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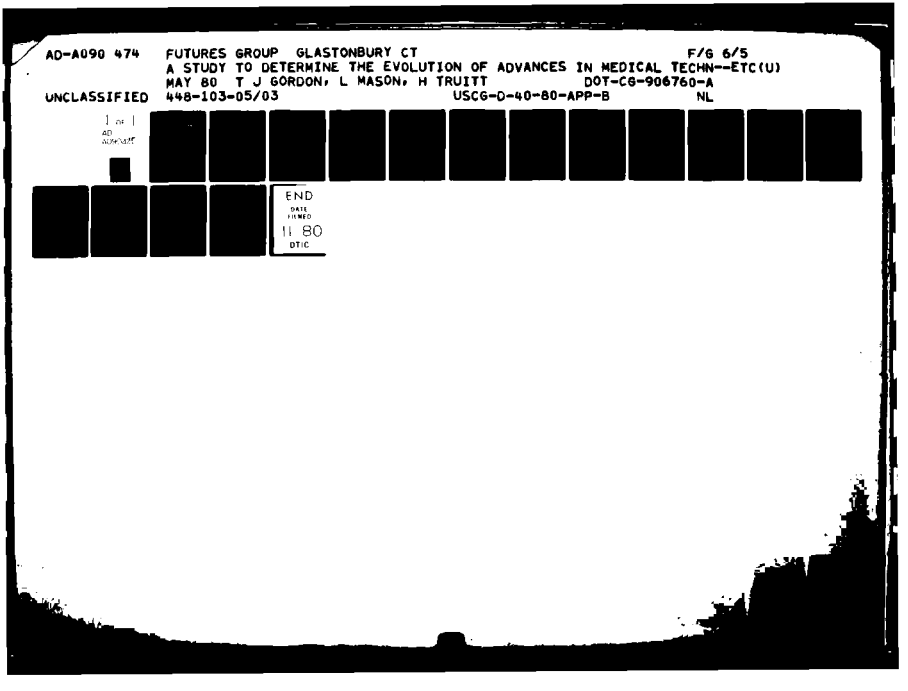

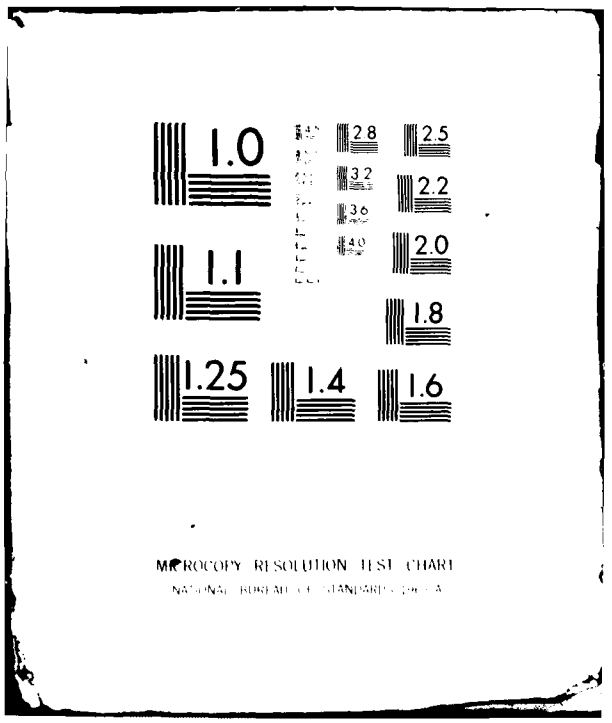
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APPENDIX B.

TREND IMPACT ANALYSIS.

