ABSTRACT

TIME REDUCTION CURVES AS APPLIED
TO CERTIFIED PUBLIC ACCOUNTING FIRMS

By

Allan Robert Wright

Changing economic conditions have affected the demand for auditing services by Certified Public Accounting firms and their ability to supply these services. Thus, audit time control methods assume greater importance, and this thesis proposes time reduction curve analysis as a useful time control technique for C.P.A. firms.

The thesis examines the concept of time reduction (learning) curves, basic elements and determinants of time reduction, and past and present applications of the curves. The audit function of public accounting is analyzed and divided into repetitive and non-repetitive aspects. Factors conducive to time reduction are considered and those relevant to auditing are extracted and divided into two categories, individual and organizational.

An empirical study of time reduction in public accounting auditing includes analysis of two and three year sequences of audit data from one hundred and two audits by fourteen C.P.A. firms. Time reduction is analyzed by type of client industry, by type of C.P.A. firm (national, regional, local), by specific C.P.A. firms, by detailed audit function (reported on a limited scale), and by eight factors conducive to time reduction. The eight factors, selected on the basis of objective measurability and data availability, were: auditor repetition on a given audit; audit stability; C.P.A. firm size;

training program at C.P.A. firm; number of auditors on the audit; years of experience in auditing the client; years of experience auditing the client's industry; and total years of public accounting experience of all auditors assigned.

Time reduction for all C.P.A. firms, year two, averaged 2.7% based on year one hours, and in year three, time reduction percentage was 4.6% based on year two hours. A widely varying pattern of time reduction emerged between: local and national C.P.A. firms; different client industries; and individual C.P.A. firms. Differences between national and local firms and among client industries reflected largely, but not entirely, differing degrees of audit stability and of repetition by auditors on given audits. (Stability refers to audit content or difficulty of the audit as compared to the prior year.) Repetitive audit functions generally exhibit more time reduction than non-repetitive ones.

Partial correlation and regression analysis of the eight selected factors produced a coefficient of determination of 52% in year two and 61% in year three of the .0001 confidence level. A strong association between time reduction and stability of audits and repetition of auditors was observed. Audit hours by men new to the audit was added as a secondary factor and proved closely associated with time reduction, particularly for national firms who used new men twice as extensively as local firms. Repetition correlated with time reduction particularly for local firms who practiced it more than national firms.

The study was limited by lack of detailed data available to a

non-member of the C.P.A. firm and by lack of objective measures for such time reduction related factors as: pre-audit client and C.P.A. firm preparation, client cooperation, uninterrupted work time, etc.

Evaluation and cost analysis is made of a hypothetical trade-off between minimum time on the first year's audit (through B factor development) and rapid time reduction on subsequent years' audits (through repetition). A tentative program of time control is suggested, incorporating time reduction techniques applicable to auditing, formulas for time calculations, forms pertinent to a control system, and the use of a time reduction specialist.

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CHAPTER I

POTENTIAL APPLICATIONS OF TIME REDUCTION CURVES IN THE AUDITING FUNCTION OF CERTIFIED PUBLIC ACCOUNTING FIRMS

The need for time control in public accounting to meet the pressures of change

In recent years, there has been significant change in the environment in which public accountants operate. Much of this change has been a result of fluctuating economic conditions and their effect on the client firms of the public accountant. These conditions were double-edged in that they affected both the public accountant's staff and the demand for audit services. All such change which brought pressure on the public accountant may be grouped into demand changes and supply changes. The effect of each demonstrated a strong need for audit time control.

Demand for public accounting audit services varied markedly over the 1969-1971 period covered by this study. During the 1969 economic expansion the demand for auditing services was high. Many existing business firms expanded, added subsidiary firms, enlarged their product mix, and added staff. In addition, many firms mechanized their data processing. Concurrently, a continuous enlargement of the governmental sector increased the number of reports required for federal agencies. As a result, the public accounting firms had difficulty in expanding staff size and quality rapidly enough to meet the increased demand for audit services. Compounding the problem was the

competitively higher pay scale of private firms seeking the best accounting graduates. All of these forces, coupled with a mounting inflation and intensified need for cost control, were transmitted into a seemingly explosive demand for public accounting audit services.

However, a new set of demand-supply relationships developed during 1970-1971 as the economy entered a recession phase. Existing client's demands declined somewhat in the merger and new product areas and possibly in the computerization area, but new demands arose in the area of routine audit performance. Smaller staffs at many client offices often gave less client assistance in preparing routine schedules (accounts receivable aging analyses, depreciation computations, etc.) and occasionally client staff quality deteriorated as turnover increased. There was also a natural client resistance to audit fee increases. Some public accounting firms, facing a stable or slightly declining demand for audit services in 1970-1971, had an abundance of staff which had been employed at relatively high salaries during the 1969 hiring efforts. Logically, the combined effect of these demand and supply changes was recurring pressure for maximum audit productivity.

The problem of controlling time in the auditing area of public accounting

The auditing time control problem lies mainly in the difficulty of developing time standards for professional and somewhat non-standardized tasks. Audits range in scope from the fairly routine to the obviously dissimilar annual audit based on changes in volume, products, personnel, etc., and finally to the audit presenting totally unexpected variables such as a complete breakdown in internal control. Time control is extremely difficult when many variables are involved.

Even in fairly routine audits, the professional nature of public accounting causes unexpected time fluctuations. The auditor is constantly deepening the scope of the audit as small discrepancies in one audit area call for a more extensive examination of that area and related areas. In a sense, the problem of audit time control is similar to control of research time with rather similar problems involved. There is a more routine side to auditing, however, composed of some recurring tasks, some constant audit standards, and some fairly consistent audit steps, as well as some basic skill requirements. It is here where time control appears most promising. These aspects may be subjected to time reduction curve analysis as discussed in Chapter IV.

Purpose of the thesis

The purpose of the thesis is to demonstrate the usefulness of time reduction curves to public accounting in controlling audit time requirements. A tentative program of time control is suggested, incorporating time reduction techniques deemed applicable to auditing, and forms pertinent to a newly developed control system are presented.

Scope and method of the thesis

The concept of the time reduction curve is examined including the components of total time reduction, an analysis of two conflicting time reduction theories, and past and present applications of the curves. (Chapters II and III) The audit function of public accounting is analyzed and divided into repetitive and non-repetitive aspects for use in an empirical study of time reduction in public accounting firms. (Chapter IV) Factors conducive to time reduction are considered;

factors relevant to the audit function are extracted and divided into two categories, individual and organizational, for control purposes. (Chapter V)

An empirical study of time reduction in the audit function of public accounting was undertaken in 1969-1971, although audit data from 1967 and 1968 was also included in the study. (Chapters VI and VII) Fourteen public accounting firms provided data on audits of the same clients over a two to three year span of audits. The study includes an examination of five separate phases of time reduction:

1. Time reduction as related to type of client firm industry (retailing, manufacturing, etc.).
2. Time reduction as related to type of C.P.A. firm (national, regional, and local).
3. Time reduction as related to specific C.P.A. firms.
4. Time reduction as associated with detailed audit functions (reported on a limited scale).
5. Time reduction as correlated with eight factors related to time reduction.

Audit functions such as verification of cash, accounts receivable, inventory, etc. were analyzed for the degree of time reduction by audit function. Lack of readily available data limited the scope of this portion of the study.

The eight factors, selected on the basis of historical research and discussion with public accounting practitioners, were deemed measurable. Several other relevant factors were omitted due to difficulties of measurement or unavailability of data. The eight selected factors were:

1. Years of experience of auditors.
2. Years of experience of the C.P.A. firm in auditing the

particular client firm.

3. Years of experience of the C.P.A. firm in auditing firms in the same industry as the firm being examined.

4. Hours of time spent on the audit by men who had worked the audit in prior years within the period of this study.

5. The degree of audit stability as to level of difficulty, change of scope, etc.

6. The number of men assigned to the audit each year within the period of this study.

7. The size of the C.P.A. firm in number of employees.

8. The presence or absence of a formal training program within the C.P.A. firm.

Only tentative conclusions were drawn from the study because of underlying limitations of the study. The need for a continuing time reduction study within the public accounting firm is stressed. Guides for such a study are proposed, as well as the use of a "model" time control sheet. The utilization of a time control specialist is advocated, and various time reduction curve applications are suggested. (Chapter VIII)

Limitations of the study

Certain limitations, which are discussed in depth in Chapter VI, appeared as the study progressed. Centering around the lack of detailed and readily available data for use by a non-member of the public accounting firm, they eliminated from examination some of the variables which appear to affect time control and time reduction. A further limitation was the lack of objective measures of the presence of some time reduction related factors. Should future studies be initiated by C.P.A. firms, many of these limitations would disappear since a member of the C.P.A. firm would have access to a large volume

of data and would be able, through experience, to objectively measure the presence or absence of time reduction factors. Specifically, the limitations are:

1. The availability of data in proper form for in depth analysis

    a. As to detailed audit function time requirements
    b. As to large number of consecutive years of audits of same client firm
    c. As to audits on a first, second, and third year basis where the first year represented a new audit

2. The lack of suitable objective measures of certain factors which may well correlate with time reduction, such as:

    a. Turnover of client personnel
    b. Degree of pre-audit preparation by client personnel
    c. Adequacy of pre-audit conference with client
    d. Ability of client firm personnel
    e. Condition of records of client firm
    f. In some cases, underlying causes of change in audit scope
    g. Presence of uninterrupted audit time during client's audit
    h. Other factors not lending themselves to objective measurement by an outsider.

Usefulness of the study

Finally, despite the limitations of this study, some knowledge has been gained of factors which underlie time reduction. This study may well serve as a "stepping stone" to future "in-house" studies. Even if, in some future internal study, all factors explaining time reduction behavior were not measurable or correlative with observed time reduction, much knowledge of the forces affecting audit time could still be gained. From such beginnings, a modern audit time control system can emerge just as industrial and clerical time control systems emerged in the past.

CHAPTER II

TIME REDUCTION CURVES - PRINCIPLES, CONCEPTS, AND CONTROVERSIES

The basic concept of the time reduction curve

The idea that time requirements per unit of produced goods could be reduced through repetitive operations has been well known to industry since the advent of the industrial revolution. Time reduction was the factor underlying the specialization in industry which began before the start of the twentieth century and which became incorporated in the time and motion study work of Frederick W. Taylor, Frank and Lillian Gilbreth, and other pioneers in this area.

Prior to World War II, perhaps the most conspicuous illustration of the advantages of repetitive operations could be seen in the production records of the Ford Motor Company. Mechanization, specialization of task, and a standardization (albeit excessive!) of car model led to the following performance:

Year	Volume of Units	Unit Sales Price[1]
1910	12,292	$950.00
1926	15,000,000 (approx.)	270.00

The unit data is expressed in cumulative units produced to date. This sharp reduction in sales price was made despite an increase in the general price level. Therefore, cost reductions, mainly through time reduction, must have been tremendous in order to make this unit sales price possible.

With such dramatic results, it was inevitable that the time reduction factor would become a permanent component of cost and production analyses. The immediate problem then was whether the rate of time reduction could be forecast with any degree of accuracy. If time per unit could be forecast for the first and last units of production of a given order, a powerful tool for estimating and controlling manpower needs, for product pricing, and for a variety of production and control techniques would have been developed. T. P. Wright's pioneering article, "Factors Affecting the Cost of Airplanes," published in 1936, stated that this time improvement was indeed quite predictable. His study, reinforced by other studies done by aircraft companies during and following World War II, led Frank J. Andress in a 1954 article to conclude "....that the rate of improvement was regular enough to be predictable."[2]

Thus, the idea of time per unit reduction through repetitive operations evolved into the basic concept of the time reduction curve that, on repetitive jobs, processes, models, etc., the time required to complete one unit can be expected to decline in a predictable manner. One definition of this phenomenon of time reduction is: "As the quantity to be produced is doubled, the cumulative average hours per unit are reduced by a given percentage."[3]

Two conditions necessary for the operation of the time reduction curve

The two conditions necessary for the operation of the time reduction curve are the proper combination of labor and machinery, and the condition that repetitive operations are not continued on a massive scale indefinitely. Concerning the combination of labor and

machinery, many writers note that the greater the amount of labor combined with a given amount of machinery, the steeper will be the time improvement curve, thus showing more rapid time improvement. Delbert Brewer suggests that:

With	75%	assembly	labor,	25%	machine	labor,	have	an	80%	curve[4]
"	50%	"	"	50%	"	"	, "	"	85%	curve
"	25%	"	"	75%	"	"	, "	"	90%	curve

The above analysis certainly does not suggest that men are more efficient than machines; rather, it implies that man is more variable in his output and improves his time per unit with successive units produced. But a machine's output is apt to be relatively stable over a period of time, while a man's output is apt to increase with successive units run. The fatigue factor must, of course, be reckoned with in a situation where production is accomplished more by men than by machines.

The second condition necessary for the operation of the time reduction curve is the limitation that repetitive operations are not continued on a massive scale indefinitely. Time reduction curve graphs often terminate at the right (volume) edge of the graph with the curve in a downward sloping condition. It would seem, therefore, that time reduction per unit would continue on for all future units produced. Thus eventually, one unit could be produced "labor free" despite the fact that labor was being employed to produce the part! The general consensus is that, in time, the curve becomes flat and shows no further time improvement. The principle involved here is that, if operations of a constant repetitive nature are conducted on a massive scale of production, the time reduction curve will ultimately prove to be inoperable or nearly so. This is particularly

true when there are no model changes involved.

An exception to this time reduction behavior with volume production was noted in the Boeing Company study of Gordon W. Link and Don A. Ellis where small time reductions were continuously made despite great experience in producing an airplane. "The fact that it (unit time) continues to decrease was shown by the B-17 contract which was still decreasing after 6,000 planes had been made."[5] This exception is probably explained by the fact that small model changes were being made during a production period of several years.

Terminology problems

One is not apt to find the term "time reduction curve" frequently used in current or historical literature dealing with time reduction. An exception to this arises in the case of the Douglas Aircraft Company which does use the term "time reduction curve." S. Alexander Billon also uses the term in his doctoral dissertation, Industrial Time Reduction Curves As Tools For Forecasting.[6] The common name which has been applied to this phenomenon is the "learning curve," but it is questionable whether a predictable time reduction on successive performances of a job can properly be called a "learning curve." Learning is variously defined as instruction, education, or acquired wisdom, knowledge, or skill. On a given job these aspects of learning may be present, but the learning may be by one worker performing the job, by those who supervise and train the workers, or it may simply represent the removal of an organizational, scheduling, or other impediment to maximum productivity. Therefore, learning alone can not describe the phenomenon of time reduction.

Pragmatically, time improvement may come even more rapidly from improved morale or from incentive pay plans which are not necessarily features of increased knowledge of the job. Thus, the term "learning curve" is at once both too narrow and too all inclusive to explain the process which takes place when time per unit of production is reduced in a predictable manner. The term is too narrow in that elements other than individual knowledge and skill are involved. Increased knowledge and skill of the supervisors, improved training programs, more efficient scheduling, and other "organizational competence" may be as potent factors making for time reduction as individual "learning." The term is too broad in that learning in the conventional sense of "acquired wisdom, knowledge, or skill" may not actually occur. On production operations, it may be difficult to contend that the knowledge or wisdom of the worker has increased, though perhaps his skill has increased. Rather than skill being developed, reduced time on a particular job may be more of a transitory thing on the worker's part so that the time reduction actually represents familiarization, rather than an increase, in basic skills.

Alternatives to the term "learning curve" have been proposed by many writers. Sanders and Blystone suggest: (The curve could be stated as....) "Progress, rather than learning curve, to include equipment improvement, better materials, and management development."[7] Another author, in citing an aircraft study, does not even identify the familiar properties of the curve, but merely calls it the "Curtis 80% Curve,"[8] while T. P. Wright's pioneering study referred to many names for the same feature: ..."Manufacturing progress function, cost-quantity relationship, cost curve, improvement curve, performance

curve."[9] Likewise, the Boeing Company in World War II used "experience curve" and also "unit experience curve"[10] and Frank J. Andress would prefer the term "productivity" rather than learning as productivity implies sustained improvement.[11] In view of the many factors present in achieving a predictable time reduction, the term "time reduction curve" evolves as the most descriptive and most accurate term.

