relative Performance Lists contain items (i) and (ii). Lists for attributes cash flow per share and profit margin contain items (i), (ii) and (iii). While lists for sales, earnings per share, and dividends per share attributes contain all four items.

(i) The mean value over the last ten years as well as whether this mean is "above," "below," or "equal to" the mean for this attribute for the other companies in this industry.

(*ii*) The mean rate of growth over the last ten years as well as whether this mean is "above," "below," or "equal to" the population mean for this attribute.

(*iii*) The expected rate of growth over the coming twelve months as well as whether this expected rate of growth is "above," "below," or "equal to" the mean of the population of expected rates of growth.

(iv) The mean, expected rate of growth over the next three to five years as well as whether this mean rate of growth is "above," "below," or "equal to" the mean of the population of mean, expected rates of growth.

1B2. The Relative Value List. Having described the procedures that determine the Relative Performance of each company within its industry, we will now examine the set of processes that determine the Relative Value of each company's stock.

As noted above each company has an attribute that records a three- to five-year forecast of its earnings per share. Although this is only an estimate, the figure is assumed to be reliable and is used, for each company to form a price earnings ratio of the forecasted earnings. As the model already contains the values for the current price earnings ratio and the historical mean of the prices earnings multiple for that company, the entries for the Relative Value List are as follows: The first consists of the difference between the mean price earnings ratio and the price earnings ratio of the forecasted earnings. This difference is taken as a per cent of the mean and is recorded as "above," "below," or "equal to" the historical mean and the current price earnings ratio. As before, this difference is taken as a per cent of the historical mean and is recorded as "above," "below," or "equal to." To clarify this process, let:

P = current market price

E = expected earnings per share for the current year

 E^* = forecasted earnings per share three to five years from now \bar{P}/E^* = ten year average of price earnings ratio

Then for each company the calculations are as follows, the results of each being recorded as "above," "below," or "equal to."

(i)
$$\frac{(\bar{P}/E) - (P/E^*)}{\bar{P}/E}$$

(ii)
$$\frac{(\bar{P}/E) - (P/E)}{\bar{P}/E}$$

The Relative Value List contains these results, plus their value on the three point scale in the order that they are produced. Thus, for each company the Relative Value List is a pair of "aboves," "belows," or "equals to" which under two possible conditions will form a pattern of only A "aboves" or "belows."

1C. THE INTERRELATIONS

Up to now we have described the mechanisms which process the data as though they were independent of each other. While this is true to a certain extent, these mechanisms are related by the processes that select the stocks suitable for current investment. In order to present these interrelations in as orderly fashion as possible, we will first examine the processes that select the "A" List under simplified conditions. By relaxing these conditions we will be able to examine the complexities as they occur.

To facilitate the exposition it is necessary to assign names to the two values which appear on the Relative Value List. Hence, if we let:

$$x = \frac{\bar{P}}{E} - \frac{P}{E^*}$$
 and $y = \frac{\bar{P}}{E} - \frac{P}{E}$

we can, in the future, refer to the values of x and y of the Relative Value List.

IC1. Selecting the "A" List. For simplicity, we shall first assume that all Economy and Industry Expectation Lists have both of their values reading "above." For such a condition to hold, the economy would have to be in the middle of a roaring boom. But ignoring this implication for a moment, we can now examine the basic operations of the selection mechanism which is composed of two parts:

(i) *The Scanner*. This mechanism examines each Economy and Industry Expectation List in turn and notes the values of adjacent pairs. In this case all adjacent pairs have the same value, *i.e.*, "above." Hence, having completed its search and finding such perfect accord the Scanner halts and the Selector takes over.

(ii) *The Selector.* Under such ideal conditions the selection process consists of searching through the Relative Value Lists of all companies and placing on the "A" List those companies whose Relative Values are recorded as:

(x) = "above," or "equal to"
(y) = "above," "equal to," or "below"

1C2. Relaxing the Conditions—A. Throughout this discussion it must be remembered that information is fed into the various categories, i.e., economy, industry, and company, at different intervals of time. Although these intervals may be chosen to suit any particular set of requirements,

we have assumed the following time lags: Information on economy and industry attributes is fed in quarterly while company attributes are adjusted monthly.