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TREND IMPACT ANALYSIS: A NEW FORECASTING TOOL

by

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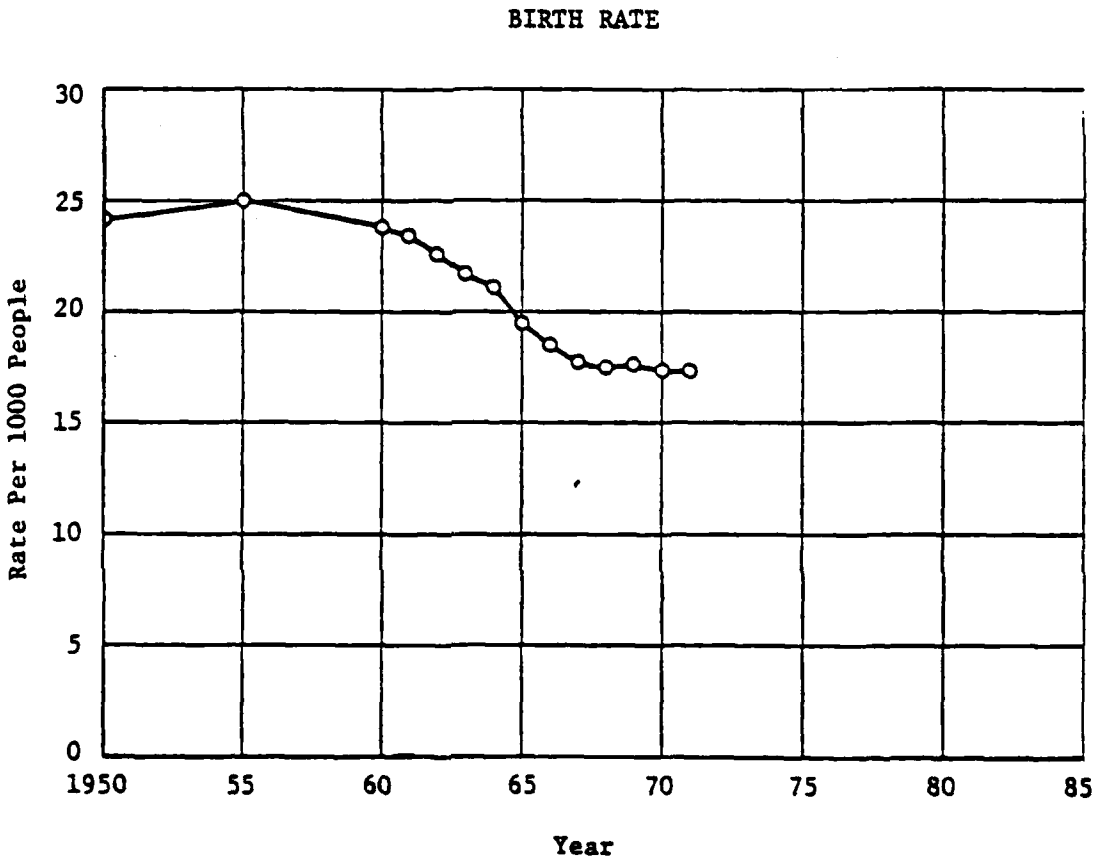
Herbert Gerjuoy

Introduction

Extending historical trends into the future is perhaps the commonest form of forecasting. Underlying nearly all trend forecasting is the assumption, often unstated, that the future will be a smooth continuation of the recent past. This assumption is rarely justifiable except for very short-term forecasting. Trends depart from their extrapolations for a variety of reasons, but one particularly important reason is that extrapolations based on past trends cannot take into account the impact of unprecedented future events. By "an unprecedented" event is meant one that does not fit into a time series and so cannot be anticipated by a forecasting procedure based on extrapolation solely from past history. Typically, unprecedented events introduce something new into the historical process. They often involve technological or social innovation.

Three examples illustrate how the occurrence of unprecedented events can influence a previously stable trend.

1. Through the 1950's and 1960's birth rate in the United States rose regularly and smoothly. The trend reversed dramatically in the late 1960's when cheap and effective contraceptives permitted the expression of new values and attitudes about ideal family size (see Fig. 1). Extrapolations based on the historical trend from 1950 through 1965 consistently over-estimated the present birth rate in the United States.



Source: U.S. Public Health Service, Vital Statistics of the United States, annual.

Figure 1.

2. Figure 2 illustrates the long-term drop in the cost of electricity in the United States. The trend towards diminishing costs began almost with the advent of the first electricity generating system and reflected the generally unstated goal of producing cheap power. Cost was reduced through economies of scale, improved technology and operating efficiency, more readily available fuels, etc. Recently, however, the cost of electricity has stabilized and begun to rise because of increasing costs of fuel, new requirements for costly anti-pollution devices, and restrictions on the size of generating plants that end or lower savings through economies of scale. An extrapolation based on all but the latest data would have missed the recent "turn-around."