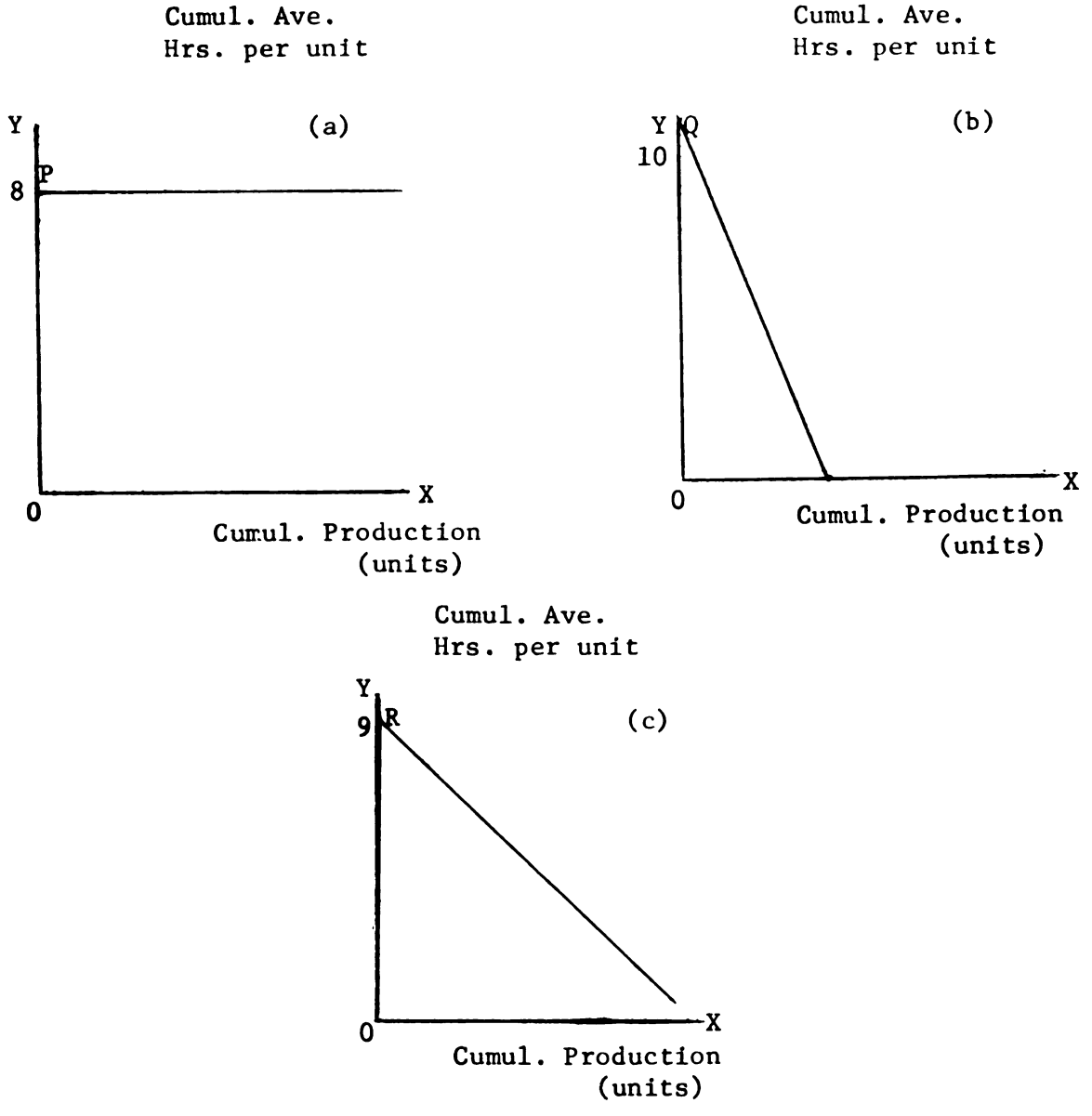
Total time reduction depends on two variables

A time reduction curve describes the time required for the first unit of production and for all subsequent units. Thus, total time reduction potential depends upon two variables:

1. Ability to reduce time per unit on all units after the first unit is produced.
2. Time required for the first unit produced.

Graphically, the time required per unit is plotted on the vertical or Y axis and the cumulative number of units is plotted on the horizontal or X axis. Time required for the first unit is known as the "Y intercept" or the "B factor." The rate of time improvement on subsequent units is known as "slope."

Three different time reduction patterns are portrayed in the graphs below.



Graph (a) represents a situation in which no time reduction occurs. Graph (b) represents very rapid time reduction, and Graph (c) shows an average time reduction pattern. Although the graphs are based on cumulative average time concepts rather than on unit time concepts, the time behavior would be basically the same under the unit

curve concept. The intercepts P, Q, and R show that in case (a), assumed time required for the first unit was 8 hours, for case (b), 10 hours, and for case (c), 9 hours.

In planning time reduction for control purposes, intercept, or time required for the first unit, and slope, the ability to reduce time on subsequent units, must both be considered.

The two types of time reduction curves: cumulative average curve and unit curve

The two common types of time reduction curves are the cumulative average curve and the unit curve. The preceding calculations treat the curve as a measure of reduction in cumulative average hours per unit produced and is most frequently referred to as the cumulative average curve. It is not a calculation of the actual time of producing the last unit but a calculation of the average hours required for all units to date. In other words, cumulative average time per unit is simply a division of cumulative production time for all units produced by the number of units produced. The second type of time reduction curve is called the unit curve because it measures the time it takes to produce a given unit. This calculation is a marginal one, i.e., it is the additional time required to produce one more unit.

The mathematical differences between these two types was clearly demonstrated by Carl Blair in his excellent comparison which follows:

TABLE 1

TWO INTERPRETATIONS OF PRODUCTION TIME YIELD DIFFERENT RESULTS[12]
(This table is based on an 85% learning curve)

	Interpretation I Time to produce: Accumulated average time			Interpretation II Time to produce: Unit time		
Number of Units	Unit Hours	Cumulative Hours	Cumulative Average Hours	Unit Hours	Cumulative Hours	Cumulative Average Hours
1	100.00	100.00	100.00	100.00	100.00	100.00
2	70.00	170.00	85.00	85.00	185.00	92.50
3	61.87	231.87	77.29	77.29	262.29	87.43
4	57.13	289.00	72.25	72.25	334.54	83.64
5	53.85	342.85	68.57	68.57	403.11	80.62
6	51.35	394.20	65.70	65.70	468.81	78.14
7	49.39	443.59	63.37	63.37	532.18	76.03
8	47.69	491.28	61.41	61.41	593.59	74.20
9	46.38	537.66	59.74	59.74	653.33	72.59
10	45.14	582.80	58.28	58.28	711.61	71.16
250	21.00	6850.00	27.40	27.40	8940.00	35.76
500	17.85	11645.00	23.29	23.29	15195.00	30.39
1000	15.17	19800.00	19.80	19.80	25840.00	25.84

Both of the foregoing tables produce an 85% learning curve. Interpretation I, Accumulated Average Time, is calculated to show the 85% curve as:

1. $\frac{\text{Cumulative Hours}}{\text{Cumulative Units}}$ = Cumulative Average Hours per Unit

2. $\frac{\text{Cumulative Average Hours per Unit through last Unit produced}}{\text{Cumulative Average Hours per Unit through earlier Units produced}}$ = Ratio of last Cumulative Average Time to former Cumulative Average Units Time

3. Cumulative Average Hours per Unit between doubled quantities should show a 15% decrease or require 85% as much time for all units to date at the doubled quantity as they did at the lower quantity.

For accumulated average time, as production is doubled from one to two units, Average Hours for all Units to date drop from 100 to 85. As production is doubled from two to four units, average hours for all units drop from 85 (at two units) to 72.25 (at four units). 72.25 hours is 85% of 85 hours.

The Unit Curve calculation, Interpretation II, produces an 85% curve as:

1. $\frac{\text{Time for most recent Unit produced}}{\text{Time for earlier Unit produced}}$ = Ratio of last Unit Time to earlier Unit Time

2. Between doubled quantities, actual time for the doubled quantity should be 85% of the time required for the lower quantity.

As Unit 2 is produced, it requires 85% as much time as Unit 1 (85 hours vs 100 hours). As Unit 4 is produced, it requires 85% as much time as Unit 2 (72.25 hours vs 85 hours).

In summation, the Cumulative Average Curve measures the average time of all units to date. The Unit Curve measures the time of each discrete unit. Thus, "85% Curves" will reflect different actual quantities of production, as the table on page 15 indicates, due to the different underlying mathematical bases described above.

Another example of such differences is Billon's comparison between the original T. P. Wright curve (a cumulative average curve) with the Boeing improvement curve, which is a unit curve or a unit average curve and reflects a 20% improvement between doubled quantities.

TABLE 2

T. P. WRIGHT'S CUMULATIVE AVERAGE CURVE

Unit	Unit Hours	Cumulative Average	Cumulative Units
1	100	100	100
2	60	80	160
3	50.6	70.2	210.6
4	45.4	64	256

TABLE 3

BOEING COMPANY'S UNIT AVERAGE CURVE[13]

Unit	Unit Hours	Cumulative Average	Cumulative Units
1	100	100	100
2	80	90	180
3	70.2	81.33	250.2
4	64	78.55	314.2

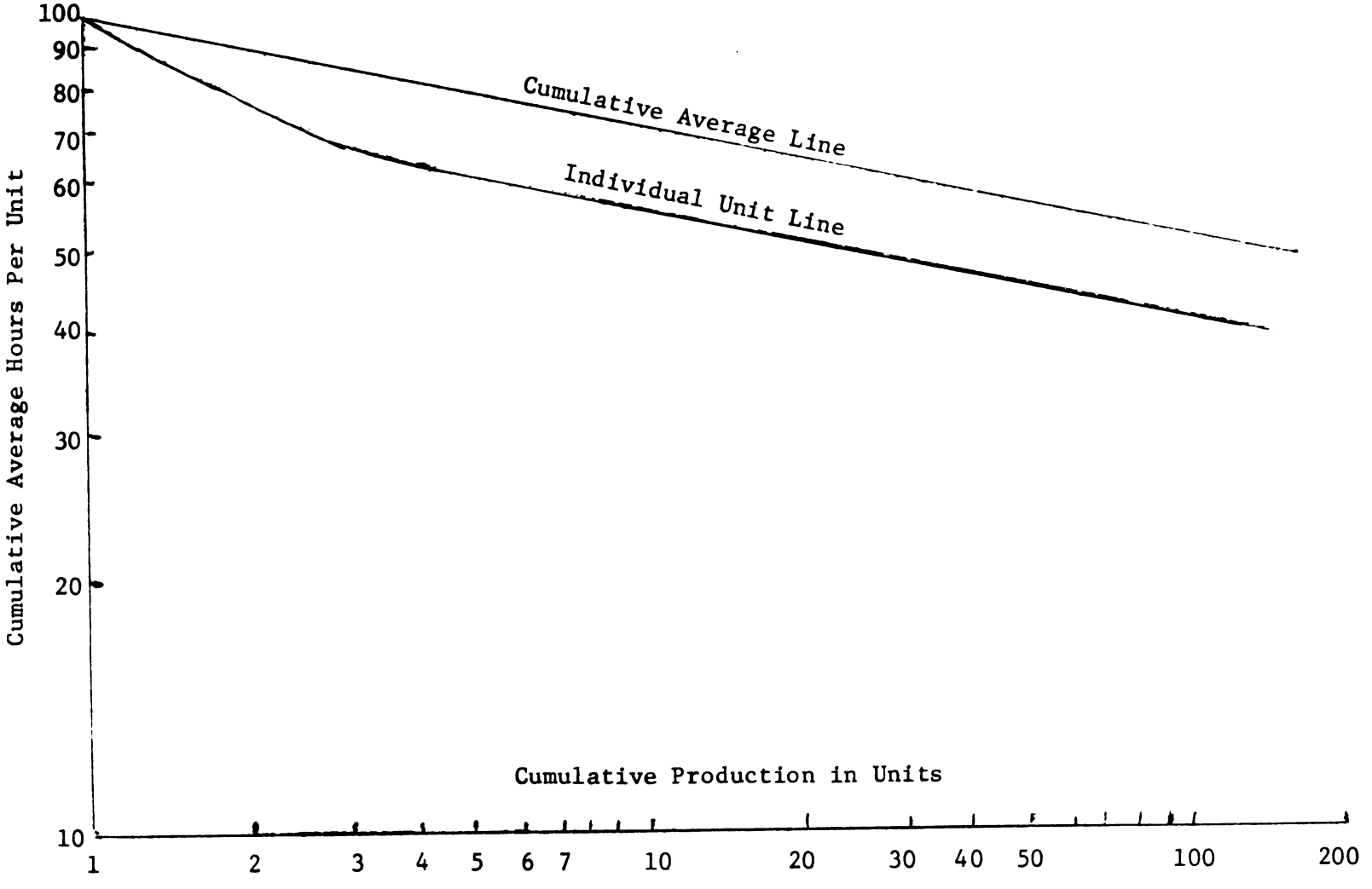
These tables represent 80% learning curves. With T. P. Wright's curve, the cumulative average column is the basis for measurement of learning (time reduction). Thus, from 1 to 2 units, time required for all units to date is 80% of the original time requirement for the first unit. Similarly, going from 2 to 4 units, time required for all units to date is 80% of the average time required for 2 units.

The Boeing Company's curve, the unit average curve, is their basis for measuring time reduction. Thus, from 1 to 2 units, time required for the second unit is 80% of the original time requirement for the first unit. Similarly, going from 2 to 4 units, time required for the 4th unit is 80% of the time required for the 2nd unit.

Raymond S. Jordan has illustrated these differences in shape of the cumulative average and unit time curves in the following graph.

Figure 1

THE TWO TYPES OF CURVES[14]



In Leonard W. Hein's graphing of the 80% learning curve, the curvature in early stages of production contrasts with the straight line behavior in latter stages of production and the additional curve depicts an "accumulated total time curve."[15]

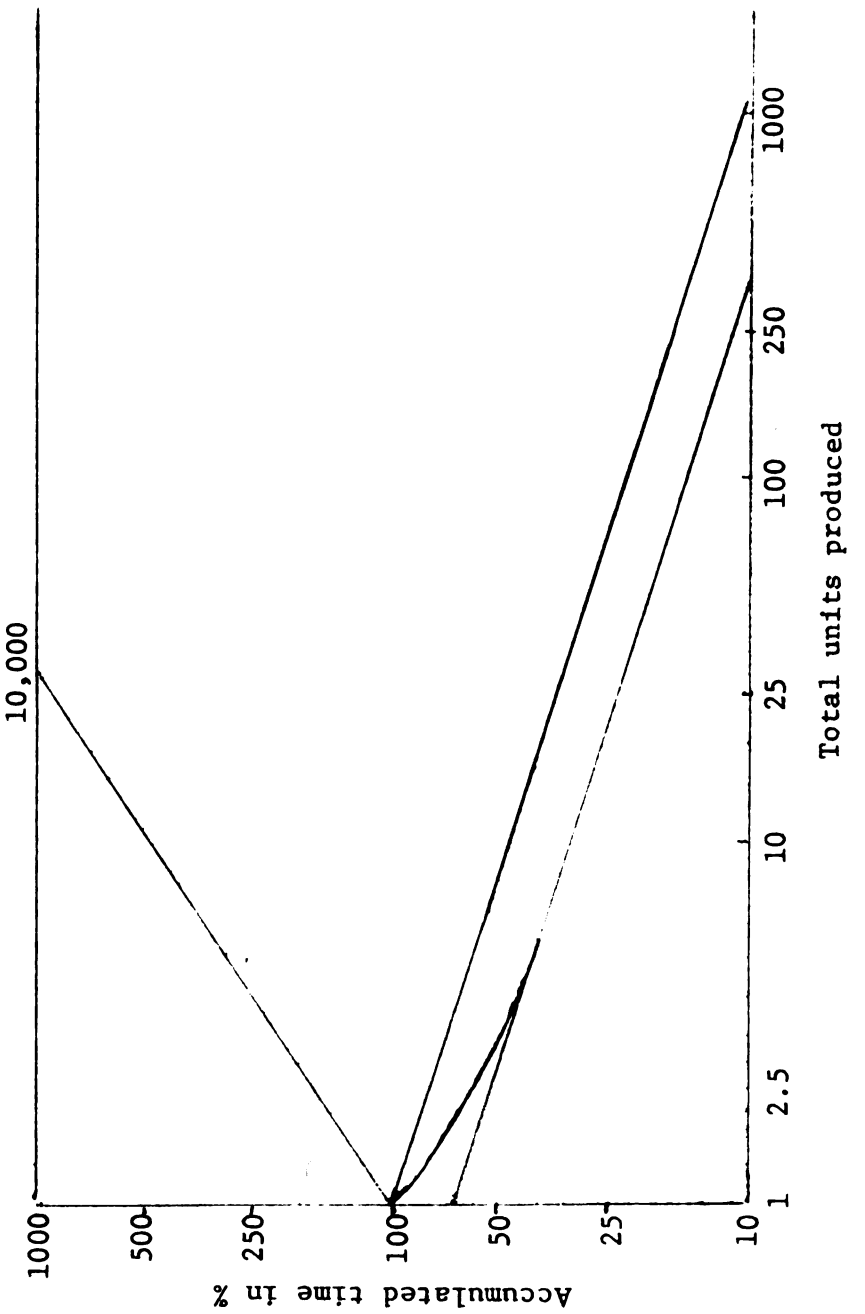


FIGURE 2

THE THREE 80% LEARNING CURVES USING LOG-LOG PAPER

Mathematical characteristics of the cumulative average curve

Cumulative average curves are often expressed as mathematical declines in cumulative average time per unit. They are not a marginal calculation cost calculation of actual cost of the last unit produced but, rather, are the average time per unit of all units produced to date. Jordan illustrated this as:

Cumulative quantity	Cumulative average hours (per unit)[16]
20 units	47.5
50 "	40.0
65 "	38.2
100 "	35.5

He further illustrated an 89% learning percentage as occurring between 50 and 100 units as:

$$\frac{\text{Units to date}}{\text{Units to prior date}} \quad \frac{\text{100 units 35.5 Cumul.Ave.Hrs.Per Unit}}{\text{50 units 40.0 Cumul.Ave.Hrs.Per Unit}} = 89\% \text{ learning curve}[17]$$

Jordan's fairly complete mathematical formulation for various learning concepts is shown below. The various headings "cumulative average value of units," "logarithmic description of the curve," "degree of learning," and "determination of negative exponent," etc. are this writer's rather than Jordan's.

Formula 1

$Y_x = K_x^{-n}$ Cumulative average value of units[18]

Y_x = cumulative average value of x units

K = value (theoretical or otherwise) of the 1st unit

n = exponent representing the slope or constant relationship between cumulative average cost and units produced

x = the number of units produced

(Here it should be noted that the value of n is negative, proving that cost declines as units produced increases.)

Formula 2

Logarithmic description of the curve[19]

On log-log paper, the curve is represented by the equation YX=(log K) minus n time log X.

Applying Jordan's formula, a 90% learning curve would be derived with logs as $X^{-.152}$ or X raised to the minus .152 power.

Formula 3

Degree of Learning[20]

At point 1, $Y = KX^{-n}$, point 2 = $Y' = K(2X)^{-n}$ then degree of learning = $\frac{Y'}{Y} = \frac{K(2X)^{-n}}{K(X)^{-n}}$ and learning % = 2^{-n}. (The number 2 indicates a doubled quantity.)

Formula 4

Determination of negative exponent[21]

Learning curve % = $\frac{1}{2^n}$, slope n = $\frac{\text{log of learning \%}}{\log 2}$

and for a 90% curve, slope n = $\frac{\text{log of .90}}{\text{log of 2}} = \frac{9.95424-10.00000}{.30103}$

= $\frac{.04576}{.30103}$ = .15201, the slope for a 90% learning curve.