Given these time differentials we will now examine the effects of adding new information, to the respective categories, in the order in which they are assumed to occur.

(i) After a change in prices or earnings per share the information is processed as per Secs. 1A and 1B above, and new values are placed on the Relative Value List. The Scanner then proceeds to check the Economy and Industry Expectation Lists and finding them unchanged initiates the selection procedure. The Selector examines the "A" List first and removes from it any companies whose entries on their Relative Lists have changed to:

 $(\mathbf{x}) =$ "below"

The Selector then proceeds to the remaining list of companies and places on the "A" List all companies whose entries on their Relative Value List now record:

$$(\mathbf{x}) =$$
 "above" or "equal to"

(ii) At the end of each quarter, new information is entered into the model on economy and industry attributes and, when relevant, on company attributes as well. Whenever new information is fed in it is processed immediately, as per Secs. 1A and 1B, and the attention of the Scanner is directed toward that category which received the new information. When more than one category receives new information, the Scanner always goes to the most general category first, *e.g.*, economy or industry, and then proceeds down through the categories noticing and recording changes as it goes. At this point changes in the Economy and Industry Expectation Lists are translated into one of two values, "hold" or "delete hold." These values are placed on the Relative Value List. Companies which were previously on the "A" List are not taken off the list. They are left there until the new information on the companies themselves decides the issue of whether they should stay on the list or not.

1C3. Relaxing the Conditions—B. In order to examine all the operations of the Scanner and the Selector, changes in the forecasted values of the Economy and Industry Expectation Lists will be divided into three categories:

(i) Forecasted Value Falls below Recent Change Value. As noted earlier, the function of the Scanner is to examine the Economy and Industry Expectation Lists of all the attributes that have received new information. In this case let us assume that information has been entered

into the model which forecasts a leveling off in capital spending, while at the same time the most recent change in this index is still rising. Given this change the Scanner will first proceed to the capital spending Expectation List. Noticing that the other economic Expectation Lists are unchanged the Scanner will descend a level and create a list of the capital intensive industries. The Scanner then examines the changes that have occurred in the Industry Expectation Lists. Since the forecasts for some of these industries will also have fallen or leveled off, the list of affected industries is reduced to that set whose forecasts have been lowered.¹³

The Selector then takes over and scans the list created by the Scanner and searches the "A" List for companies belonging to those industries. All such companies are subjected to the following test:

(a) Mark all companies "hold" which have entry (x) on the Relative Value List recorded as "equal to."

If the forecasts for the other economic attributes fall, the Scanner searches all industry Expectation Lists for corresponding changes, makes a list of those industries whose forecasted values have fallen and presents this list to the Selector which applies the same set of tests as before.

(ii) Recent Change Value Falls Below Forecasted Value. In this case the functions of the Scanner and Selector are essentially the same as in (i) except that the Selector applies one extra test.

If economic indices have turned down the performance of some industries and companies will also have turned down. This means that basic changes in company evaluations may be taking place at the same time. However, since these changes are completed first the function of the Scanner is still to create a list of the affected industries, and of the Selector to apply the following tests to those companies on the "A" List which belong to the affected industries.

(a) Mark all companies "hold" which have entry (x) on the Relative Value List recorded as "equal to."

(β) Mark all companies "hold" which have entry (y) on the Relative Value List recorded as "below."

(iii) Forecasted Values and Recent Change Values Both Turn Down. Under these conditions, although the Scanner performs in the same manner, a change occurs in the tests applied by the Selector. Instead of testing the companies presented to it by the Scanner on the basis of the tests given above, the Selector makes the following more rigorous tests:

¹³ The assumption here is that the forecasts for total capital spending cannot change without a corresponding change in one or all of the capital intensive industries. The only exception to this rule is the Construction Industry which is also included on the list of industries to be examined if there is a fall in the expected level of capital spending.

 (γ) Remove all companies from the "A" List which have entry (x) on the Relative Value List recorded as "equal to."

(β) Mark all companies "hold" which have entry (y) on the Relative Value List recorded as "below."