3. The long-term trend in the United States toward the sale of automobiles of increasingly greater weight and horsepower has begun to change appreciably in recent months. This change may be the result of concern about increasing costs of gasoline, new public attitudes about conservation of the environment, or both.

Many other examples can, of course, be cited. The point is that deviations from historically-based extrapolations usually seem to reflect the impact of unprecedented events.

Trend Impact Analysis (TIA)* is a new forecasting method that permits extrapolations of historical trends to be modified in view of expectations about future events which could influence the trends. This technique permits a manager interested in tracking a particular trend to include and systematically examine the effect of possible future events which he or his advisors believe to be important. The events which he can include can span a wide spectrum, including: technological, political, social, economic, and value oriented changes. Consider, for example, a manager

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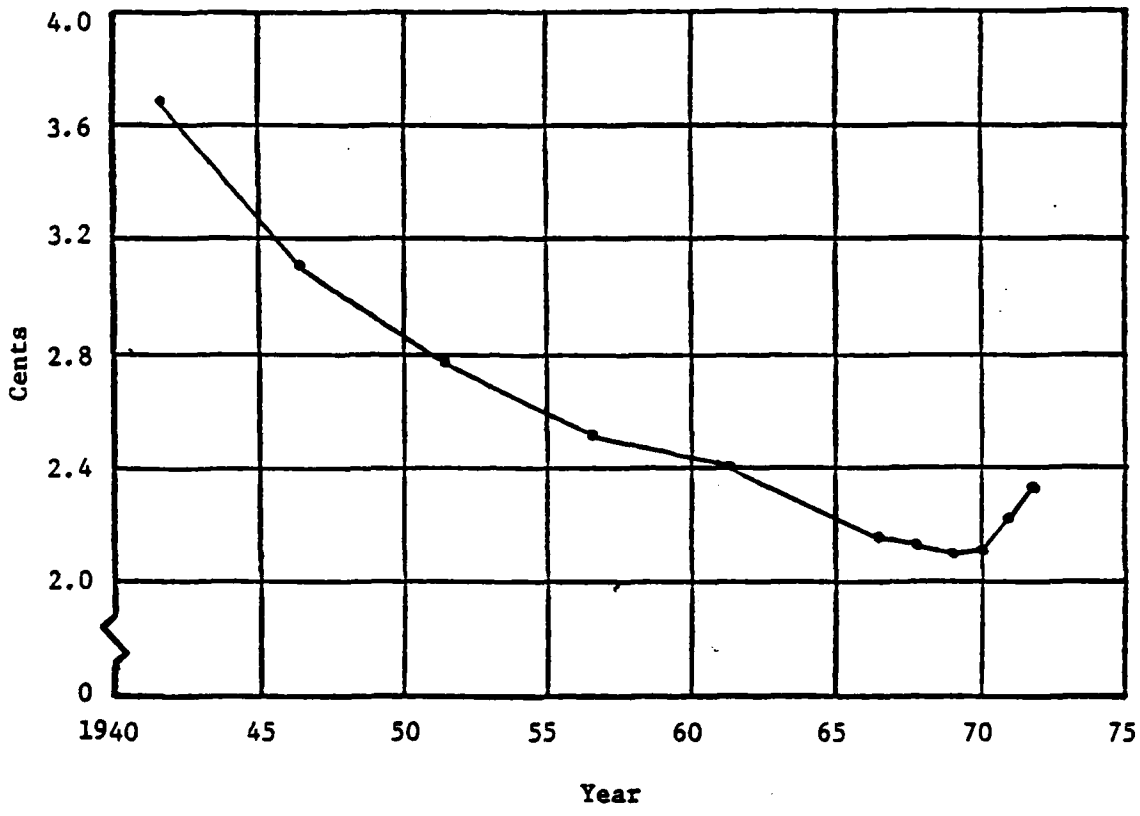
*TIA was jointly invented by the authors of this paper, W. I. Boucher of The Futures Group, and Futures Group consultants, D. Holmes and J. Russman.



Source: Edison Electric Institute, Questions and Answers About the Electric Utility Industry, annual.