Frank Andress defines the curve as:

$Y=KX^n$ (Where Y = cumulative average man hours for units[22]

K = number of man hours to build the first unit

X = number of completed units

n = log(% of learning curve/log (2))

Wayne J. Morse uses the following formula for projection of production time.[23]

$$Y=\frac{a}{X^b}$$

*(Where X = the cumulative production (measured on the horizontal axis)

Y = the cumulative average hours per unit (measured on the vertical axis)

a = the cost, or time it takes to produce the first unit (the intercept on the vertical axis represents this production time)

b = a parameter of the model which accounts for its slope

*Morse's formula assumes that b will always be sloping downward to the right and that this carries a plus sign.

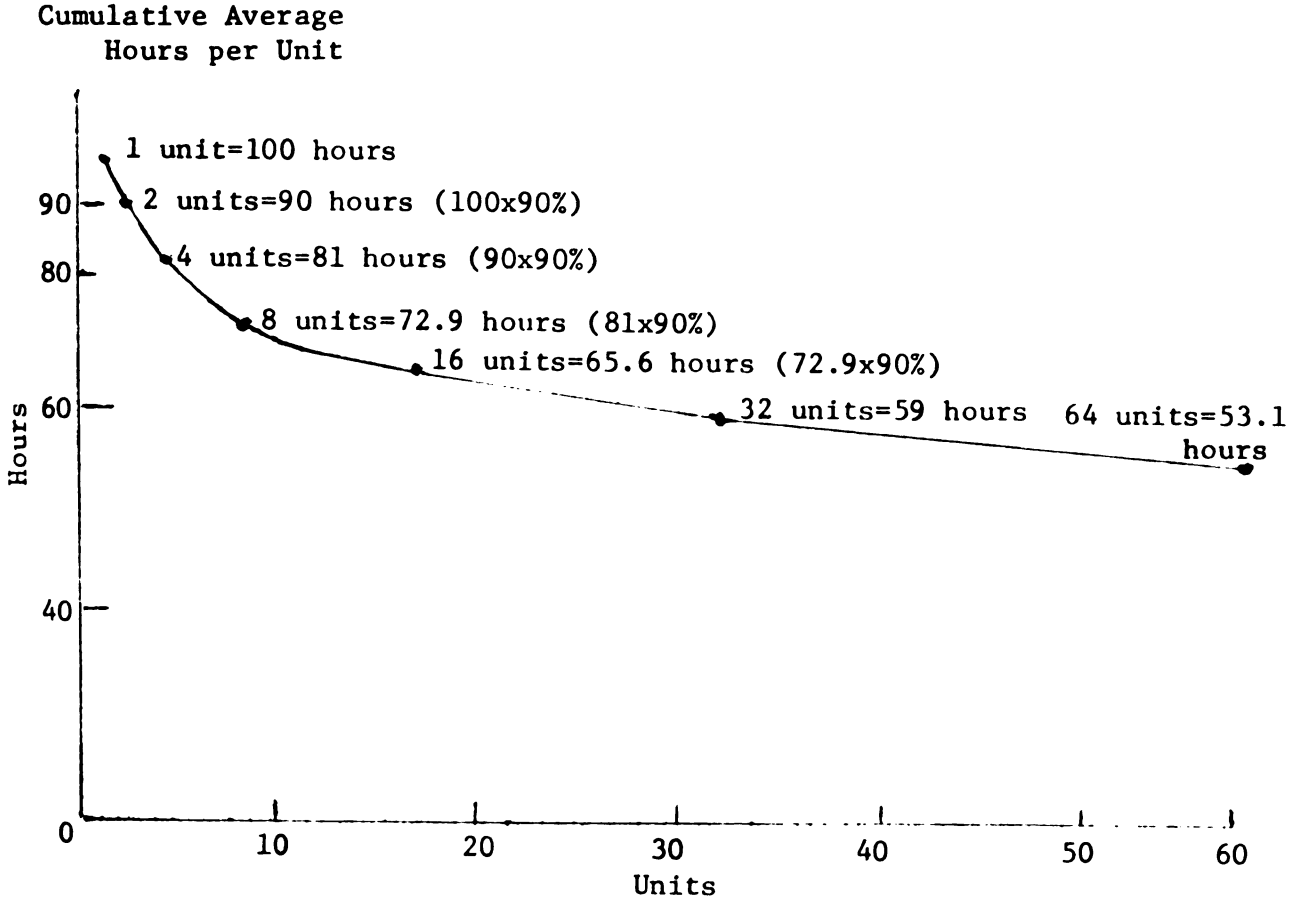
Graphical portrayal of the cumulative average curve

The time reduction curve may be plotted on semi-log or log-log paper. On semi-log paper, the curve is curvilinear with the slope flattening out as rate of time reduction finally begins to decrease. On log-log paper, however, the curve is quite dramatic in that it becomes a straight line. The decline in time required becomes a function of the units produced, and the citation of the relation of time reduction to units produced is a 20% reduction or an 80% learning curve, as heretofore mentioned.

The time improvement curve illustrated below, adopted from Delbert L. Brewer, is in semi-log form.[24]

FIGURE 3

CUMULATIVE AVERAGE TIME IMPROVEMENT CURVE



Brewer's graph describes a 90% curve in that each time cumulative production hours double the cumulative average hours per unit is 90% of the former cumulative average hours per unit.

The more frequently encountered 80% curve with doubling of cumulative hours to date has been put in log-log form as follows by James A. Broadston.

FIGURE 4

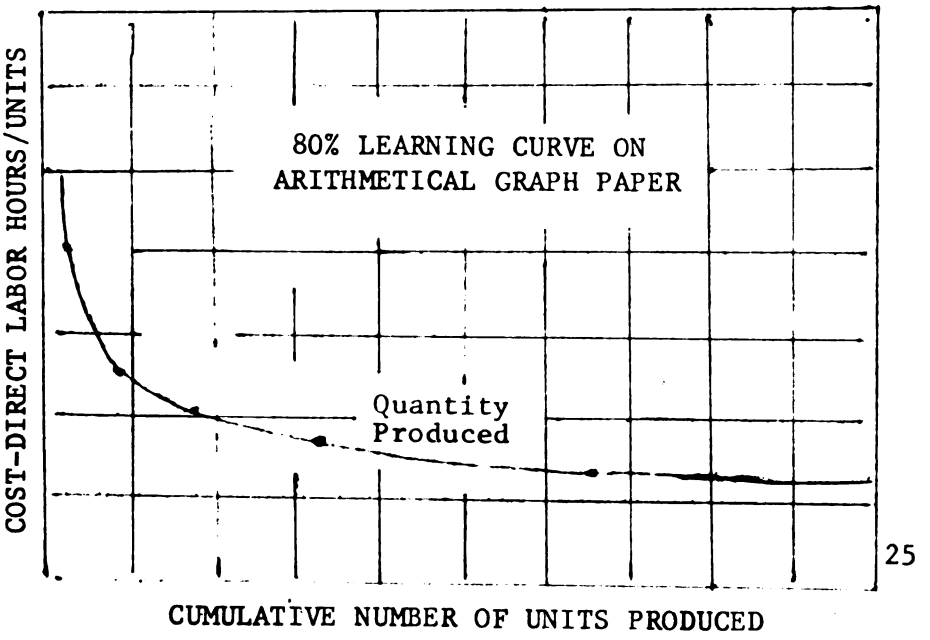
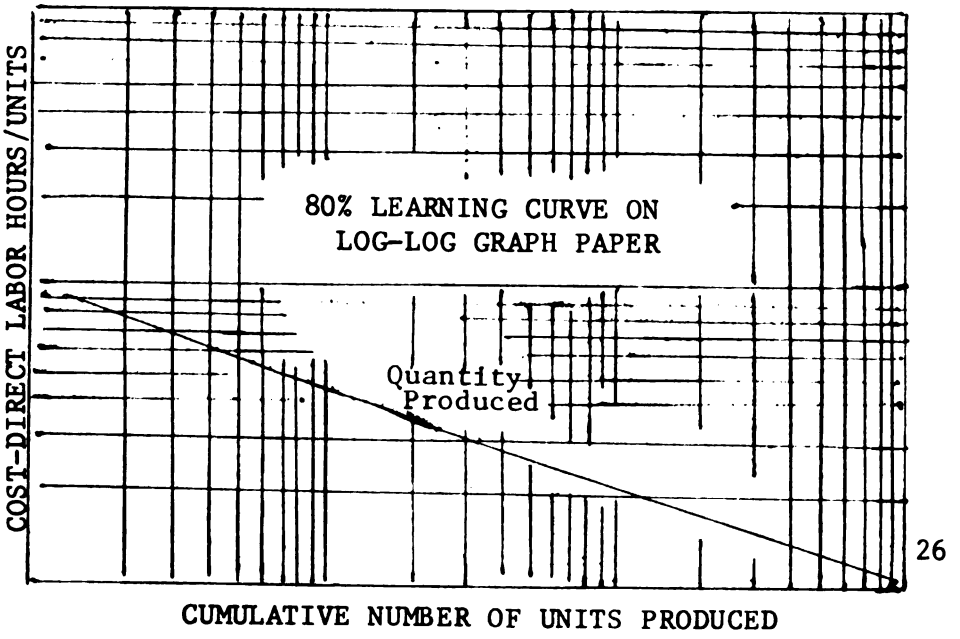


FIGURE 5



This graph clearly brings out the behavior of an 80% learning curve. Where 1 unit requires 10 hours, a doubling to 2 units will result in an average hours per unit of 8 hours, a further doubling to 4 units will cause 6.4 hours to be the average hours per unit when 4 are produced, etc.

The time reduction or learning behavior thus illustrated is the phenomenon which is probably responsible for the great interest in learning curves, namely, that time reduction follows a straight line pattern on this graph. Jordan therefore articulated this behavior in the form of a principle: "On log-log paper, if the distance between doubled quantities remains constant and the rate of decrease between doubled quantities remains constant, the resulting plot will be a straight line."[27] On log-log paper, equal distances measured horizontally or vertically, indicate equal percentage change. Thus, if units produced (measured horizontally) double, and if time required (measured vertically) is constantly 80% of an earlier time, then a straight line relationship must result. Equal horizontal movements bring uniform vertical movements.

Obviously then, the straight line behavior of time reduction in log-log form is a useful characteristic which predicates that time reduction can be anticipated, plotted, and used far more easily than if the pattern were curvilinear.

Mathematical characteristics of the unit curve

Since the unit curve is a marginal calculation of time to produce the last or added unit, it reflects the actual time to produce a given unit. Its tabular analysis, presented on pages 15 and 17, can

be amplified by a consideration of its mathematical and graphical characteristics. All of which suggest distinct advantages of this curve for public accounting.

The Boeing Company which is a prime developer and exponent of the use of time reduction curves developed the following formula called the "Basic Equation":

(1) $Y = Cx^{-n}$

N = slope
C = man hours of ship no. 1
x = unit no. of any ship beyond 1
Y = man hours at unit x

When the logs of each side of equation (1) are used a formula that can be solved for the slope, N, exists.

(2) $\text{Log } Y = \text{Log } C - N \text{ Log } x$[28]

The Boeing 80% Curve shows that the actual time to produce the second unit was 80% of the actual time to produce the first unit. The actual time to produce the fourth unit, similarly, was 80% of the time required to produce the second unit.

Ronald Brenneck also expresses for the unit curve a straight line learning curve progression as follows:

$Y = \frac{K}{XN}$ [29]

(Where Y = unit hours at any unit X
K = hours at unit 1
N = slope or learning rate)

Brenneck's formula may be convered to the Boeing formula by multiplying each side by XN. Then, YXN = K, and $Y = K\text{-}X^{N}$, so that Log Y = Log K - NLogX as in the Boeing formula.

Graphical portrayal of an 80% curve

The following two pages present an 80% unit curve using the three common types of graph paper.

FIGURE 6

UNIT HOUR CURVE ON FULL-LOGARITHMIC GRID

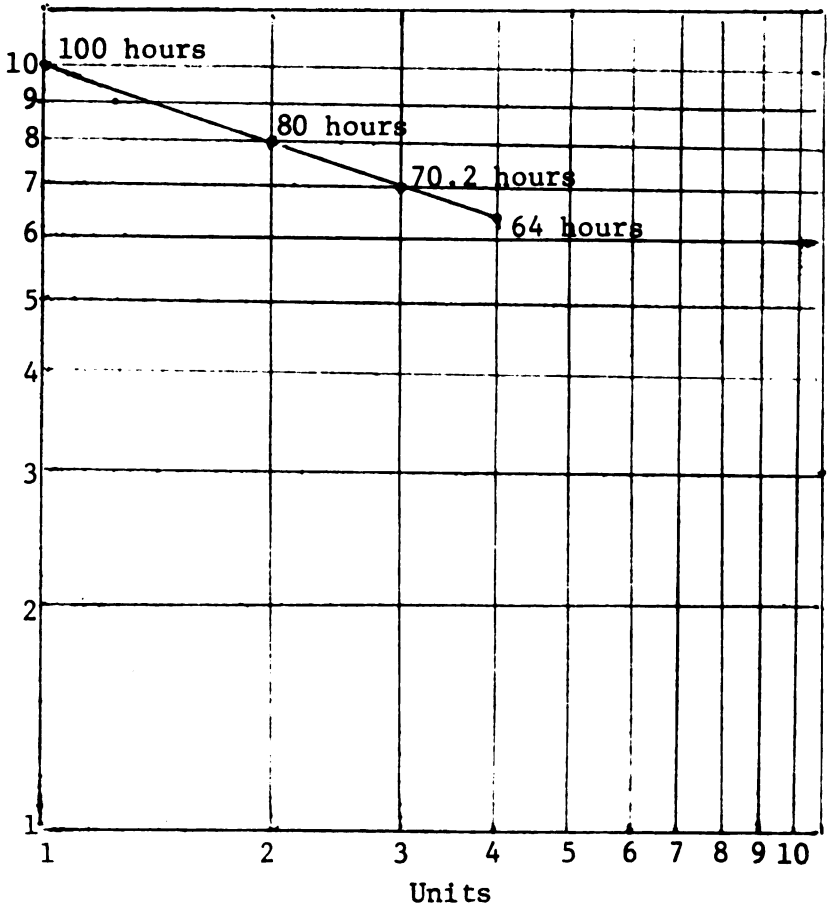


FIGURE 7

UNIT HOUR CURVE ON SEMI-LOGARITHMIC GRID

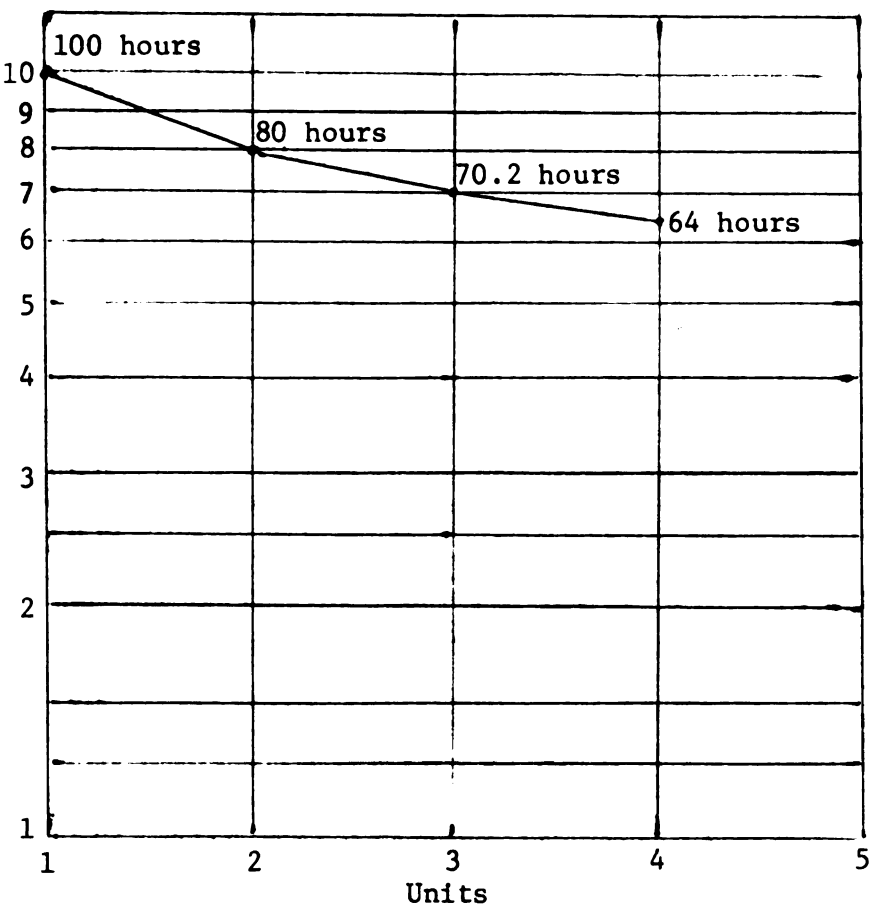
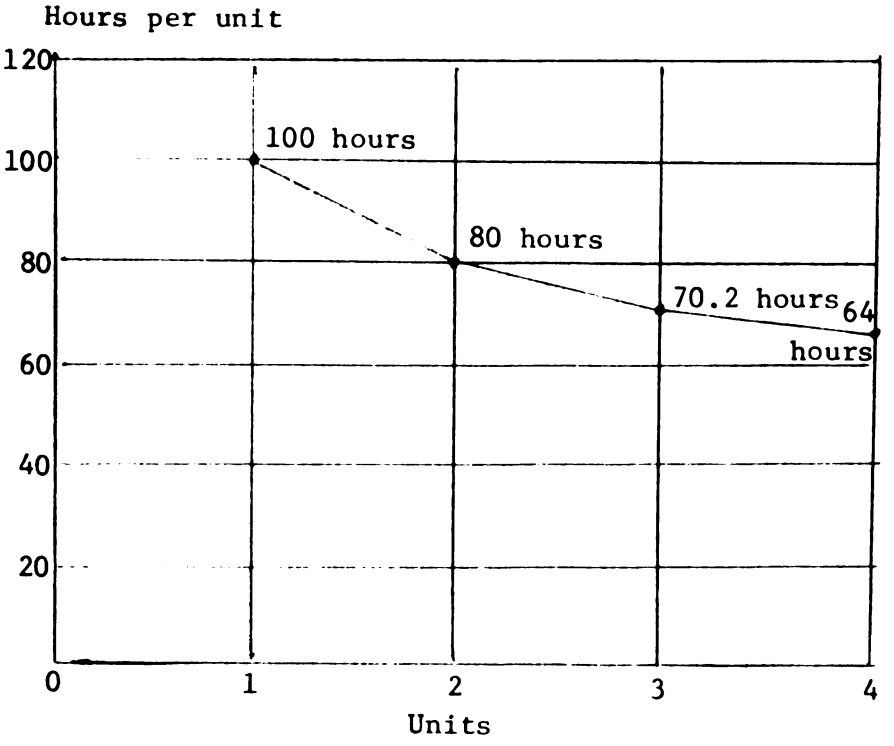


FIGURE 8

UNIT HOUR CURVE ON ARITHMETIC GRID



Reconciling differences in concept and usefulness of the two curves

There are problems of terminology, of appropriate mathematical application, and of unique control needs of business firms present in the consideration of the concepts and usefulness of the two curves. A problem of concept and usefulness is presented by Boeing Company's Link and Ellis who wrote in a company publication: "Since the cumulative average curve is not a straight line, it is not as suitable for estimating or control as the unit curve; in addition, any deviations from the trend will not be noticeable in the cumulative average value."[30]

However, much of the literature on the two curves does not agree with the conclusions set forth by these men because of current practices. Boeing uses the unit hour method but many other firms use the cumulative average hour method.