Clearly, the three categories of forecast changes are not mutually exclusive and at any given point in time one would not expect to find the model in one particular category but rather in some combination of the three. This situation in no way changes the functions of the Scanner and Selector; it merely requires them to take each category in turn and perform the required operations sequentially.

When forecast and recent change values are moving up, instead of down as described above, the testing procedures of the Selector are reversed. Instead of marking companies with "hold" and removing them from the "A" List, a "hold" is replaced by a "delete hold" and companies are restored to the "A" List.

The Formulation of an Investment Policy

By and large, trust investors formulate investment policies for two types of funds: (1) large trust funds, e.g., Common Trust Funds (excluding Pension and similar types of funds, and (2) individual trust accounts.

As we are primarily interested in the investment decisions pertaining to the latter set of accounts, the model does not consider the problem of investing the funds of Common Trust Funds. The decision on whether to invest an account in a Fund or not, however, is relevant to the decision process. Although the rules governing this process are not explicitly included in the model—that is, the model is only concerned with investing the funds of individual accounts—a brief discussion of these rules is included here.

2A. COMMON TRUST FUNDS

As the cost of management per dollar invested is much lower in Common Trust Funds than in individual accounts, banks prefer to invest small accounts in their funds. In order to persuade clients to participate in these funds, banks are forced to make the funds' goals explicit. In practice these funds have goals which range from an emphasis on capital appreciation to stability of principal with emphasis on current income.

As the legal restriction governing the investment of Common Trust Funds have ben discussed elsewhere (Clarkson, 1962), the rules outlined here pertain only to the decision on whether to invest the assets of individual accounts in one of these funds.

(a) All "legal"¹⁴ trusts are eligible for investment in a Common Trust Fund. Accounts which are not legal trusts and/or whose beneficiaries have waived legal requirements are not so invested.

(b) All legal trusts that have assets of less than K dollars are automatically placed in a Common Trust Fund.¹⁵

(c) Legal trusts greater than K dollars may or may not be placed in a Common Trust Fund. As noted before, no account may participate for more than 100,000. Thus, in the range between K dollars and 100,000 the decision will be determined by the degree of correspondence between the goals of the account and the expected results of the Common Trust Fund.

2B. INDIVIDUAL TRUST ACCOUNTS

In order to determine a client's goal, the investment officer has two main sources of information: an administrative officer's interview with the client, and the written record. The former provides the investor with some subjective impressions of the client and the latter with a copy of the legal instrument (often a will) setting up the trust. In most cases this document contains information about the beneficiary, the investment powers of the bank, what is to be done with the principal, the desired amount of income, etc. The instrument also contains information about the beneficiary's age, marital status, number and age of dependents, place of legal residence, income-tax bracket, and status and age of future beneficiaries if any.

Armed with this data, the investment officer must now decide on an investment policy for the account. This policy must lie somewhere along the continuum between the extremes of growth and income and the process that determines it is as follows:

¹⁴ "Legal investment' statutes fall into two general categories: (1) those that restrict all or part of the investments to specific investments or specific classes of investments, and (2) those that limit investment in non-legal securities to a given percentage of the account or fund. The statutory limitations on investment in non-legal securities range from 30 percent to 50 percent of the market value (in one state, inventory value) of the fund." Survey of Common Trust Funds, 1959, Federal Reserve Bulletin, May, 1960, p. 480.

Pennsylvania belongs in the first category and "legal" stocks are defined by law (Act No. 340, 1951) as those securities which, if preferred stocks have paid dividends for sixteen years and which, if common stocks have had positive earnings and have paid dividends in twelve out of the last sixteen years. A list of securities meeting these requirements is prepared by the Pennsylvania Bankers Association. (Corporate Securities Considered Legal Investments for Trust Funds in the State of Pennsylvania, Trust Division, Pennsylvania Bankers Association, October, 1960).

Many people when setting up the trust relation specifically waive these investment restrictions. Thus, "legal" refers to situations in which the investment officer must comply with these investment restrictions.

¹⁸ To protect this Bank's anonymity, the precise dollar figures are not revealed. Nationally, the average Common Trust Fund participation is approximately \$23,000. Federal Reserve Bulletin, May, 1960, p. 481.