Figure 2. ELECTRICITY USED IN THE HOME
AVERAGE REVENUE PER KILOWATT-HOUR

interested in tracking the price of raw material delivered from a source overseas. An extrapolation of available historical data certainly could be used for a forecast, but the manager might feel that many contingencies make an extrapolation of past trends very unrealistic. Trend Impact Analysis is a technique he could use to analyze the consequences of future developments on this future trend.

He would follow two principal steps: First, a curve would be fitted to historical data so as to calculate the future trend given no unprecedented future events. Second, expert judgments would be used to identify a set of future events which, if they occurred, would cause deviations from the extrapolation of the historical data. For each such event, the experts would determine probability of its occurrence as a function of time and its expected "impact," should the event occur, on the future trend. An event with high impact is one expected to swing the trend relatively far, in a positive or negative direction, from its unimpacted course. These concepts are illustrated in Figure 3.

To illustrate, Figure 4 shows historical data for the percentage of pharmaceutical manufacturers' sales to hospitals, clinics, and laboratories on a "surprise-free" extrapolation of the historical curve. A variety of important, but unprecedented, future events could affect this trend. One such event might be initiation by leading drug manufacturers of a policy of direct sales to hospitals, clinics, and laboratories as opposed to marketing through appeals and advertising addressed to physicians. Such a shift might be expected to swing the curve upward; in this case, a "surprise-free" extrapolation would underestimate future sales.

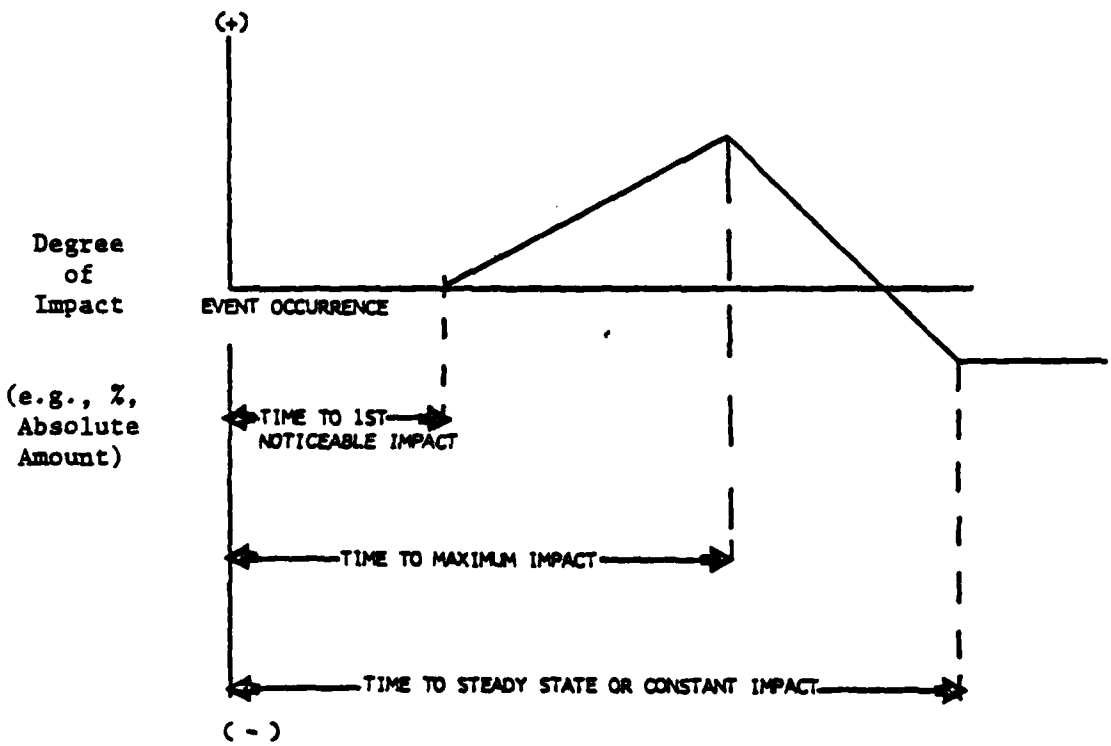
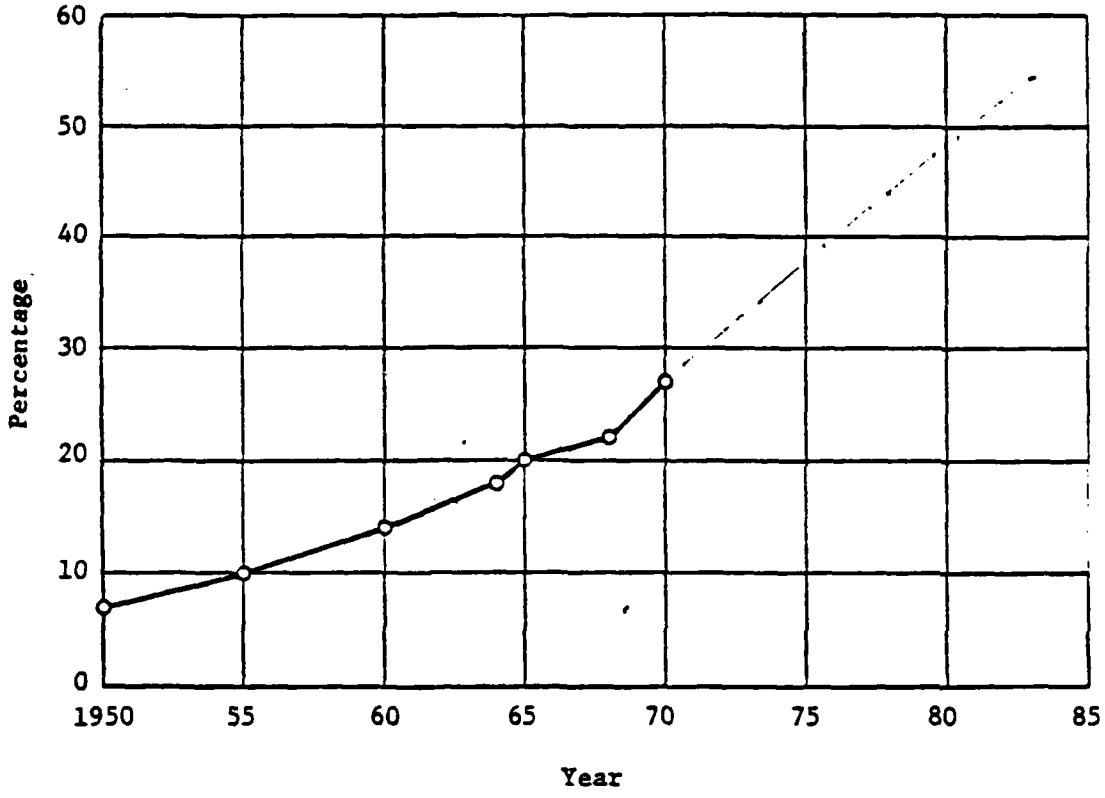