The differences in practices may be attributed to many firms accepting T. P. Wright's original derivation of the curve and to some confusion concerning the properties of the curve. The Link and Ellis quotation flatly reverses the data in Jordan's graph. On page 18 Jordan claims that the cumulative average line is straight, and the individual unit line is curved, but Link and Ellis feel that the cumulative average line is curved and that the unit hours line is a straight line. This difference in viewpoint is a result of Jordan applying the formula for a given percentage of learning curve based on the cumulative average hours formula while Link and Ellis use the formula for a given percentage of learning curve based on the unit curve formula.

A few examples will illustrate how easily such differences can be reconciled. In industry where there are large production runs, the curves under either formula will straighten after the first few units

have been completed, thus showing that both curves have the same basic slope in their latter stages. On page 18 the lines on the two graphs become parallel after unit 5. Furthermore, in industrial applications the two curves may be interchanged by a set of mathematical formulas as noted briefly here:

Jordan shows the relation between the cumulative average curve and the unit curve as:

$1 + N$

For a 90% curve, $1 + (-.152) = .848$[31]

The above formula would convert a cumulative average type of learning curve slope to the slope of a 90% unit time curve.

To predict the time required on additional units beyond a given volume of units produced to date, Jordan's following formula could be applied.

Formula 5

Formula for added quantity[32]

$$F = \frac{(1.0 + P)^{1+N} - 1.0}{P}$$

F = factor for an additional quantity

P = additional quantity as a % of the previous cumulative quantity

1+N = factor for conversion from cumulative average to individual unit

Corroborating this is Andress' explanation that a mathematical formula can be applied to convert cumulative average hours per unit to unit hours when necessary.

$U = (N+1)KX^n$ (Where U = man hours for a unit[33]

(N+1) = conversion factor, and for an 80% curve (N+1) = +0.67807

K = number of man hours to build the first unit

X = number of completed units

n = log(% of learning curve/log (2))

Finally Leonard Hein whose accumulated total time curve is graphed on page 19 states the mathematical formula for it as does Frank Andress.

$Y = AX^c$ Y = cumulative average cost per unit[34]
A = a constant
X = units
c = slope

Hein's curve for total time is useful for purposes of determining total time and labor pay requirements on a volume basis.

Frank Andress would derive the curve as:

$T = KX^n$ Where T = total man hours to build a predetermined[35] number of units
K = a constant
X = number of units
n = slope

The most suitable time reduction curve for public accounting

To determine which curve is the most relevant for use by the public accountant, it is necessary to sum up the characteristics of the two curves and then ascertain how these fit the time control needs of the public accountant. The cumulative average curve is useful for pricing, budgeting, and other purposes. The estimated average time (or average labor cost) for the last unit to be produced may be multiplied by all units produced to date to arrive at the total labor time

(or labor cost) for all units. This can be the basis for setting prices on a unit basis or for establishing the total budget. The figure for estimated or budgeted total labor cost will become a key figure in financial drain analysis. The total labor hours figure will help establish labor time and manpower requirements. One disadvantage for the public accountant in using this curve is that the time required per unit is not readily available.

The unit curve seems more uniquely suited to the public accountant for his control needs. The public accountant needs to predict as accurately as possible the time required for the "next" unit. This unit represents an upcoming audit. While the average time to perform a series of years' audits may have use in long range fee estimation, the short term requirement of immediate time predictability seems more pertinent. This writer agrees with the Boeing Company that the unit curve will point up differences in actual and estimated time more easily than will the cumulative average curve.

CHAPTER III

HISTORICAL RESEARCH - PAST AND PRESENT APPLICATIONS OF TIME REDUCTION CURVES

Pioneer studies

Pioneering studies in time reduction curves extend roughly over the forty year period between the publication of Dr. William P. Bryan's study in 1897 and that of T. P. Wright in 1936. In his study in the area of telegraph code learning Bryan observed a quick time reduction in the early stages of learning with a tapering off of time reduction later on, thereby isolating the process of the time reduction phenomenon.[36] Leslie McDill, during his employment with the McCook Field Company at what is presently Wright-Patterson Field, and James R. Crawford of Lockheed Aircraft Company applied the curve to the airframe industry.[37]

However, the farsighted study by T. P. Wright in 1936 was the remarkable one. While emphasizing the basic theme that "repetitive work and learning curves go together," the study also stated that the curve is applicable to industries other than aircraft, the construction industry being a case in point. Wright also saw the relation of the curves to group time reduction so long as the group's aim was to accomplish a common task more efficiently.[38] Wright seemed to look to the future when he discussed the environment as a factor affecting learning.[39] Seemingly he anticipated the role of organization structure,

interaction theory, and other modern concepts relating to the environment in its effect on productivity. His recognition of group effort paralleled that of the Western Electric research of Elton W. Mayo and his staff, which also focused on the importance of dealing with the worker as a member of a group in order to obtain group effort maximization. This latter work published during the same period corroborated Wright's conclusions.

World War II studies

Two principal studies, the Stanford Research Institute study and the British Ministry of Aircraft Production study, which covered the major portion of aircraft production in World War II, arrived at the same overall conclusion: All of the different types of aircraft had a common rate of improvement on time required per plane.[40] In addition the Stanford study developed the Stanford Curves from all of World War II and post-war airframe production data.[41] Concurring investigations such as the Boeing studies by Link and Ellis and by Smith, Lansing, Brown and Horton and the 1957 Wright-Patterson Air Force Base study confirmed, reinforced, and interpreted the findings of the British and California groups.

At Boeing the valuable work of Link and Ellis recorded the time reduction curve over the life of the B-17 airplane production.[42] In the Smith, Lansing, Brown and Horton study, the authors, using the Stanford Curves which described a 70.7% time reduction slope for airframes, stated that B factors had to be applied to airframe producers to arrive at this 70.7% curve.[43] The B factor concept implied that there is some minimum time requirement for producing the first unit.

In a $Y=aX^{-b}$ formula for a straight line curve, the (a) would correspond to the B factor. This is the starting point for eventual time reduction, and the highest time per unit which should be required. The eventual time per unit (Y) would depend then on original time (a) less the degree of learning or improvement percentage (b) for any given number of units produced (X). (The b becomes -b in time reduction formulas to show time reduction.) Thus, it was concluded that a high degree of learning may not necessarily reflect favorably on a firm, but may indicate that the firm was just quite inefficient to begin with! Finally, at the Wright-Patterson Air Force Base, the study reinforced the need for a constant mix of machine time and human time to predict time reduction percentages.[44]

A recent study

The interesting and relatively recent (1964) study by William F. Wilkerson conclusively established the acceptance of the time reduction phenomenon.[45] He discussed the use of learning curves from the viewpoint of a government auditor, tracing out the accounting process for firms doing business under government contract. He noted that time reduction in some manufacturing operations has become so predictable that it is sometimes built into the contract price when the government contracts with civilian producers, e.g., if a government contract should be terminated before the occurrence of the time reduction built into the contract, the civilian firm would be reimbursed for the added cost of high cost production. The high cost production, of course, refers to operating in the upper segment of the time reduction curve. This contract clause offers strong evidence of

the acceptance and predictability of the time reduction curve.

Industries in which time reduction curves may be useful

Since the most prominent application of time reduction techniques has been in the aircraft industry and the extensive Stanford Institute studies of aircraft time reduction have laid the basis for peacetime aircraft procurement by governmental agencies, time reduction is a cornerstone of industry-government airplane contract negotiations; but there are many other industries in which time reduction curves are or may be useful. For instance, in Francis J. Montgomery's study of the production of the first 1,500 Liberty vessels made in 1943, as production expanded from 2 to 900 ships, the time required per ship dropped by fifty per cent.[46] Likewise Billon indicates that 60% of metal manufacturers surveyed used time reduction curves in forecasting.[47] Werner Hirsch reported in the 1952 study of large machine manufacturing that the 80% learning curve between doubled quantities appeared common in this industry also.[48] Similarly, available articles on current applications of the learning curve, though not abundant, do imply that there is fairly widespread use of the time reduction curve concept in industry today. Nicholas Baloff indicates the extent of current use of the curve:

> ...the generalized model has provided every efficient descriptions of many product and process start-ups in a variety of highly mechanized forms of manufacture in these United States industries: steel, basic paper products manufacturing, glass container manufacturing, and automated manufacturing of electrical conductor and electronic switching components.[49]

Frank Andress specifically substantiates by citing several modern applications of time reduction curves in such widespread

industries as machine shops, residential home construction, shipbuilding, home appliances, and electronics.[50] Rolfe Wyer states that learning curves have been used with great success among refrigerator manufacturers. He presents an example of extreme accuracy in estimation of cost through use of the learning curves. Just after commencing production on a new refrigerator line, he is able, with time reduction curve analysis, to predict the cost of units far into the future, based on estimated units to be produced.[51] Lastly, Raymond Jordan in his excellent book on the learning curve discusses an extensive study of learning rates in the gear-making industry, in which a learning rate of 93% is typical.[52]

One unusual application of the curve came in an industry whose product was not defined but which had a problem of frequent short run operations. The application was summarized by Frank J. Powers in his article, "Costs Strike Out With Learning Curve Incentives."[53] This summary is not only interesting but particularly applicable as some of the problems of short-time reduction periods which were encountered seem similar to those problems encountered by the public accountant. Short run operations normally might not include the repetitive operations to the extent necessary for the curve to operate to its fullest advantage. Yet, on operations continued indefinitely, there is a flattening out or plateau effect, where time improvement is almost imperceptible.[54] Apparently, 95% of these short run jobs are never repeated at the company in this study. In addition to this, the assembly line contained varying numbers of employees, ranging from one to fifteen operators. A table from the study sheds some light on the actual method used by this firm.

TABLE 4

CALCULATION OF DAILY ALLOWANCE

Learning Days	% Learning Performance	Daily Task	Daily Allowance[55] Per Operator (Hours)
1	60.0	600	40.0% x 8 = 3.20
2	70.5	705	29.5% x 8 = 2.36
3	75.5	755	24.5% x 8 = 1.96
4	80.0	800	20.0% x 8 = 1.60
5	87.0	870	13.0% x 8 = 1.04
6	100.0	1000	0% x 8 = 0

An incentive system was geared to the time reduction curve to solve the problem of learning new operations quickly. Also, when the group of operators exceeded three in number, the company added a group familiarization allowance. The length of the learning period is decided by a conference of the related managers. Finally, the company maintains a list of learning times for all such short run jobs as bench marks for setting times on new jobs.[56]

Specific purposes for which time reduction curves are used

Beyond the general use of time reduction curves for plotting expected time reduction in labor hours per unit, there are some other specific applications of the curves. These applications when examined in detail show that the curves have great flexibility and that their use is limited only by the imagination of the users.

1. Labor turnover problems

   The time loss from departure of experienced employees is well known to industry. As one reference, "Determining the Cost of Labor Turnover,"[57] clearly outlines, if people terminate employment in the declining phases of the time reduction curve, new employees will replace them and start at the "top" of the learning curve. With time

reduction curves, however, management can better quantify the actual cost of a worker starting fresh at the upper portion of the learning curve. Time required per unit will be high as the new "learning" experience must reoccur.

2. Estimating ending inventory

Rather than basing an estimated ending inventory on average cost (which may or may not represent a true average cost,) John Gawa suggests that the inventory value be based on the learning curve.[58] This process can be quite accurate. When time declines in the very predictable pattern indicated by the learning curve, approximate time required for the last unit can be determined. This time may be in excess of the time required to complete this unit on an average basis. (The average time is contemplated over the entire time reduction process and, on unfinished goods, we may be at various stages of time reduction at the end of an accounting period.) Thus, more accurate inventory determination may be facilitated. John Gawa has merely suggested the use of the curves for inventory valuation. The above analysis is largely this writer's, but it rests heavily on a very detailed analysis of the matter by Wayne Morse who described the actual use of time reduction curves to value inventory by the Boeing Company.[59]

3. Financial drain analysis

Writing from the excellent vantage point of an employee of the United States Army Audit Agency - an agency which

appears to be fully aware of potentials of the time reduction curve - John Gawa analyzed financial drain.[60] In analyzing the feasibility of a bid from an airframe subcontractor, he discovered the adequacy of a firm's resources to meet needed commitments is important. To illustrate his findings, a detailed schedule reproduced below brings out the dramatic effect that an 80% time reduction curve can have on a firm's costs and profits. It is noteworthy that time reduction behavior represents a unit curve of the type that the Boeing Company appears to favor. The behavior is a true 80% curve with 20% reduction between doubled accumulated units. The calculations following the table are the writer's for the purpose of refreshing the reader with a brief review of the operation of this unit type of time reduction curve.

TABLE 5

SCHEDULE OF FINANCIAL DRAIN

Unit No.	Direct Labor Hours	Direct Labor Cost	OHD.	Material	G & A	Profit This Unit	Cumulative Profits
1	100.00	$200.00	$200.00	100.00	50.00	-192.32	-192.32
2	80.00	160.00	160.00	100.00	42.00	-104.32	-296.64
3	70.21	140.42	140.42	100.00	38.08	- 61.24	-357.88
4	64.00	128.00	128.00	100.00	35.60	- 33.92	-391.80
5	59.56	119.12	119.12	100.00	33.82	- 14.38	-406.18
6	56.16	112.32	112.32	100.00	32.46	+ .58	-405.60
7	53.45	106.90	106.90	100.00	31.38	+ 12.50	-393.10
8	51.20	102.40	102.40	100.00	30.48	+ 22.40	-370.70
9	49.29	98.58	98.58	100.00	29.72	+ 30.80	-339.90
10	47.65	95.30	95.30	100.00	29.06	+ 38.02	-301.88
11	46.21	92.42	92.42	100.00	28.48	+ 44.36	-257.52
12	44.93	89.86	89.86	100.00	27.97	+ 49.99	-207.53
13	43.79	87.58	87.58	100.00	27.52	+ 55.00	-152.53
14	42.76	85.52	85.52	100.00	27.10	+ 59.54	- 92.99
15	41.82	83.64	83.64	100.00	26.73	+ 63.67	- 29.32
16	40.96	81.92	81.92	100.00	26.38	+ 69.46	+ 40.14
17	40.17	80.34	80.34	100.00	26.07	+ 70.93	+111.07
18	39.42	78.84	78.84	100.00	25.77	+ 74.23	+185.30
19	38.75	77.50	77.50	100.00	25.50	+ 77.18	+262.48
20	38.12	76.24	76.24	100.00	25.35	+ 79.95	+342.43

Illustrative calculations:

Unit No.	Direct Labor Hours	Direct Labor Hours Reduction	% Hours Reduction
1	100.00		
2	80.00	20.00	$\frac{20}{100} = 20\%$
4	64.00	16.00	$\frac{16}{80} = 20\%$
8	51.20	12.80	$\frac{12.80}{64} = 20\%$
16	40.96	10.24	$\frac{10.24}{51.20} = 20\%$

In connection with the preceding schedule of financial drain, Raymond S. Jordan would note that progress payments may be needed to

aid such a contractor in his early stages of low production and high financial drain.[61]

4. Make or buy decisions

The time reduction curve has proved useful when a company is faced with a decision of making a product which it does not usually make or buying the product from another firm. If a company must interrupt production to produce this type of item, a double time loss occurs.

a. They will be starting at a high point in unit hour requirements for the newly produced item.

b. Resuming production, after an interruption to produce the new part, causes them to go to a higher point on the new time reduction curve compared to their prior point on the curve.

Frank Andress has considered this make or buy phenomenon in some depth, and he feels that a short run decision may call for a firm to make a particular new item. Long run considerations, however, must include the potential of buying from another contractor to reduce time according to that firm's time reduction curve.[62] If another contractor has produced this item previously, he will have a low time requirement on initial production of this order, while the firm which is considering building the item will be starting at the higher initial time requirement on its time reduction curve. Andress seems to be referring to the slope of the curve as well as the difference in relative B factors among various firms. Both of these factors affect ability over a given span of units to reduce time required per unit.

5. Clerical time reduction

The area of clerical time control has never been emphasized as much as industrial time control and perhaps this is due to the less repetitive nature of the work. Any studies in this area would thus be relevant to developing a time control system for public accounting. Maurice Kilbridge applied time reduction curves to clerical operations of a generally repetitive nature in his study of a mail order house. Kilbridge was successful in isolating six factors affecting time reduction. When the effects of these factors were evaluated, Kilbridge found a high correlation between presence of a particular factor and time reduction.[63] The factors evaluated were:

a. Skill and dexterity
b. Knowledge of methods, procedures, media or materials
c. Analysis and judgement
d. General complexity
e. Use of office machine or equipment
f. Length of cycle

Some of these factors may be relevant to public accounting particularly factors b, c, and d. They were not evaluated in the empirical study of time reduction as it appeared that they should be evaluated by a member of the C.P.A. firm for proper appraisal.