(1) The Scanner. Information on the client is fed into the model in the form of a list which contains the following attributes: (i) The desired amount of growth, (ii) The desired amount of income, (iii) Whether current income is sufficient for the client's needs, (iv) The desired amount of stability of income and principal, (v) Income-tax bracket, (vi) Client's profession, (vii) Client's place of legal residence, (viii) Whether trust is revocable or not, and (ix) Whether trust is legal or not. The function of the Scanner is to proceed through the first six of these attributes testing for the value of each in turn.¹⁶ The tests consist of classifying the values of attributes (i), (ii), (iv), (v), and (vi) on the basis of whether they are below a median value or not. The criteria for these tests are given to the model in advance and the Scanner converts the values of the attribute into a two-valued scale—"Low," or "Not Low" which correspond to being below or not below the particular criterion. Attributes (iii) and (vii) are scaled on a "Yes," "No" basis.

The results of these tests are placed on a list so that for each client there is a particular pattern of test answers. Thus for a client in the legal profession, who is a resident of Pennsylvania and has a large current income, a high tax bracket, and desires to build an estate to provide for his retirement, the pattern generated by the Scanner would read: (i) "~ Low," (ii) "Low," (iii) "Yes," (iv) "Low," (v) "~ Low," (vi) "~ Low," (vii) "Yes."

(2) The Selector. The function of the Selector is to take the list generated by the Scanner and convert it into the appropriate investment policy. Clearly, the number of possible combinations of growth and income is large. But, in practice they can be characterized in the following manner:¹⁷

- (i) Growth Account. In these accounts assets are expected to appreciate at an average rate of 10% per year over a ten-year period. Income is not stressed and fluctuations in principal are tolerated.
- (ii) Growth and Income Account. Here assets are expected to appreciate at 5-6% per year, while dividend yield should approach 2-3% per year.
- (iii) Income and Growth. In this type of account assets are only expected to appreciate at 3-4% per year. The desired dividend yield is 3-4% per year and the stability of the income stream is stressed.
- (iv) Income Account. Here the size and stability of the income streams are stressed with the expected dividend yield being

¹⁶ Attributes (viii) and (ix) are used by the portfolio-selection process.

¹⁷ It should be noted that the figures used here are in no way fixed and will in fact vary with changing market conditions.



Figure 3. Selector for investment policy.

4-6% per year. In this type of account growth (capital appreciation) is not stressed.

The Selector chooses an investment policy for a particular client by applying a set of tests to the pattern of answers given to the Selector by the Scanner. The flow chart for this procedure is given in Fig. 3, and essentially consists of applying different sets of tests depending on the type of pattern derived by the Scanner. Thus, the Selector chooses the appropriate investment policy by correctly identifying the pattern of answers that is presented to it.

The Selection of a Portfolio

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To facilitate the explanation of the selection procedures it is worthwhile interrupting the discussion for a moment to outline the information that is on hand prior to choosing a set of stocks for a particular portfolio.

(a) A list of stocks, the "A" List, which contains those stocks that are judged to be suitable for current investment. These stocks are cate-gorized by industry.

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(b) For each company on the "A" List there is a Relative Value List, a set of Relative Performance Lists, as well as historical, current, and forecasted information on sales, earnings, dividend yield, and other attributes.

(c) A list of information on the client for whom this portfolio is to be selected. This list includes the information discussed in the second section as well as an attribute that records the sum of money which is to be invested in common stocks.

(d) An investment policy that was chosen for this client as outlined above.

Given this information, the selection of a portfolio is essentially a process of mapping the set of industries and companies in (a) onto the investment policy in (d). This process yields a subset of industries and their respective companies that is reduced to a particular set of stocks for a portfolio by the addition of the information in (b) and (c), and the application of a set of tests based on this information. The actual processes governing this selection procedure are as follows:

3A. SELECTION OF INDUSTRIES APPROPRIATE TO THE INVESTMENT POLICY

Despite the large overlap between the characteristics of various industries, the investment officer associates a set of industries with each goal. As this association depends on the characteristics of the goal as well as the general characteristics of the companies within each industry, the particular set of industries associated with a given goal may include some of the industries which are associated with other goals. For example, some industries contain companies which vary only slightly in their individual characteristics, e.g., banks, or utilities, while others, like oils, are more heterogeneous and appear on several lists. As the investment officer's classification of an industry's characteristics change very slowly with time, no attempt was made to determine how these attitudes and associations were developed. Instead, these lists were derived by direct questioning and examination of the investment officer's behavior. The model, then, takes these lists as given and by searching through the "A" List derives, for each goal, a list of those industries and companies that are on the "A" List. Thus, for each goal there is now a list of industries whose companies are both currently acceptable as well as suited to the investment performance desired from the portfolio.