Figure 3. TYPICAL EVENT IMPACT ESTIMATE



Source: Drug News Weekly, The Drugstore Market - USA, various issues.

Figure 4. PERCENTAGE OF DRUG MANUFACTURERS' SALES TO HOSPITALS, CLINICS, AND LABORATORIES

and an "impacted" curve would be a better forecast. Trend Impact Analysis provides a systematic means for combining "surprise-free" extrapolations with judgments about the probabilities and impacts of selected future events.

Here's how the technique works. Surprise-free extrapolation is the first step. Most curve fitting routines require that the general shape of a curve that fits a set of historical data first be specified; then a curve-fitting algorithm is used to select a specific curve which falls as close as possible to the given data. The algorithm then extrapolates the curve to generate the surprise-free forecast. Selection of the proper general curve shape can be difficult. Two different curve shapes can, for example, each fit the historical data very well and yet produce markedly different extrapolations. In effect, then, selecting the curve shape may predetermine the surprise-free forecast. In TIA, the program itself selects the "best" curve shape from a set of alternatives. Each of the equations is used to "fit" the historical data; the one which provides the best fit is used for the surprise-free extrapolation. Alternatively, the user can specify upper and lower bounds or can allow the selection of the best-fitting curve that falls outside those bounds. (See Table 1 for our algorithms.)