The mail order house study, as well as the Powers study on short run operations,[64] indicate that, by establishing a time reduction curve through observation of actual time reduction behavior, standards can eventually be determined for repetitive tasks. Hindrances to achieving standards

can now be costed out and the variance properly assigned. The variance in the Kilbridge study would result from an insufficiency on the task, of those factors promoting time reduction. These first steps toward a more sophisticated cost accounting system may have some usefulness in developing a time control system for audit time.

6. Checking actual costs against projected costs

Whenever actual costs exceed budgeted costs, an analysis is in order. Either the estimate was incorrect or the time control technique was inadequate. In government contract work, departures from projected costs, as originally submitted on a bid, must often be explained in detail to the governmental agency. William Boren suggests that the time reduction curve will be useful in this respect in that causes of the cost variance may lie in:

a. Learning curve percentage was in error. (Perhaps too low a percentage was used. If 85% was used, go to 90% in the future.)

b. Unforseen inefficiencies occurred. (Possibly engineering or drawing changes.)[65]

Again, an understanding of factors underlying the curve may well help us to understand variances from the anticipated time reduction. Variances are probably seen in changes in underlying factors.

Time reduction can be returned to the normal pattern shown by the curve if only these underlying factors are restored to their normal condition.

7. Miscellaneous uses of time reduction curves.

The following tabulation is an overview of the many uses of time reduction curves and of the authors advocating each particular use.

Use	Authors Citing Particular Use
1. Setting selling price	Brenneck; Brown, Smith, Lansing, Horton
2. Projecting labor loads	" " " " "
3. Determining manpower requirements	" " " " "
4. Controlling shop labor	" " " " "
5. Determining realistic prices for shop labor	" " " " "
6. Establishing starting load costs for new products	" " " " "
7. Examining training programs for new employees	" " " " "
8. Facilitating make or buy decisions	Brenneck, Jordan, Andress
9. Saving on inventory storage and handling costs, by limiting inventory size to that called for by the learning curve	Wilkerson
10. Effecting transfer of excess workers	"
11. Evaluating cost to company of change orders	"
12. Determining cost of not completing a given contract	Wyer
13. Reflecting on efficiency of 2nd and 3rd shift operations	Billon
14. Giving goals to workers	"

15. Costing of trained worker terminations	Billon
16. Evaluating progress and predicting if employees will reach standard	Kilbridge
17. Determining effectiveness of training program	"
18. Determining learner's allowance	"
19. Setting a standard cost of employee training and of employee turnover	"
20. Preparing manning tables and replacement schedules	"
21. Setting a standard cost	Reimers

CHAPTER IV

THE NATURE OF AUDITING BY CERTIFIED PUBLIC ACCOUNTANTS

The presence of repetitive aspects in auditing

As in any performance task, auditing is intrinsically, though perhaps not obviously, repetitive. Even its operative base, the application of constant audit standards, is of necessity a repeated activity which validates all the others: audit functions (or tasks), audit steps, basic skill requirements, and organizational demands. In this study, the term "audit functions" refers to the normal examination of each item on a balance sheet. Thus the examination of cash, of accounts receivable, and of inventory are recurring audit functions.

"Audit standards" relate to the minimum amount of testing, validating, confirmation, etc. needed for the public accountant to certify that the accounting records appear satisfactory.

The "audit steps" are the actions taken to accomplish each function and these also tend to be repetitive. A partial listing of these functions, in conjunction with their respective audit steps, follows:

Cash

1. Bank reconciliations
2. Footing of cash journals
3. Tracing of ledger postings
4. Internal control analysis (partly repetitive)
5. Petty cash examination

Accounts receivable

1. Confirmation work
2. Verification of sub-ledger and control account
3. Aging schedule preparation
4. Examination of write-offs as to propriety
5. Tracing of ledger postings

Inventories

1. Observation of physical inventory
2. Test checks of physical inventory
3. Examination of inventory cut-off procedure
4. Testing extensions and footings of inventory listing
5. Testing cost to market value

The reader will recognize this listing of repetitive steps as only partial. Any standard auditing text, such as Montgomery's, would list many, many more of them. A good auditing book would also acknowledge that the audit steps are repetitive only in the sense of setting some minimum norm for examination of a client's records. Beyond this minimum examination, and indeed during that process, aspects of judgment, imagination, and intuition enter the picture. Differences in the client's internal control, in its management competence, and in the firm's objectives all lead to alteration of examination techniques, extent of audit samples, etc. That is, repetitive steps are applied, using the judgment of the public accountant based on his prior experience, training, intelligence, etc. All of these considerations of how to audit the client may also be tempered by economic considerations of the client and of the public accounting firm.

The one aspect which is repetitive, although variable, and which is most worthy of consideration by public accountants in developing a control system is the basic skill of the auditor. Minimally this skill contains four characteristics:

1. Attention to detail
2. Mathematical reasoning ability
3. Ability of self-expression
4. Conceptual ability (ability to interrelate events, persons, places, etc.)

The auditor must continuously give close attention to detail. Evidence of errors in the accounting process or of fraudulent activities is usually obtained from one or two small discrepancies. Mathematical reasoning ability is needed to trace out a complex chain of effects stemming from actual or proposed accounting treatments of events in the client firms. An ability in oral and written expression is required during an audit and in presenting the final audit report to the client. Finally, the auditor should possess conceptual ability to relate observations in one audit area to those in other audit areas, thus determining the overall quality of the client's accounting performance, weak and strong areas, etc. All of the above skills tend to be repetitive from one audit to another.

The final repetitive aspect in auditing might be called organizational demands and this is perhaps the most variable of the repetitive aspects. In each audit there are conferences with client firm members during which any changes in operations from prior years are noted for their effect on the audit. Auditors may have to familiarize themselves with new key employees and with any accounting procedure changes, and they may wish to select specific areas for audit stress. Although these organizational demands may vary in extent from client to client and from year to year with the same client, these organizational demands are repetitive in nature.

The relation of the repetitive aspects in auditing to a control system

Manifestly, there is a two-fold relationship between repetitive aspects in auditing and the control system needed over audit time requirements. The audit functions, including their steps and the basic skill of the auditors, are repetitive aspects which may lend themselves to analysis and control.

1. 1,000 inventory extensions should require a given amount of time, confirmation of 1,000 accounts receivable might require another given amount of time, etc. The audit function itself would require a certain time which represented the sum of these individual steps.

2. The basic skill of the auditor should be continuously measured and evaluated. If this skill is increasing, as it should over a period of time, then two beneficial results of his increased skill will occur:

   (a) A decrease in time requirements on repetitive tasks. The decrease can be matched against some average or expected time reduction noted in point 1 above.

   (b) Improved ability to cope with unusual situations which contain nonrecurring factors.

Thus, the two-fold relationship involves isolation of repetitive aspects for which time standards may be established. It also involves measurement of the basic skill of the auditor in terms of his performance against these estimated time standards. The time control system must accomplish these tasks of setting standards and measuring performance.

Presence of non-repetitive aspects in auditing

An audit for a given client can change rather dramatically from year to year for a variety of reasons. However, the observations made in this study or advanced by practitioners isolate only eight causes. These causes, though not necessarily in the order of their

importance, are:

1. Scope of audit change or change in the level of difficulty of an audit
2. Internal control changes
3. Personnel changes in the client's office
4. Special studies for the client
5. Computerization of accounts and records
6. Environmental changes
7. Expansion of duties
8. Economic changes

All of these are non-repetitive for any given client and are, therefore, of great importance in any consideration of a control system.

Changes in audit scope or level of audit difficulty can result from several underlying factors. Introduction of new products by a firm and the resulting new cost standards, effect on the firm's resources, possible new collection policies, etc. may require a more extensive audit than in prior years. A merger with another firm can also cause an increase in audit scope as now two sets of records must become one with new accounts being created. Property valuations need to be analyzed and, particularly in the year of merger, a more elaborate set of financial statements need to be prepared. A spin-off, resembling a merger in reverse, also calls for a change in the accounts, though one not so time consuming perhaps. Fluctuations in sales volume can result in more accounting transactions and thus require more audit testing to cover a given percentage of business conducted. Centralization or decentralization may cause the basic unit of entity measurement to change. Measuring accounting performance at one location and at several locations requires a different set of accounting reports, controls, data gathering facilities, etc. The auditor must respond with an increased or possibly reduced level of examination. Finally,

the quality of accounting work at the client's office can vary, increasing or decreasing the testing and observation necessary on the auditor's part.

Internal control changes markedly affect time requirements in auditing. Any fluctuations in the quality of internal control, for example, undermine the very cornerstone of the auditor's ability to audit on the basis of sampling some transactions for testing and examination while omitting others. Decreases in the apparent degree of internal control can cause an increase in the items sampled and effect the use of more complete and vigorous audit steps.

Personnel changes by the client could be qualitative and/or quantitative in nature. In either event, they effect a need for re-familiarization by the auditor, and may affect the quality of the accounting performance of the client, thus changing audit time requirements. A change in personnel can affect audit time as the auditor must evaluate a new employee's performance in some operations which had been considered safe, or relatively so, when an experienced employee was performing the task. If new personnel also entail a realignment of duties, time may also be consumed in contacting different people for data, assistance, etc.

Special studies for the client can be exceedingly time consuming; they may be unique or one-of-a-kind tasks. These can range from the feasibility of a new product, new plant, or new key accounting personnel to a registration statement for the Securities and Exchange Commission.

Client computerization of accounts and records may either increase or decrease audit time requirements. In the initial years

of installation, new audit techniques must be devised and internal control must be reviewed. The "footprints" available for establishing an audit "trail" have now vanished. In later years, audit time at computerized firms may possibly be reduced as the chance of error in processing of data is diminished.

Environmental changes can occur in the realm of increased governmental reporting standards, in changes in accepted accounting principles, and in the auditor's legal liability to the client. The area of Medicare statements from hospitals is a case in point illustrating how an increase in required information can expand audit time requirements. Similarly, a firm doing a larger volume of government contract work may find stricter reporting standards necessary than those required for its privately consumed output. Rapidly changing accounting principles call for a more frequent review of these principles as applied to events occurring on any given audit. A recent development is the increasing number of law suits involving public accounting firms which may necessitate more extensive audits in the future.

There can be an expansion of the auditor's duties from such causes as personnel shortages in the client firm. The auditor may have to prepare schedules which the client had previously prepared, such as accounts receivable, aging statements, etc. Personnel changes may even cause the auditor to provide continuing accounting services until key personnel are replaced. This stop-gap procedure, while very time consuming, may assure maintenance of a quality accounting performance until replacements are obtained.

Economic conditions not only affect the client firm but

specifically affect the auditor also. Special cost cutting studies may be called for in recessionary periods, merger analysis in prosperous periods, etc. Flexibility is necessary in designing an audit to fit the changing needs of the firm as it responds to changes in economic conditions. For example, a decline in the client's economic status and ability to pay for the audit may call for change in audit method. The auditor may seek more client aid in preparation of schedules, analyses, etc. and may also choose to use the "cycling" technique in which some audit areas are stressed in one year and ignored in the next year.

The relation of non-repetitive aspects in auditing to a control system

An adequate time control system should record the amount of time spent on non-repetitive aspects of the audit. Further, this time should be separated into classes for purposes of billing the client and for evaluating the performance of the public accounting firm. Two classes might be:

1. Audit firm related aspects
2. Client firm related aspects

Category (1) would include amount of time required due to inadequate pre-audit planning, inexperience of the audit staff, lack of knowledge of the industry being audited, etc. These aspects should elicit a thorough review of the entire training process, assignment of auditors, and pre-audit preparation by the public accounting firm. The review would question whether these particular non-repetitive aspects could be anticipated, thus minimizing their effect on audit time. This review is essential since audit time resulting from

presence of these aspects is often absorbed by the public accounting firm and is not charged to the client.

Category (2) would include audit time required due to such aspects as personnel changes, internal control problems, new product introduction, etc. which appear to result from the client's actions. These aspects are often the basis for an audit fee increase. Therefore, the careful evaluation of whether or not an item belongs in this category is mandatory for fee justification. Possibly there is a pattern to these aspects such as a hint of internal control problems in the prior audit. Recognition of such a pattern would thus allow the public accounting firm to make a more timely response to similar problems on future audits.

The need to measure the "mix" of repetitive and non-repetitive aspects present on the audit

Any control system for public accounting should measure the mix of repetitive versus non-repetitive aspects and the expected time reduction in view of the mix present. Since time reduction is associated with the presence of repetitive aspects and with a minimum of the time consuming non-repetitive aspects, there should be a close correlation of observed time reduction and the presence of a high degree of repetitive aspects. Obviously, if an audit is largely repetitive in nature, time reduction should be expected and, if it does not occur, the public accountant may look to his own internal management for the cause of this failure to control time.

CHAPTER V

INDIVIDUAL AND ORGANIZATIONAL FACTORS AFFECTING TIME REDUCTION IN AUDITING

The concept of factors underlying time reduction

Time reduction can be facilitated and controlled through an understanding of those factors-forces, skills, conditions, etc.--which promote time reduction. These factors are applied to work situations which contain varying degrees of repetitive and non-repetitive aspects. The factors are applied in varying degrees in order to control non-repetitive aspects and to exploit the potential of the repetitive aspects, thus promoting maximum time reduction.

Individual factors differentiated from organizational factors

From the results of past time reduction studies and from interviews with public accounting practitioners, two categories of factors conducive to time reduction seemed to emerge. One category was composed of factors which related to characteristics or qualities of the individual, such a knowledge, skill, and judgment. The second category was composed of factors which related to organizational techniques, such as scheduling improvements, advance planning, etc. For further discussion and analyses, the factors are referred to as individual factors and organizational factors.

Basic individual factors which seem relevant to time reduction in the public accounting audit function

The research and interviews resulted in a compilation of a list of five main individual factors conducive to time reduction and relevant to the auditing function in public accounting. These are:

1. Degree of metal effort required
2. Knowledge, skill, and judgment
3. Experience
4. Training
5. Attitude toward time reduction

The degree of mental effort required by the auditor is considerable and variable. He must be alert, intuitive, and able to learn from and to correlate his experiences on various audits. According to James L. Crawford, the Lockheed Aircraft Company officer: "- - -The jobs which require the most mental effort improve at the most rapid rate. The mental effort may be due either to complexity of the work or lack of experience of the operators."[66]

The individual factor of knowledge, skill, and judgment is required to a considerable degree in auditing. The knowledge required for effective audit performance ranges from an understanding of simple bookkeeping to a comprehension of the implications which a proposed merger may have for long run capital structure of the firm. Skill and judgment are required over a similarly wide range, extending from arithmetical skills to management advisory skills, and from judgment of the timing of a cash count to a decision on the type of data pertinent for an annual report.

Experience must be considered as a prominent factor underlying time reduction. The time reduction curve is based in part upon accumulation of experience as more units are produced. Experience brings

familiarity to a task and this in turn promotes time reduction. In public accounting, experience could be measured in a variety of contexts. The number of years which an auditor spent in public accounting would be one measure of experience. This measure would usually indicate that the auditor was experienced on all or most of the audit functions, such as cash, inventory, etc. This type of experience might assure a minimum time required to perform each function on a new audit, and thus a new audit might require only familiarization with a new industry, new personnel, and other organizational aspects. A second type of experience might be the experience of an auditor on an individual client's audit. In this type of experience, organizational aspects should normally present less of a problem in the later years of the audit and time reduction should be expected then.

The question of which type of experience best correlates with time reduction in the public accounting audit function is similar to the question of how time per unit is determined with industrial time reduction curves. Time is reduced by applying to the first unit time (called Y intercept, or B factor) a certain rate of time improvement (slope or -b exponent). Time on the first unit is a reflection of initial skill in production based on accumulated general experience with products similar to the new product being considered. This was the meaning of the Stanford studies in applying B or levels of experience factors to airframe producers to get an average first unit time. Beyond the first unit, speed of familiarization seems to be the remaining determinant of time improvement. It might be noted that the area of potential time reduction is limited for a firm which is initially very skillful. Perhaps the years spent in public accounting

and the intensity of experience in those years, e.g., progression through a series of increasingly difficult audits, may affect initial time required on a new audit. Beyond this point, familiarization with this particular audit may well be the principal cause of time reduction on subsequent years' audits. The experience of an auditor on an individual client's audit would promote this familiarization and should promote time reduction. Each type of experience seems relevant for reducing audit time. In determining the best measure of experience to use (or whether to use both measures) for correlation with time reduction, consideration must be given to the alternatives of rapid auditor rotation versus allowing substantial repetition of auditors on a given audit. Later in this study, an attempt will be made to measure hypothetically the cost of this trade-off between rotation and specific audit experience.

Training represents a further input into time reduction ability as it cuts across factors of mental ability, skill, knowledge, and even judgment. It can even substitute for lack of experience in some audit phases. Marvin L. Taylor sums up several related factors conducive to time reduction as: "...the man, training, skill, experience."[67] Training can serve to reduce time by clarifying proper audit steps, by demonstrating techniques for carrying out each step, by demonstrating ways to test internal control, etc. The auditor can thus be alerted to events which may occur in an audit (within limits) and thus be better prepared to face situations as they arise.

Finally, the auditor's attitude toward time reduction may in itself be a factor promoting or retarding time reduction. In industry, attitudes favorable to time reduction have long been encouraged by

incentive pay scales, profit sharing, and cost savings sharing plans. Perhaps the latter two plans and/or other techniques may be used in public accounting to foster an attitude favorable to time reduction. Several authors have stressed the importance of developing this desire to reduce time. Winfred B. Hirschman stated: "Furthermore, improvements are always possible over time so long as people are encouraged to seek them."[68] In the same vein, T. P. Wright noted: "...There is a need to believe that progress is possible for the learning curve to work."[69]

Basic organizational factors which seem relevant to time reduction in the public accounting audit function

From the results of past time reduction studies and from interviews with public accounting practitioners, a list of organizational factors conducive to time reduction and relevant to the auditing function in public accounting was compiled. The organizational factors selected for analysis in this study are:

1. Uninterrupted audit assignments
2. Presence of short tasks at well separated intervals
3. Scheduling improvement
4. Effective manpower use
5. Advance planning needs

When audits can proceed in an uninterrupted manner, some time reduction benefits occur. The audit group may work as a team, proceeding step by step to complete the audit. The steps are interrelated and the lack of completion of one step may slow progression on another step or even impede completion of the entire audit. The time reduction curve operates best when a task is continuous. If an industrial task is interrupted, refamiliarization is needed upon return to the original task. The fact that an audit is conducted yearly makes for

some discontinuity in the task. The most serious break in continuity, however, may occur when the audit is interrupted to shift some or all of the audit personnel to another audit. In industrial terms, this interruption of a task and return to the task produces the phenomenon of "scallops." Hirschman states that this behavior is represented by a sharp increase in time on a time reduction curve which had previously been sloping downward. He refers to this as a "toeing up" of the curve.[70] The occurrence of interrupted audit time may thus require analysis by the public accountant as to effects on audit time to determine whether the same "toeing up" effect may not exist. If it does exist, then means of prevention of audit interruption must be stressed.