3B. SELECTION OF COMPANIES

Once the list of industries has been generated, the companies on this list are selected for participation by the application of still another Scanner-Selector mechanism.

In this case the Scanner and the Selector have two separate functions. The first is to check the list of information on the client and see if the trust is a legal trust and/or whether the client is a resident of Pennsylvania [attributes (ix) and (vii)]. If either or both are the case the Selector applies one or both of the following two tests:

(i) If the trust is a true fiduciary relation all the companies on the given list that do not have legal status in Pennsylvania are rejected.

(ii) If the client is a resident of Pennsylvania, all the companies that are subject to property tax in Pennsylvania are rejected.

Having eliminated all companies that do not meet the only two absolute criteria the model then takes the remaining list of companies and applies to it the set of tests that are associated with each investment policy.

The Scanner performs the task of ordering the companies in each industry on the basis of the dominant attribute of the investment policy. For example, if an Income Portfolio was being selected the Scanner would rank order the companies in each industry on the basis of yield. The Selector takes the first company from the industry that is at the head of this list and applies a set of tests to it.

The tests consist of a series of binary decisions on the performance and expectations of important attributes. As the importance of particular attributes depends on the investment policy that is being applied, the series of tests varies with each investment goal.

The set of tests is qualitative in nature and is applied, in turn, to the companies within each industry. Unless the value of some attribute is very much out of line with what it should be, the Selector will accept the first company that is processed. If for some reason the first company does not pass the tests, the Selector moves on to the second company and repeats the process. If no company from that industry is able to pass through the set of tests, the Selector moves on to the next industry. If after processing all the industries funds remain to be invested, the Selector returns to the first industry from which no selection was made and recommences processing. This time processing begins at that test that immediately proceeds the spot where the Selector stopped on the first run through. As soon as a company is selected the Scanner and Selector move on to the next industry.

To further clarify this process, consider the set of tests which the Selector applies in order to choose growth portfolios (see Fig. 4). As can be seen from the flow chart, the tests are grouped in hierarchies. Thus, if Company A passes Test 3 it will go directly to Test 5. But, if it does not pass Test 5, it must pass Tests 6, 7, and 8, before it can be accepted back into the mainstream of tests. If no company from a particular industry succeeds in being accepted, and the Selector returns to it in order



Figure 4. Growth-portfolio discrimination net.

to recommence testing, then this testing would occur in the following way. If company A was first rejected at Test 6, the Selector would now begin testing at Test 7. In this particular case, testing might continue until a company was selected. However, as each Discrimination Net has a test that all participations must meet, it is entirely possible for the model to reject all companies within a given industry.

3C. DIVERSIFICATION

Diversification is achieved by insisting that all accounts participate in at least *five* industries, and that participation in stocks be limited, in general, to *one* per industry. When the portfolio includes bonds and preferred stocks, each \$10,000 invested in bonds or preferreds is taken to be equivalent to a participation in one industry. Hence, for an account of \$50,000

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with \$20,000 invested in government bonds, the model would require that the remaining funds be invested in at least three industries.¹⁸

3D. SIZE OF PARTICIPATION

The number of shares to be purchased of each company that is selected for participation is determined by the "Share Selector." The essence of this process is given by the following rules:

(1) The total funds to be invested in common stocks are divided by the number of participations desired.¹⁹ This produces the average number of dollars to be invested in each company.

(2) To determine the number of shares to be purchased, the average number of dollars to be invested in each company is divided by the price of the particular company's stock. This figure is always rounded to the nearest multiple of five, and whenever the funds available for each participation permit it, round lots, e.g., 100 shares, are purchased.