Human judgment and imagination are central to the second step of TIA. Here, the program modifies the surprise-free extrapolation to take into account important unprecedented future events. First, a list of such events is prepared. These events should be plausible, potentially

TABLE 1

EQUATION

$V = M Y - B$

$\log V = M Y + B$

$\log V = M \log Y - B$

$V = M \log Y + B$

$\frac{1}{V} = M Y + B$

$\frac{1}{V} = M \frac{1}{Y} + B$

$V = M \frac{1}{Y} + B$

$\log \log V = M Y + B$

$\log \log V = M \log Y + B$

$\log \frac{1}{V} = M \frac{1}{Y} + B$

$\frac{1}{\log V} = M Y + B$

$\frac{1}{V} = M \log Y + B$

$\frac{1}{\log V} = M \log Y + B$

NOTE: M = SLOPE
B = ADDITIVE CONSTANT
Y = YEAR - 1900
V = CALCULATED VALUE

powerful in impact, and verifiable in retrospect. The source of this list of events might be, typically, a literature search, a questionnaire survey, or a consensus among consultants. Whatever the source, the events selected comprise an inventory of potential forces which could lead to a departure from a surprise-free future.

Several judgments are made about each selected event. First, estimates are made of the probability of occurrence of each event as a function of time. Second, the impact of each event on the trend under study is estimated. Impacts can be specified in several ways; our procedure involves specification of:

1. The time from the occurrence of the impacting event until the trend begins to respond.
2. The time from the occurrence of the impacting event until the impact on the trend is largest.
3. The magnitude of that largest impact.
4. The time from the occurrence of the impacting event until the impact reaches a final or steady-state level.
5. The magnitude of that steady-state impact.

Each of the three specified times and the impact magnitudes associated with them are taken to be completely independent. For example, the maximum impact might be positive, and the steady-state impact negative, or the steady-state impact might be zero, meaning that the impact is only temporary. Finally, the maximum impact might be the same as the steady-state impact.

The TIA program combines the impact and event-probability judgments with the results of the surprise-free extrapolation to produce an adjusted extrapolation, plus estimates of upper and lower quartile limits. The

expected value of the combined impacts is computed by summing the products of the probabilities of the impacting events for each year in which they are possible with the magnitude of their expected impacts, taking into account the specified impact lags.

The present approach treats the events as though they were independent of one another; if they are coupled, that is, if the occurrence of one is likely to influence the probability of another, cross-impact approaches should be included in the solution. Thus, the impact estimate is produced as the sum of independent random variables. The net result is that the variance of the impact-adjusted forecast is the sum of the variance of the trend extrapolation (as measured by the square of the standard error of estimate) and the variances of the impacts of the associated events (calculated from the probabilities of the events).*

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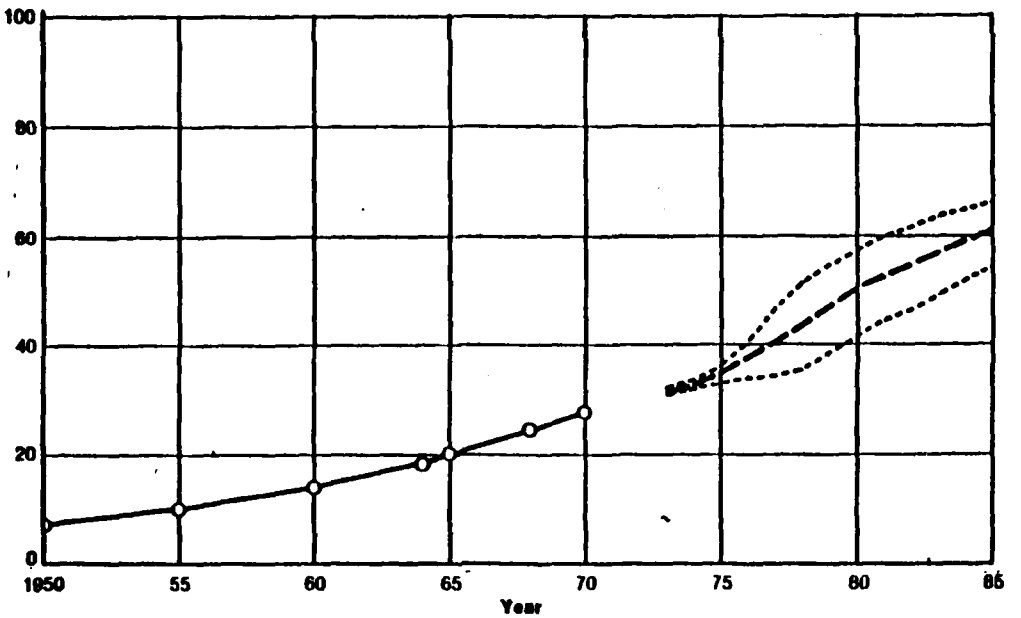
*Thus, where P_{ye} is the likelihood that event e will occur in year y, and $a_{y_k-y,e}$ is the impact that event e would give rise to (y_k-y) years after its occurrence, the expected value of the impact in year y_k would be $\sum_e \sum_{y=y_o}^{y_k} \left(P_{ye}\right)\left(a_{y_k-y,e}\right)$ where y_o is the present year (e.g., 1973).