Auditing is also typified by relatively short tasks conducted at well separated intervals. Frank Andress, in describing this situation as it exists in industry, feels that here learning is important and that great time savings are possible. He cites the need for advance planning and for methods analysis in such circumstances.[71] This is the kind of planning which must precede an audit and which facilitates time control. Regarding the length of the production run, and perhaps of the audit, an interesting observation was that of Vincent Shroad, Jr., who discussed the possibility of using the time reduction curve for "repeat business" to predict time requirements. He believes that a firm should show an unfavorable variance if the order size is less than some standard size order.[72] Marvin L. Taylor also felt that lot size and production rate affected time reduction.[73] Perhaps on some small audits, the combination of audit experience, ability, etc. may not be optimum for time reduction. The relation

of audit size in terms of potential time reduction is thus an organizational factor which may be worthy of examination.

Scheduling improvement can affect time reduction in that efficient scheduling can reduce interruptions and thus affect the continuity of audit assignments as discussed previously. It can also make the most effective use of manpower as described below. Schedules must be tailored to match the client's need for periodic examination and reports, and to match the public accounting firm's ability to provide proper audit personnel.

Effective use of manpower would include a range of considerations from proper training of staff, to assignment of the correct number of auditors, and finally to obtaining the proper mix of experience, knowledge, auditing ability, management ability, etc. among the assigned personnel. Time reduction may well correlate with any or all of these factors. For example, auditors with background in the industry being audited who possess the technical auditing skills needed for the audit problems anticipated, e.g., mergers, computerization studies, etc., should be assigned in proper number. The number of auditors assigned can, itself, present problems in that too many can lead to confusion and too few can lead to overwork of those few.

Finally, advance planning seems a fundamental organizational factor in that problems of improved scheduling, effective manpower use, dealing with short, intermittent tasks, and creating uninterrupted audit assignments all stem from proper advance planning. The public accounting firm management must thus be skillful in anticipating client needs and public accounting firm capacity to satisfy these needs.

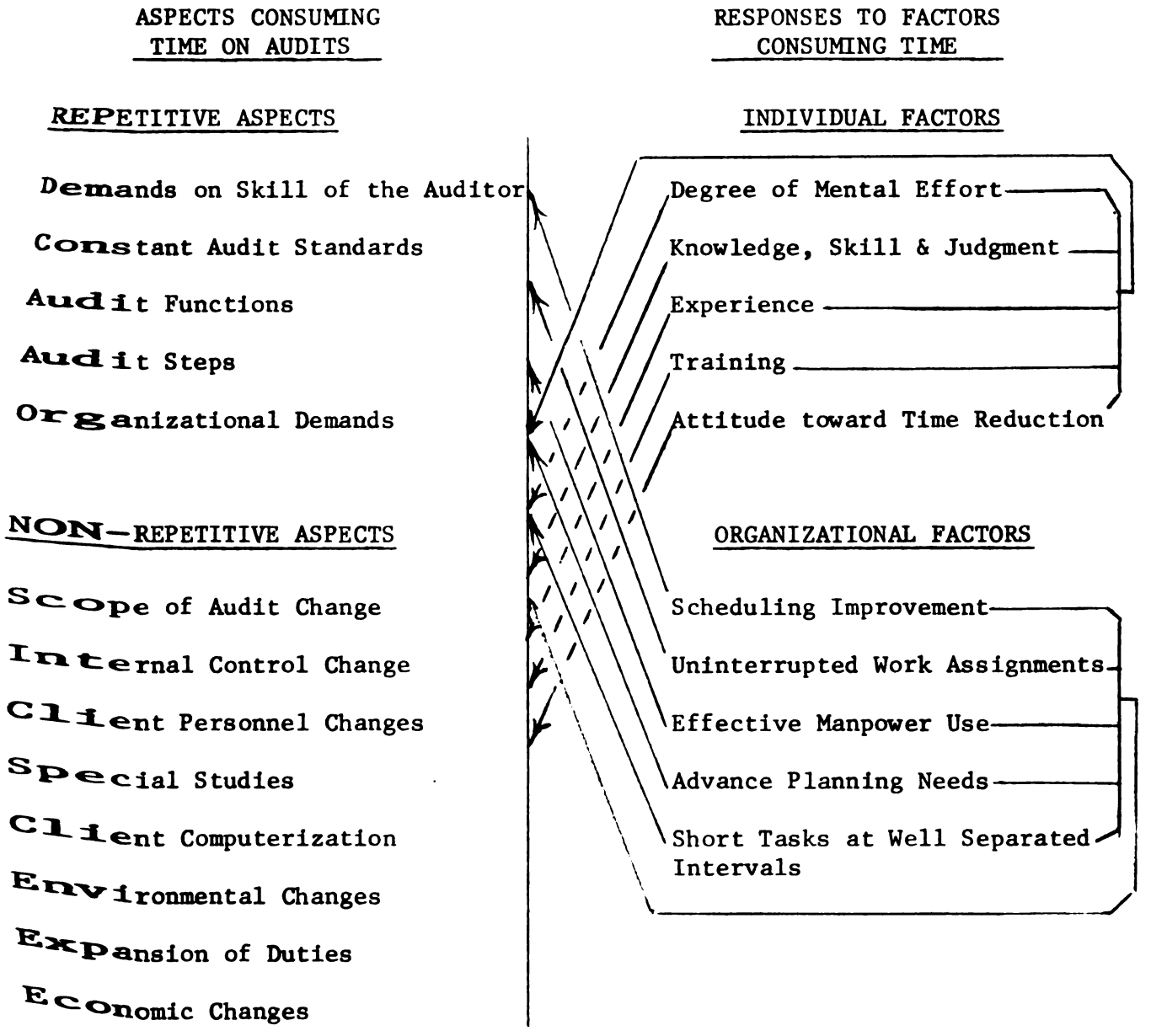
Management's role in control of the factors or skills underlying time reduction

Public accounting management can assure that maximum individual or organizational factors are applied to the audit at the proper time, in the proper amounts, and in correct proportions. In essence, management applies individual and organizational factors in the effort to control the effect (on time) of repetitive and non-repetitive aspects. A hypothetical example may help point out management's role in time control. Public accounting firm X holds a pre-audit conference with client Y, conducted just before the audit date, without examination of the previous year's working papers. The conference is perforce brief and cursory in nature. Thus, neither a prior year's weakness in internal control nor the fact that the firm is considering making a public offering of securities is disclosed. Much additional auditing work is therefore entailed, some of it of a non-repetitive nature. Staff which is experienced in preparing S.E.C. statements is not available when needed, or is transferred in from other in-process audits, thus interrupting the continuity of those audits. Much time might have been saved by proper advance planning, scheduling, avoiding of interrupted work runs, etc. The handling of organizational factors by the management of the public accounting firm seems at fault. Despite these errors, individual factors such as experience, training, and the basic skill of the accountant might have provided the flexibility needed to deal with this host of non-repetitive aspects. Auditors possessing such backgrounds are, however, valuable resources of the firm and their use must be judicious and warranted in terms of time reduction needs.

A graphical summary of the public accountant's suggested response to all aspects of the audit might appear as follows:

FIGURE 9

THE TIME REDUCTION EFFORT IN PUBLIC ACCOUNTING
RESPONSE TO ASPECTS CONSUMING AUDIT TIME



Control of time through isolation and application of time reduction factors

Determination of those specific factors which promote time reduction is not a particularly difficult task. Time reduction literature contains many references to these factors and interviews with management in particular enterprises will help to isolate those factors peculiar to a given enterprise. What is difficult, however, is the isolation of the effects which each factor has upon time reduction, i.e., how much time reduction each factor appears to effect. If this time reduction potential could be determined, then management would achieve maximum time reduction by causing the proper factors to be applied to a task at the right time, in the right proportion, etc. Deviations from planned time reduction would be explained by a departure from the proper "mix" of these factors.

The problem of isolating time reduction factors is one of statistical correlation. Ideally, each task could be measured for the degree of presence of these factors at one time and the time required for task completion noted. The same observations could be made on a subsequent produced unit (or completed audit). Finally, a composite graph, formula, etc. could be prepared showing the degree of presence of the factors and the degree of time reduction observed. The next step would be to try to isolate each factor's effect on time reduction by partial regression or correlation analysis. This would present no great problem if all other conditions of the task remained constant. A problem in some enterprises is that these conditions may not stay constant. Auditing is a case in point and certain conditions of the task, repetitive and non-repetitive aspects, are not always

constant. Thus, measurement is needed not only of the factors present on a task, but of the variability of the task itself.

The Kilbridge study[74] and the one by Frank Powers[75] on short run industrial operations were the only two studies observed which attempted to measure the contribution of various factors to time reduction. In his study of clerical operations in a mail order house, Kilbridge, in consultation with supervisory staff, arrived at these five factors affecting time reduction: "...skill and dexterity; knowledge of methods, procedure, media, or materials; analysis and judgment; use of office machines; cycle time." Point values were assigned to each factor present on each job and a list of point values per job was prepared. The relation of points to learning time was estimated and an equation was prepared. From the equation and a conversion chart a standard or expected time reduction curve was prepared for each job. As jobs were completed, the actual time performance curves and estimated time performance curves were nearly identical. Thus, the importance of each factor present on a job in reducing time on the job had been proven. This is a procedure which may be applicable to public accounting in isolating the factors and measuring their effect on time reduction.

A philosophy of management in public accounting

Management in any sphere represents a mixture of two types of skills: management-technical skill and human relations skills. In public accounting, the management-technical skills include technical work and management techniques (budgeting, scheduling, pay systems, etc.) in supervising that work. Human relations skills are, as the

name implies, skills used in dealing with people. These skills would include understanding, motivation, communication skills, etc. Efforts to control the individual and organizational factors must be made through the use of these two skills. Relying solely on a-priori reasoning, the factors might be grouped as follows:

FIGURE 10

CONTROL OF FACTORS BY MANAGEMENT

Individual and Organizational Factors	Factor May be Controllable By: Management-Technical Skills	Human Relations Skills
Individual		
Knowledge, skill, judgment	X	
Degree of Mental Effort		X
Experience	X	
Training	X	
Attitude toward time reduc.	X	X
Organizational		
Continuous production vs interrupted runs	X	
Short tasks at well separated intervals	X	
Scheduling improvements	XX	
Effective use of manpower	XX	X
Advance planning need	X	

X = Partially controllable by management
XX = Generally controllable by management

The underlying rationale for the foregoing chart is based on several assumptions: 1. That individual factors are only slightly controllable by public accounting management. 2. That the auditor is a professional person, not generally motivated by charismatic management. 3. That the auditor is a person who responds to challenges to his ability. 4. That the auditor respects and responds to management which

is as professional in nature as is the auditor in performing his duties. 5. That some organizational factors as "continuous production" and "short tasks" are factors of only slight control by public accountants, and must be compensated for by optimum application of other factors.

Thus, if the foregoing chart may be accepted, it suggests that management, by practicing proper techniques, can do much to effect improvements in factors which underlie time reduction. This improvement can come from applying management techniques more often than through applying leadership or charismatic skills.

CHAPTER VI

AN EMPIRICAL STUDY OF TIME REDUCTION IN THE AUDIT FUNCTION IN PUBLIC ACCOUNTING FIRMS

The purpose of the empirical study

In order to accomplish the purpose of the thesis, which is to demonstrate the usefulness of time reduction curves to public accounting in controlling audit time requirements, an empirical study was conducted to determine whether there were any patterns of time reduction. If there was much repetition involved in some audits, it might be assumed that a time reduction curve should exist. The more the individual and organizational factors were brought to bear on successive audits, the more time reduction might be observed. Although the study focuses on the behavior of time reduction with the presence of factors bearing on time reduction, there has been so little research in this area that other phases of time reduction also had to be considered. Accordingly, time reduction was analyzed in four additional contexts: by type of client firm industry (retailing, manufacturing, etc.), by type of public accounting firm (national, regional, and local) by individual C.P.A. firm, and by detailed audit function. The most beneficial result which could emerge from this study would be the discovery of a pattern of time reduction relationships for types of C.P.A. firms, for types of client industries, for individual firms, and for the detailed audit functions. From such relationships

much can be learned about conditions conducive to time reduction. Equally beneficial would be the discovery of a strong, positive correlation of observed time reduction with each of the eight factors examined which are:

1. Years of experience of auditors
2. Years of experience of the C.P.A. firm in auditing the particular client firm
3. Years of experience of the C.P.A. firm in auditing firms in the same industry as the firm being examined
4. Hours of time spent on the audit by men who had worked the audit in prior years within the period of this study
5. The degree of audit stability as to level of difficulty, change of scope, etc.
6. The number of men assigned to the audit each year within the period of this study
7. The size of the C.P.A. firm in number of employees
8. The presence or absence of a formal training program within the C.P.A. firm

Such a result would encourage public accounting firms, when possible, to plan, schedule, and staff audits so that the eight factors would be present or considered in pre-audit planning. The minimum result would be increased knowledge of the time reduction process in public accounting and of the problems present in attempting to reduce time.

The feasibility of the study

To determine the feasibility of the study and to avoid repetition of any earlier studies by practitioners, a number of Certified Public Accounting firms including the "big eight" were canvassed. These firms responded unanimously that such a study had never been undertaken to their knowledge. In response to the question of feasibility, the "big eight" firms were generally not too encouraging about the outcome of such a study as the detailed list of their comments and those received from other public accounting firms in Appendices A and

B indicates. Their most common and significant reservations on the feasibility of the study stemmed from two main causes: client firm variability and public accounting firm staff and assignment variability.

The public accounting firm officials consulted felt that there was client firm variability caused by change in audit scope from year to year. They mentioned that public accounting firm staff variability occurred due to their desire to allow the individual auditors to progress professionally through rapid rotation on client engagements. According to the officials interviewed, the individual auditor apparently has this same desire for rapid rotation. Obviously, unstable audits performed by varying personnel each year may present so many variables that correlation analysis of factor effect on time reduction may be greatly complicated.

All the authoritative and experiential objections to the study are strong and valid objections. They may be shortsighted ones, however, for three incontrovertible reasons. First, it is certainly obvious that there is a need to measure the cost in added audit time which arises from the client firm variability. As far as possible, time needs to be reduced by proper planning so that maximum audit engagements can be accomplished at minimum time consistent with quality auditing. (Occasionally, a 100% error in estimated and actual audit time was encountered on single audit engagements.) Time reduction curves may show the cost of variability from added time above last year's time or from failure to reduce time below that of last year as the time reduction curve theory implies in repeat operations.

Second, the costs and benefits associated with rapid rotation

of personnel through various audits does not appear to have been measured in dollar terms. It is an assumption that the nature of the man and the public accounting firm demands this rotation, but public accountants cannot assume a proposition not expressed in money terms when they themselves often criticize such unsupported reasoning by their clients. When the auditor examines propositions of client plant expansion, merger feasibility, make or buy choice, etc., he operates largely on a pragmatic basis, comparing incremental costs and revenues. Until such analysis is attempted, no recommendation should be made by the public accounting firm concerning these propositions. Time reduction curves, if prepared, may help reveal the costs, if any, of staff turnover on audits.

Third, in contacting some public accounting firms, the writer perceived a natural resistance of professionals to the idea that a professional's time could be "time studied;" there was a feeling that everything about the work was so non-routine that any attempt to analyze time was a futile effort. This may be true, but until an examination is made to determine the existence of repetitive aspects, or of any other pattern of time reduction, it would seem rather premature to pass judgment. Several firms, however, were more optimistic in that they felt that time reduction on audits did exist, although they held reservations as to the exact predictability of time reduction from year to year. Those firms which agreed to cooperate in the study felt that any additional knowledge of audit time control which could be gained would justify the time and effort expended, thereby justifying the minimum objective of this study.

The scope and method of the empirical study

Fourteen Certified Public Accounting firms, three national, one regional, and nine local, with locations in three cities of varying size, cooperated in the study. They made available the audit data, covering a two to three year period, for one hundred and two client firms, including large and small firms from eight different industries.

The empirical study was composed of five main phases:

1. Time reduction as related to type of client firm industry (retailing, manufacturing, etc.).
2. Time reduction as related to type of C.P.A. firm (national, regional, and local).
3. Time reduction as related to specific C.P.A. firms.
4. Time reduction as associated with detailed audit functions (reported on a limited scale).
5. Time reduction as correlated with eight factors related to time reduction.

The first phase of the study concerned the examination of audit data of eight separate client firm industries in an effort to determine whether there was any pattern of time improvement. This evaluation focuses attention on industries which are most and least susceptible to audit time reduction. This knowledge could lead to a further inquiry into the presence of non-repetitive aspects in some industries, loss of time through familiarization with complex industries, etc.

The second phase considered time reduction by type of C.P.A. firm: national, regional, and local. Audit time reduction differences may reflect on the type of organization of the firms, on their varying rotation policies, and on other characteristics of the type of C.P.A. firm.

The third phase concerned time reduction by individual C.P.A. firms, and preparation of time reduction curves for each public accounting firm as well as a curve for the total time of all audits observed. It was felt that this information would be of interest to the participating firms.

The fourth phase consisted of an examination of the detailed audit functions. Cash, accounts receivable, and most of the normal audit functions were examined on a limited basis to determine time reduction behavior by function. This data could prove useful to firms in budgeting time for an audit. If some functions show a consistent decline in time required, this may eventually become the basis for time reduction standards. This study may point out those areas which, by their variability, seem to contain non-repetitive aspects. This knowledge may help in pre-audit conferences, in scheduling, and in manpower assignment to audits. Thus, if inventory observation required more time than the prior year because of a shortage of client personnel trained in taking inventory, training could be initiated by the client that would reduce time on this function, and the public accounting firm would not need to assign additional personnel for inventory.