Clearly, this selection process can only continue as long as there are funds remaining for investment. When the funds have been used up, the selection process stops, and the stocks that have been chosen become the required portfolio.

Testing the Model

In order to test the model's ability to reproduce the behavior of the trust investor—*i.e.*, to simulate the trust investment process—the model was required to select portfolios for a particular set of actual trust accounts. In particular, stock-exchange and other data were fed into the computer to cover the first and third quarters of 1960. The running program was then presented with data on four of the bank's new clients, for whom the trust investor had selected portfolios during the same two quarters, and the program was required to generate its portfolios for these accounts. The portfolios are presented in Figs. 5 and 6, along with the selections made by the trust officer for the same accounts. The generated portfolios were then compared with other portfolios generated by various random and naïve models. The results of these tests indicate that the trust

¹⁸ As can be seen from the above, the investment officer's "rule of thumb" seeks to spread risk by diversification. But as Markowitz has shown (H. Markowitz, *Portfolio Selection*, p. 109, New York, 1959) when the returns on securities are correlated, this may not be accomplished if the amount invested for the client is relatively small.

¹⁹ For accounts of \$50,000 or less the usual number of participations is five, each \$10,000 of bonds and preferreds counting as one. For accounts greater than \$50,000 the minimum number is usually five as approximately \$10,000 is invested in each Participation.

Simulation of A	Account 1, 1/8/60
Growth	Account
Funds available for	r investment: \$22,000
The program selected:	The Trust Officer selected:
60 General American Transportation	30 Corning Glass
50 Dow Chemical	50 Dow Chemical
10 I.B.M.	10 I.B.M.
60 Merck and Company	50 Merck and Company
45 Owens Corning Fiberglass	50 Owens Corning Fiberglass
Simulation of A	1 ccount 2, 6/10/60

Simulation of Account 2, 6/10/60 Income and Growth Account Funds available for investment: \$37,500

The program selected:	The Trust Officer selected:
100 American Can Co.	100 American Can Co.
100 Continental Insurance	100 Continental Insurance
100 Equitable Gas Co.	100 Equitable Gas Co.
100 Duquesne Light Co.	100 General Public Utilities
100 Libbey Owens Ford	100 Libbey Owens Ford
100 International Harvester	50 National Lead
100 Philadelphia Electric	100 Philadelphia Electric
100 Phillips Petroleum	100 Phillips Petroleum
100 Socony Mobil	100 Socony Mobil

Figure 5. Comparison of portfolios selected by the model and by a trust officer: Accounts 1 and 2.

Simulation of Account 3, 7/8/60 Income and Growth Account Funds available for investment: \$31,000

The program selected:	The Trust Officer selected:
100 American Can Co.	100 American Can Co.
100 Continental Insurance	100 Continental Insurance
100 Duquesne Light	100 Duquesne Light
100 Equitable Gas	100 Equitable Gas
100 Pennsylvania Power and Light	100 General Public Utilities
100 International Harvester	100 International Harvester
100 Libbey Owens Ford	100 Libbey Owens Ford
100 Socony Mobil Oil	100 Socony Mobil Oil

Simulation of Account 4, 8/26/60 Income Account Funds available for investment: \$28,000

The program selected:	The Trust Officer selected:
100 American Can Co.	100 American Can Co.
100 Continental Insurance	100 Continental Insurance
100 Duquesne Light	100 Duquesne Light
100 Equitable Gas	100 Equitable Gas
100 Pennsylvania Power and Light	100 General Public Utilities
100 International Harvester	100 International Harvester
100 Phillips Petroleum	100 Phillips Petroleum

Figure 6. Comparison of portfolios selected by the model and by a trust officer: Accounts 3 and 4.

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investment program selected a greater proportion of correct securities than did any one of the alternative models.

To obtain additional confirmation, the testing process was carried one step further—that is, the processes by which the portfolios are generated were submitted to empirical test. The test consisted of comparing the stream of output of the trust investment model to the recorded decision behavior of the trust investor. This test was applied to several of the mechanisms incorporated in the model. While it is not possible to state that all the processes were unequivocally confirmed, the evidence strongly supports the hypothesis that the model's mechanisms capture a considerable portion of the trust investment process.