Two procedures have been used to estimate the upper and lower quartiles. In earlier work, the first four moments of the expected impact distribution were concluded, and the Pearson function was found whose moments most closely approximated the moments obtained. The quartiles were then calculated from tabulated values of the selected Pearson function. More recently, the quartiles are estimated from the mean positive deviation from the expected value and the mean negative deviation, each computed separately.

We have used Trend Impact Analysis in three applications. The first two are associated with technology assessments. Here, typically, the future course of socio-economic variables are judged in terms of the expected impact of the technologies under study. The third application area dealt with the pharmaceutical industry. The pharmaceutical forecasts were made in the course of preparing a new service, PROSPECTS, which describes events, trends, and forces which can influence the industry. In all, some 50 indicators were examined and several events were analyzed per indicator. In some cases, deviation from the surprise-free extrapolation is very marked. For example, Figure 5 shows the percentage of drug manufacturer's sales to hospitals, clinics, and laboratories. This percentage has been rising in the recent past as a result of a trend toward elimination of middlemen in an effort to reduce prices; judgments about the impact of unprecedented future events (Figure 6) indicate that the trend will accelerate within the next decade (compare Figure 5 with Figure 4). If a user of these data were to disagree with some of the judgments used, he could simply test the effect of his perceptions by re-running the program with new probabilities or impacts for the forecasted events.

Furthermore, Trend Impact Analysis is well suited for policy evaluation. Imagine, for example, that a manager wished to modify the course of a specific time series indicator. He could test his contemplated approach by changing the probabilities and impacts which it would affect. By accomplishing two runs, one with the policy and one without, the effect of the policy on the indicator could be clearly demonstrated.



Source: Drug News Weekly, *The Drugstore Market - USA*, various issues.

Figure 5. PERCENTAGE OF PHARMACEUTICAL MANUFACTURERS' SALES TO HOSPITALS, CLINICS, AND LABORATORIES

events used in impact analysis

SCOUT FILE NUMBER	FORECAST	ESTIMATED PROBABILITY BY YEAR SHOWN		YEARS TO FIRST IMPACT	YEARS TO MAXIMUM IMPACT	MAXIMUM IMPACT (PERCENT)	FORECAST SOURCE CODE
021277	Single unit drug packaging accounts for at least 50% of drug products sales.	.99	1975	1	10	-5	769
020985	Enactment of federal legislation regulating prices of health and drug products.	.25	1975	2	3	5	3226
020989	Development of a national drug formulary by the FDA.	.50	1978	2	5	5	3226
009310	Establishment of regional centers for clinical examination, and centralization and standardization of clinical examination data.	.25	1978	1	7	5	213
020988	Enactment of federal legislation requiring generic labeling.	.50	1978	1	2	7	3226
016246	The majority of U.S. hospitals are associated with a health maintenance organization system.	.50	1982	1	3	10	294
016244	Enrollment by 90% of the U.S. population in health maintenance organizations which emphasize preventive rather than remedial medicine and provide a broad range of medical services to subscribers for a fixed contract fee paid in advance.	.10	1975	1	7	15	215
020987	The three top drug manufacturers initiate a policy of direct sales to hospitals, clinics and laboratories.	.70	1978	1	3	20	3226

Figure 6. EVENTS INCLUDED IN TIA OF FIGURE 5.

Trend Impact Analysis is a forecasting tool of considerable power. It is relatively inexpensive and easy to use. The technique provides greater accuracy for trend extrapolation for approaches to futures research.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