The fifth phase included an examination of those individual and organizational factors noted in Chapter V which appeared to be correlative with time reduction. Unfortunately, some of the factors could not be used by the researcher because he was a person outside of the public accounting firm. Therefore, out of five individual factors promoting time reduction (mental effort; knowledge, skill, and judgment; experience; training; and attitude toward time

reduction), only two (experience and training) could be studied on the basis of set criteria. These set criteria were data availability and measurability in an objective manner.

Experience was evaluated in four different contexts: individual's experience in public accounting; individual's experience on a given audit; the public accounting firm's experience in auditing the firm; and the public accounting firm's experience in auditing the type of industry. Training was also selected for examination and was evaluated solely on the basis of the presence or absence of a formal company training program. The remaining unexamined factors (mental effort; knowledge, skill, and judgment; and attitude toward time reduction) were not examined as these are especially difficult for an outsider to measure. These factors can and should be examined by public accounting managers to ascertain whether these three powerful forces are being developed in and evaluated in audit personnel.

Partial correlation and regression analysis was applied to determine the degree of time reduction associated with each of the four different types of experience. The same procedure was followed for training and time reduction.

Of the five organizational factors lised in Chapter V (continuous production vs interrupted work assignments; short tasks at well separated intervals; the need for advance planning; scheduling improvement; and effective use of manpower), two factors (advance planning and effective use of manpower) were selected for examination. These were selected on the same basis used in the selection of individual factors, i.e., data availability and objective measurability. One measure of the need for advance planning was the degree of change in

scope and/or in problems encountered in the audit. Two measures of effective use of manpower were examined and these were the number of employees of the public accounting firm and the number of men assigned to the audit. It was felt that the size of staff may reflect on the number of levels through which an audit must proceed for checking before final completion and thus reflect on time requirements.

Advance planning could at least partially reduce the changes in scope of an audit. It is true that all changes in scope may not be anticipated (and thus minimized in their effect on audit time) but possibly some may be anticipated. Measuring the number of employees in the public accounting firm was felt meaningful since it may reflect the amount of experience which may be drawn upon in unusual situations, and the number of management levels (assuming the larger the firm, the more levels) which must be involved with the audit. It was an attempt to measure the productivity of small vs large firms. The number of men assigned to the audit was construed as a measure similar to that of direct labor in a manufacturing situation. Through the selection of the two measures of number of men of men in the firm and number assigned to the audit, a rough measure of the relation of direct labor and indirect labor could be obtained. The remaining two organizational factors (continuous production vs interrupted work assignments and short tasks at well separated intervals) were not examined due to lack of available data. Scheduling improvement was not examined as a separate factor but it may be included under the results of effective use of manpower analysis.

The factors and their specific aspects which were examined in the study are:

Individual Factors	Specific Aspect of the Factor Which Is Examined
Experience	1. Auditor's years of experience in public accounting
	2. Auditor's years of experience on this audit in study period
	3. Firm's years of experience on this audit
	4. Firm's years of experience on client's industry
Training	5. Presence or absence of formal company training program
Organizational Factors	
Advance planning	6. Audit stability
Effective use of manpower	7. Number of employees in the public accounting firm
	8. Number of auditors assigned to the audit

The attempt at correlation analysis by factor was a very productive area of the study and the other four phases were applied mainly to supplement the factor examination and to learn more of general influences on audit time.

Limitations of the empirical study

The limitations, which forced a contraction in the scope of some phases of this study, were summarized in Chapter I as:

1. The availability of data in proper form for in depth analysis
    a. As to detailed audit function time requirements
    b. As to large number of consecutive years of audits of same client firm
    c. As to audits on a first, second, and third year basis where the first year represented a new audit
2. The lack of suitable objective measures of certain factors which may well correlate with time reduction, such as:
    a. Turnover of client personnel
    b. Degree of pre-audit preparation by client personnel
    c. Adequacy of pre-audit conference with client
    d. Ability of client firm personnel
    e. Condition of records of client firm
    f. In some cases, underlying causes of change in audit scope

g. Presence of uninterrupted audit time during client's audit
h. Other factors not lending themselves to objective measurement by an outsider

Most of these limitations would not exist if a study were performed by public accounting firm officials who, by their access to detailed and current data, would have an advantage over an outsider making such a study. The limitations centered around the lack of availability of data for in depth analysis and lack of suitable objective measures of certain factors which may correlate with time reduction.

Data availability presented a problem in that some data from the third year of a sequence of audits was still in process at the time of this investigation. To pursue earlier years' audits and thus have a three year sequence caused problems associated with non-current data, such as recalling the experience in public accounting of departed firm members, the scope change from year to year, etc. Also, non-current data caused difficulties in itemizing information on continuous production vs interrupted work runs. In addition, a shortage of first year audits of new clients prevented a deep examination of the rapid time reduction which might be expected in years two and three, due to overcoming some organizational factors (advance planning in particular) associated with new audits. Either a more extensive sample size or a public accounting firm member concentrating on a study of audits over several years may locate more new audits.

Lack of suitable objective measures presented a problem in that it is difficult to place an objective value on degree of mental effort, on knowledge, skill, and judgment, and on the auditor's

attitude toward time reduction.

Therefore, individual and organizational factors underlying time reduction which could not be examined were: degree of mental effort; knowledge, skill, and judgment; continuous production vs interrupted work assignments; short tasks at well separated intervals; and attitude of the auditor toward time reduction. These all seemed worthy of examination, but either lack of data or of an objective measuring device nullified evaluation of these factors. Most of these could possibly be evaluated by members of the public accounting firm.

For identical reasons, other elements, advanced by practitioners as important in promoting audit time reduction, could not be examined. These factors were: turnover of client personnel; degree of pre-audit preparation by client personnel; adequacy of pre-audit preparation by client personnel; ability of client firm personnel; condition of records of client firm; and, in some cases, underlying causes of change in audit scope. It is felt that all of these factors would lend themselves quite well to evaluation by a member of the public accounting firm.

A further limitation of the study lay in detailed audit function examination. Often records were not maintained in sufficient detail to observe time required per audit function, such as cash, accounts receivable, etc. Often, only audit time per man per day was recorded and not the time spent on each function. Thus, sample size had to be severely restricted in this area. This limitation cannot be overcome until all firms maintain detailed records of time spent on individual audit functions.

The final limitation which is related to all the other

limitations is the confidential nature of public accounting records. This slowed the study somewhat and consumed an inordinate amount of the public accountant's time. The names of client firms were not and could not be revealed, thus placing some of the data gathering duties upon the public accountant. Furthermore, a potentially productive area of research, that of time worked and not billed to the client, could not be examined. Again, as with so many of the limitations cited above, these problems could be overcome by a public accounting firm member assigned the task of time reduction research. Eventually then, a practical time control system could emerge as developed by the Certified Public Accounting firms.

CHAPTER VII

RESULTS OF THE STUDY OF TIME REDUCTION IN PUBLIC ACCOUNTING FIRMS

An empirical analysis of time reduction by public accounting firms

An empirical analysis of time reduction was made in order to explore the nature of time reduction by Certified Public Accounting firms, and to attempt to determine whether any patterns or correlations of time reduction useful in controlling audit time existed. One hundred and two audits, conducted by fourteen public accounting firms over a two or three year period for eight client industry groups, were reviewed. One audit, considered to be non-typical because of unusual client growth, was excluded from the study, making a total of one hundred and one audits examined in the non-statistical section of the study. Twelve audits from the one regional firm were excluded from the statistical portion due to incomplete data. Thus, eighty-nine audits were evaluated statistically for a two-year audit sequence and, of these, sixty-five were also examined over a three-year sequence. The empirical study was composed of five phases:

1. Data accumulation and time reduction analysis by type of client industry (retailing, manufacturing, etc.)
2. Data accumulation and time reduction curve preparation for national, regional, and local C.P.A. firms.
3. Analysis of time reduction by individual C.P.A. firm.
4. Analysis of time reduction by detailed audit function (cash, accounts receivable, etc.)

5. Regression and correlation analysis for eight time reduction related factors present on audits.

The data accumulation for the first four phases of time reduction (by client industry, by type of C.P.A. firm, by individual firm, and by detailed audit function) is supplemental to the statistical analysis in the latter part of this chapter. These phases represent an attempt to probe the nature of time reduction in a non-statistical sense, seeking apparent associations of time reduction with type of client industry, type of C.P.A. firm, individual firm, and detailed audit functions. Thus, it is a preliminary investigation which culminates in an examination of specific factors relating to time reduction. So little research has been done in the area of time reduction in non-industrial situations that it was felt that both a broad and a specific statistical approach were needed.

Analysis of time reduction by type of client industry

Time reduction was analyzed in relation to the type of client industry: retail firms; miscellaneous firms; non-profit associations; schools and colleges; cities, villages, and townships; churches, hospitals, and country clubs; manufacturers; and banks and savings and loan associations. Table 6 on the following page portrays time reduction by industry and indicates total overall time reduction on all audits observed. For year two, time reduction was slightly in excess of 2.7% and for year three, the reduction was 4.6%. This calculation indicates that, on the average, the audits performed in the second year required 2.7% less time than in the first year and 4.6% less time in the third year than in the second year.

It appears that the rate of time reduction is accelerating,

TABLE 6

SUMMARY OF TIME REDUCTION BY MAJOR TYPE OF INDUSTRY OF CLIENT FIRMS

Type of Client Firm	No. of Firms	Hours of Audit Time Year 1	Year 2	Year 3	Hours Reduced (Increased) Year 2		Year 3	% of Time Reduction (Increase) Year 2		Year 3
					3 Yr. Audits	2 Yr. Audits		3 Yr. Audits	2 Yr. Audits	
Retailing	(25)									
3 Year Audits		5577	5778	5257	(201)		521	3.6		9.0
2 Year Audits		1193	1167	--		26			2.2	
Miscellaneous Firms	(13)									
3 Year Audits		1301	1065	1149	236		(84)	18.1		7.9
2 Year Audits		550	411			139			25.3	
Non-Profit Assns.	(10)									
3 Year Audits		275	251	328	24		(77)	8.7		(30.7)
2 Year Audits		760	757			3			.04	
Schools & Colleges	(11)									
3 Year Audits		2564	2238	2371	326		(133)	12.7		(5.9)
2 Year Audits		904	881			23			2.5	
Cities, Villages, Townships	(7)									
3 Year Audits		1752	1670	1315	82		355	4.9		21.3
2 Year Audits		204	202			2			1.0	
Church, Hospitals, Country Club	(7)									
3 Year Audits		918	812	888	106		(76)	11.5		(9.3)
2 Year Audits		1044	1591			(547)			(52.4)	

TABLE 6--Continued

Type of Client Firm	No. of Firms	Hours of Audit Time Year 1	Year 2	Year 3	Hours Reduced (Increase) Year 2		Year 3	% of Time Reduction (Increase) Year 2		Year 3
					3 Yr. Audits	2 Yr. Audits		3 Yr. Audits	2 Yr. Audits	
Manufacturing	(26)									
3 Year Audits		6890	6968	6517	78		451	(1.1)		6.5
2 Year Audits		1409	1222			187			13.3	
Unusual Audit		1715	2096	2414	(381)		(318)	22.2		(15.2)
Banks, Savings & Loan Ass'ns.	(3)									
3 Year Audits		1171	1109	1154	62		(45)	5.3		(4.1)
2 Year Audits		439	262			177			40.3	
TOTALS	(102)	28666	28480	21393	176		594 Memo Only*			
-Excl. Unusual Audit		-1715	-2096	-2414	381		318			
ADJUSTED TOTALS		26951	26384	18979						
3 Year Audit Totals		20448	19891	18979	557		912	2.7		4.6
2 Year Audit Totals		6503	6493			10			.01	
		26951	26384	18979	557	10	912			

*Will not cross foot due to non-comparable data. See 3 year and 2 year audit calculations.

a finding which is not consistent with time reduction theory which states that most of the time reduction comes at the start of a process with the rate of time reduction declining in latter stages. The reason for this accelerated reduction must lie in changes in the combination of those factors underlying time reduction which are present on the second and third years' audits. Excluded from the calculations in Table 6 was an unusual audit which was considered by the public accountant to be non-typical since the client firm had an unusual growth experience. With this audit included, second year time reduction percentage would be 0.6% (176/28666) and the third year reduction would be 3.0% (594 or 912 reduction - 318 unusual audit increase divided by 19,891.)

Table 6 summarizes time reduction by client industry. Separate calculations are included for two year audits and for three year audits since time reduction is calculated on different bases for each sequence, as the example indicates:

Retailing:

$$\frac{\text{Time Reduced (Increased) in Year 2 of a 3 Year Audit Sequence}}{\text{Year 1 Hours on a 3 Year Audit Sequence}} = \frac{(201)\text{ Hours}}{5577\text{ Hours}} = (3.6\%)$$

$$\frac{\text{Time Reduced (Increased) in Year 2 of a 2 Year Audit Sequence}}{\text{Year 1 Hours on a 2 Year Audit Sequence}} = \frac{26\text{ Hours}}{1193\text{ Hours}} = 2.2\%$$

$$\frac{\text{Time Reduced (Increased) in Year 3 of a 3 Year Audit Sequence}}{\text{Year 2 Hours on a 3 Year Audit Sequence}} = \frac{521\text{ Hours}}{5778\text{ Hours}} = 9.0\%$$

Ranking the industries in order of greatest overall time reduction for years two and three combined produces the following result:

Type of Industry	Time Reduction Percentages (Incr)		
	Year 1	Year 2	Total
Miscellaneous Firms	43.4	7.9%	51.3%
Banks and Savings & Loan Assns.	45.8%	(4.1%)	41.7%
Cities, Villages, and Townships	5.9%	21.3%	27.2%
Manufacturing	12.2%	6.5%	18.7%
Schools and Colleges	15.2%	(5.9%)	9.3%
Retailing	(1.4%)	9.0%	7.6%
Non-Profit Associations	8.7%	(30.7%)	(22.0%)
Churches, Hospitals, & Country Clubs	(40.9%)	(9.3%)	(50.2%)

The greatest amount of time reduction was experienced by the group of miscellaneous firms which was composed of: iron and metal companies, public utilities, labor unions, printing companies, real estate firms, forging shops, etc. The variations in time reduction by client industry may well reflect differences in audit stability in each industry. The concept of stability relates to change in the audit scope or content from year to year. The causes of content change have been discussed in Chapters I and IV and in Appendix B, and nearly all public accounting firms interviewed cited the great effects on audit time which were caused by content changes. As an aid in measuring the degree of audit stability, the firms were requested to rate each audit's stability compared to the prior year on the basis of the following scale:

(1) Substantially fewer problems and/or reduced amount of work
(2) Mild reduction in problems and/or required amount of work
(3) Substantially the same as in prior years
(4) Mild increase in problems and/or required amount of work
(5) Substantially increased problems and/or increased amount of work

Since each audit is thus rated according to its stability, it is possible to determine stability for an industry by grouping the stability ratings of the firms within that industry. Industry stability can then be compared with observed time reduction by industry to determine whether any correlation exists. The stability ratings for the audits in the miscellaneous firm group include: eleven audits with a 3 rating, one audit with a 5 rating, and one audit with a 1 rating.

The second ranked banks and savings and loan associations included three audits all rated 3 while the cities, villages, and townships category contained five audits rated 3 and two audits rated 4. Twenty-six manufacturing audits containing eighteen stable ratings, two better than stable, and six less than stable, placed fourth in the time reduction percentage attained. Thus, a strong association between time reduction and the stability of an industry's audits appears to exist even with the small sample size of this study and with the unequal representation of firms from each industry.

Churches, hospitals, and country clubs achieved the lowest percentage of time reduction, actually an increase in time of 50.2%, with seven audits rated 3 and four audits rated less than stable. It would seem logical to assume these to be relatively stable audits in content and thus conducive to time reduction, since it would not be expected that this group would normally have mergers, new products, or other major causes of changes in audit scope. However, either of two forces may be operating to prevent time reduction: the quality of accounting staff in these client firms or the pressure of change in demands for accounting data. With hospitals, the latter cause appears feasible as revealed in discussions with C.P.A. practitioners. Increased

Medicare reporting requirements have increased audit time requirements. As to the effect and feasibility of the former cause, this is based on a priori reasoning, but with a period of accelerating demand for accountants, perhaps qualified accountants were difficult for these firms to obtain or to retain. A correlation of variables other than stability with time reduction is demonstrated in the factor analysis section of this chapter.

TABLE 7

SUMMARY OF TIME REDUCTION BY NATIONAL, REGIONAL, AND LOCAL CERTIFIED PUBLIC ACCOUNTING FIRMS

Type of Client Firm	No.	National Firms							
		Hours of Audit Time			Hours Reduced (Incr)			% of Time Reduction (Incr)	
					Year 2		Year 3	Year 2	Year 3
		Year 1	Year 2	Year 3	2 Yr. Audits	3 Yr. Audits		2 Yr. Audits	3 Yr. Audits	
Retailing	(2)									
3 Year Audits		1831	1565	1441		266	124		14.5	7.9
2 Year Audits										
Miscellaneous Firms	(7)									
3 Year Audits		542	465	462		77	3		14.2	.06
2 Year Audits		360	247		113			31.4		
Non-Profit Associations										
3 Year Audits										
2 Year Audits										
Schools & Colleges	(2)									
3 Year Audits		1370	1195	1387		175	(192)		12.8	(16.1)
2 Year Audits										
Cities, Villages, Townships										
3 Year Audits										
2 Year Audits										
Church, Hospitals, Country Club	(1)									
3 Year Audits		500	386	439		114	(53)		22.8	(13.7)
2 Year Audits										

TABLE 7--Continued

Type of Client Firm	No.	National Firms: Hours of Audit Time Year 1	Year 2	Year 3	Hours Reduced (Incr) Year 2: 2 Yr. Audits	Year 2: 3 Yr. Audits	Year 3	% of Time Reduction (Incr) Year 2: 2 Yr. Audits	Year 2: 3 Yr. Audits	Year 3
Manufacturing	(15)									
3 Year Audits		6421	6822	6787		(401)	35		(6.2)	(.5)
2 Year Audits		675	538		137			20.3		
Banks, Savings & Loan Assns.	(2)									
3 Year Audits		614	616	569		(2)	47		(.03)	7.6
2 Year Audits		439	262		177			40.3		
TOTALS	(29)	12752	12096	11085	427	229				
						656 Combined				
Total 3 Year Audits		11278	11049	11085		229	(36)		.02	(.003)
Total 2 Year Audits		1474	1047		427			29.0		
-Unusual 3 Year Audit		-1715	-2096	-2414		381	318			
Adj. Total 3 Year Audits		9563	8953	8671		610	282		6.4	3.1

TABLE 7--Continued

Type of Client Firm	No.	Regional Firm								
		Hours of Audit Time			Hours Reduced (Incr)			% of Time Reduction (Incr)		
					Year 2		Year 3	Year 2		Year 3
		Year 1	Year 2	Year 3	2 Yr. Audits	3 Yr. Audits		2 Yr. Audits	3 Yr. Audits	
Retailing	(3)									
3 Year Audits		177	101	151		76	(50)		42.9	(50.0)
2 Year Audits		82	61		21			25.6		
Miscellaneous Firms	(1)									
3 Year Audits		160	140	173		20	(33)		12.5	(23.6)
2 Year Audits										
Non-Profit Associations										
3 Year Audits										
2 Year Audits										
Schools & Colleges	(2)									
3 Year Audits										
2 Year Audits		707	710		(3)			(.04)		
Cities, Villages, Townships	(2)									
3 Year Audits		777	761	474		16	287		2.0	37.7
2 Year Audits										
Church, Hospitals, Country Club	(4)									
3 Year Audits		81	133	185		(52)	(52)		(64.1)	(39.1)
2 Year Audits		1044	1591		(547)			(52.4)		

TABLE 7--Continued

Type of Client Firm	No.	Regional Firm: Hours of Audit Time Year 1	Year 2	Year 3	Hours Reduced (Incr) Year 2: 2 Yr. Audits	Year 2: 3 Yr. Audits	Year 3	% of Time Reduction (Incr) Year 2: 2 Yr. Audits	Year 2: 3 Yr. Audits	Year 3
Manufacturing										
3 Year Audits										
2 Year Audits										
Banks, Savings & Loan Assns.										
3 Year Audits										
2 Year Audits										
TOTALS	(12)	3028	3497	983	(529)	60				
						(469) Combined				
Total 3 Year Audits		1195	1135	983		60	152		5.0	13.4
Total 2 Year Audits		1833	2362		(529)			28.8		

TABLE 7--Continued

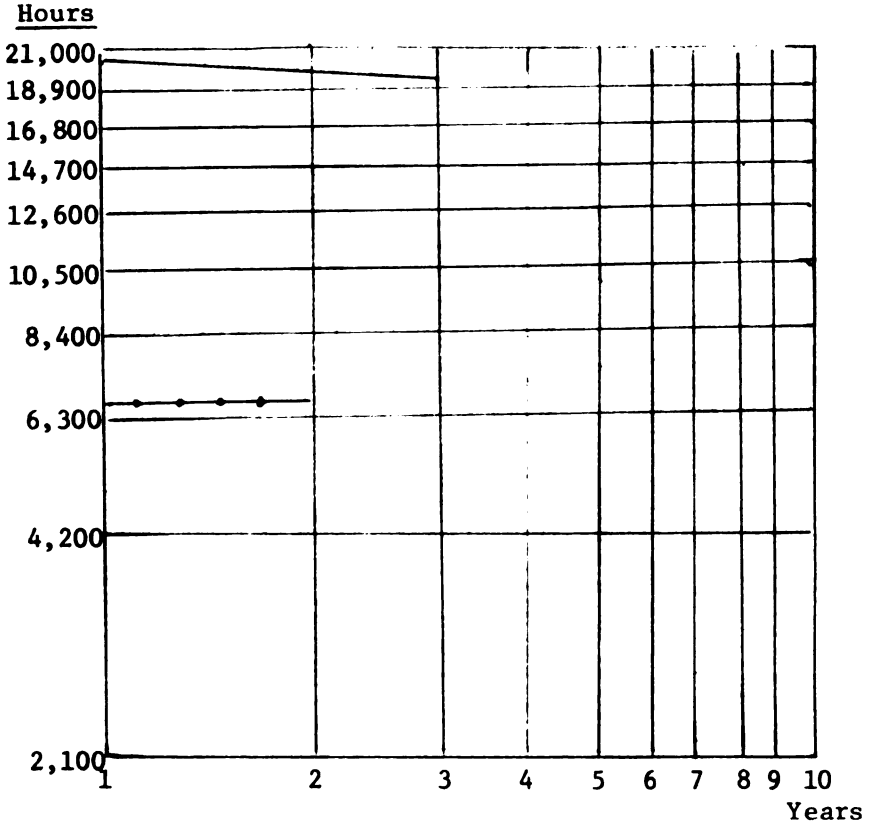
Type of Client Firm	No.	Local Firms								
		Hours of Audit Time			Hours Reduced (Incr)			% of Time Reduction (Incr)		
		Year 1	Year 2	Year 3	Year 2		Year 3	Year 2		Year 3
					2 Yr. Audits	3 Yr. Audits		2 Yr. Audits	3 Yr. Audits	
Retailing	(20)									
3 Year Audits		3569	4112	3665		(543)	447		(15.2)	10.9
2 Year Audits		1111	1106		5			.04		
Miscellaneous Firms	(5)									
3 Year Audits		599	460	514		139	(54)		23.2	(11.7)
2 Year Audits		190	164		26			13.7		
Non-Profit Associations	(10)									
3 Year Audits		275	251	328		24	(77)		8.7	(30.7)
2 Year Audits		760	757		3			.04		
Schools & Colleges	(7)									
3 Year Audits		1194	1043	984		151	59		12.7	5.7
2 Year Audits		197	171		26			13.2		
Cities, Villages, Townships	(5)									
3 Year Audits		971	909	841		62	68		6.4	7.5
2 Year Audits		208	202		6			2.9		
Church, Hospitals, Country Club	(2)									
3 Year Audits		337	293	264		44	29		13.0	9.9
2 Year Audits										

TABLE 7--Continued

Type of Client Firm	No.	Local Firms: Hours of Audit Time Year 1	Year 2	Year 3	Hours Reduced (Incr) Year 2: 2 Yr. Audits	Year 2: 3 Yr. Audits	Year 3	% of Time Reduction (Incr) Year 2: 2 Yr. Audits	Year 2: 3 Yr. Audits	Year 3
Manufacturing	(11)									
3 Year Audits		2184	2242	2144		(58)	98		(2.6)	4.4
2 Year Audits		734	684		50			6.8		
Banks, Savings & Loan Assns.	(1)									
3 Year Audits		557	493	585		64	(92)		11.5	18.7
2 Year Audits										
TOTALS	(61)	12886	12887	9325	116	(117)				
					Combined(1)					
Total 3 Year Audits		9686	9803	9325		(117)	478		(1.2)	4.9
Total 2 Year Audits		3200	3084		116			3.6		

FIGURE 11

TIME REDUCTION - ALL AUDITS

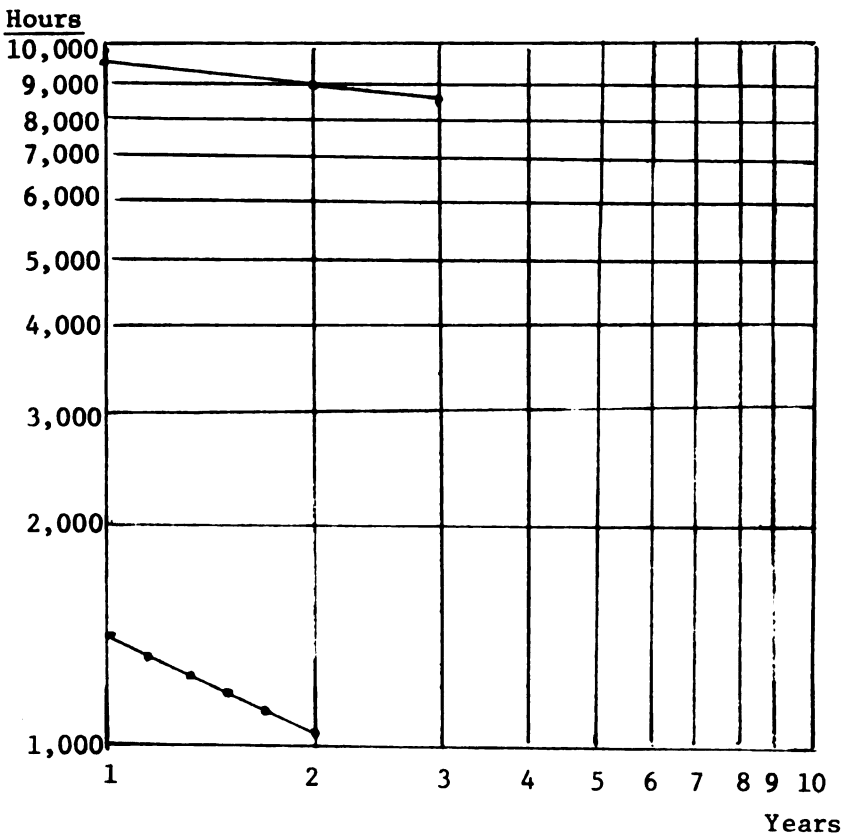


3 Year Audits (——)		2 Year Audits (– – –)	
Year 1	20,448 Hours	Year 1	6,503 Hours
Year 2	19,891 Hours	Year 2	6,493 Hours
Year 3	18,979 Hours		

(NOTE: All time reduction graphs are plotted on log-log paper, thus showing equal percentage change for equal graphical distance)

FIGURE 12

TIME REDUCTION - ALL NATIONAL FIRMS



4 Firms

28 Audits

22 - 3 Year Audits (——)

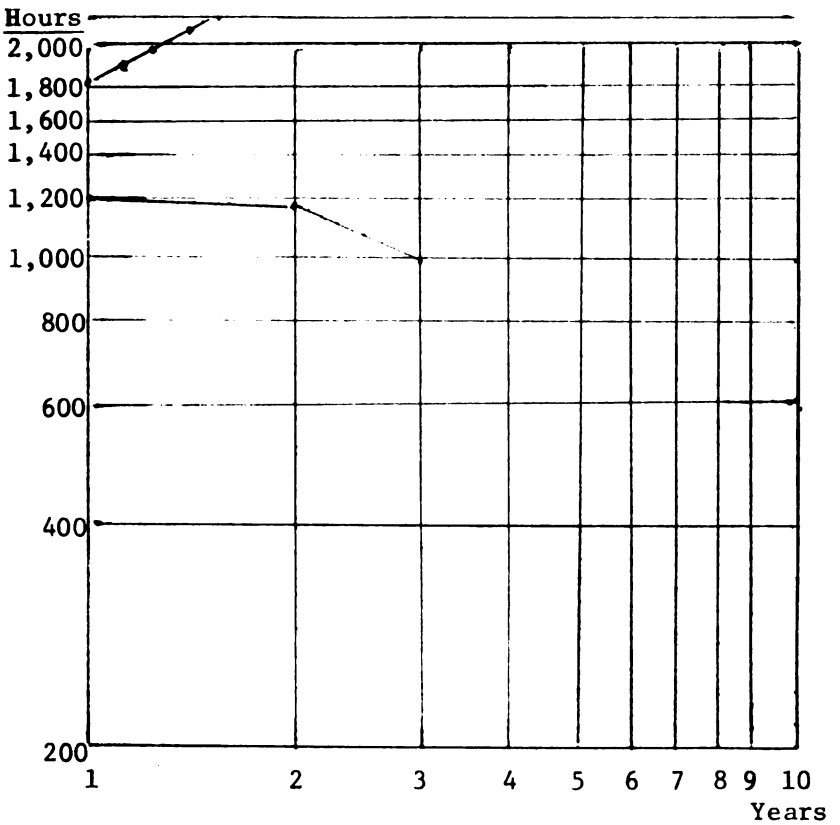
Year	Time
1	9563
2	8953
3	8671

6 - 2 Year Audits (·—·—)

Year	Time
1	1474
2	1047

FIGURE 13

TIME REDUCTION - REGIONAL FIRM



1 Firms

12 Audits

7 - 3 Year Audits (——)

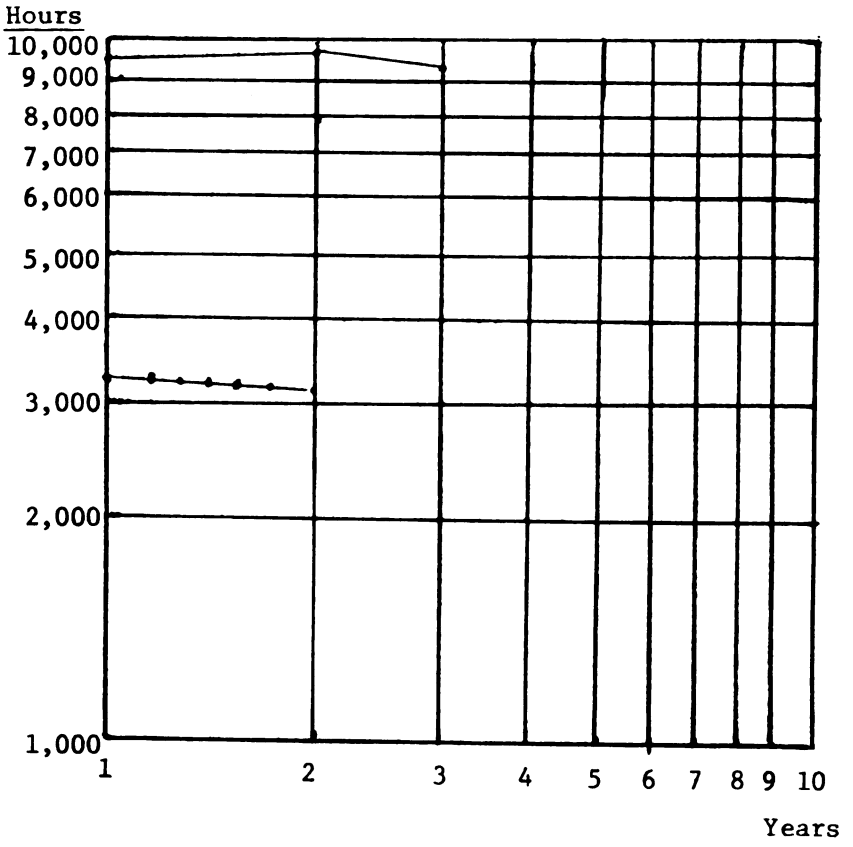
Year	Time
1	1195
2	1135
3	983

5 - 2 Year Audits (– – –)

Year	Time
1	1833
2	2362

FIGURE 14

TIME REDUCTION - ALL LOCAL FIRMS



9 Firms

61 Audits

43 - 3 Year Audits (——)

Year	Time
1	9686
2	9803
3	9325

18 - 2 Year Audits (—·—)

Year	Time
1	3200
2	3084

Analysis of time reduction by type of C.P.A. firm

Recapping the data from Table 7, the following comparison is made of time reduction by national, regional, and local C.P.A. firms:

TABLE 8

COMPARISON OF TIME REDUCTION BY TYPE OF C.P.A. FIRM

CPA Firms Type -	No.	3 Year Audits No. of Audits	3 Year Audits % Time Reduc. (Incr) Year 2	3 Year Audits % Time Reduc. (Incr) Year 3	2 Year Audits No. of Audits	2 Year Audits % Time Reduc. Year 2	Total Audits
National	4	22	6.4	3.1	6	29.0	28
Regional	1	7	5.0	13.4	5	28.0	12
Local	9	43	(1.2)	4.9	18	3.6	61
Totals	14	72			29		101

(Does not include unusual audit by national firm which lowers percentage to .02 for Year 2 and .003 for Year 3.)

This schedule must be interpreted with some care. The percentages are calculated on varying size bases, for a different number of audits of dissimilar size by public accounting firms of unlike size. The hours spent on audits by national and local firms are similar, as Table 7 shows hours for national firms as: Year 1, 12,752; Year 2, 12,096; Year 3, 11,085 and hours for local firms as: Year 1, 12,886; Year 2, 12,887; Year 3, 9,325. If the unusual audit by one national firm is deleted, the national firm has slightly fewer total hours each year than the local firm. (National Year 1, 11,037; Year 2, 10,000; and Year 3, 8,671 hours.) However, some conclusions on relative performance of the three types of C.P.A. firms can be derived from this comparison. On three year audits the rate of time reduction for

national firms is declining. The one regional firm appeared to have great time improvement in the third year audits, although this firm had two audits in which time was greatly reduced in the third year while time reduction performance on other audits was not outstanding. The sampling process may have been weak at this point as a representative sample was requested and control over audits available for submission was difficult. The local firms indicate the greatest rate of improvement in their time reduction performance.

TABLE 9

IMPROVEMENT RATIOS IN AUDIT HOURS BY TYPE OF C.P.A. FIRM

	3 Year Audits		Improvement Ratio
	Year 2 Reduction %	Year 3 Reduction %	Year 3/Year 2
National	6.4	3.1	-48% (Incr)
Regional	5.0	13.4	268%
Local	(1.2)(Incr)	4.9	508%*

*Mathematically, this calculation cannot be made since a positive figure divided by a negative figure must produce a negative figure. In a non-mathematical sense, the calculation may be made in that the local firms went from an increase in time to a reduction in time.

A trend appears in the above analysis even though so many variables are involved that judgment of causes of this behavior becomes complex. It may be that the national firms have a lower B factor or early year time reduction potential and this could be part of the cause of the behavior. If a firm has a high degree of experience and competence, the early years of an audit are performed at a low time requirement and further improvement decreases over the years. Conversely, less experienced firms may markedly improve a time requirement which was

initially high.

Comparison of time reduction performance of the three types of C.P.A. firms may also be analyzed on the basis of number and percentage of audits showing time improvement. This method equalizes the comparison by minimizing the advantage of the regional firm with its two large time reductions in the third year as indicated in the following tables:

TABLE 10

PERCENTAGE OF AUDITS WITH REDUCED TIME

	Year 2 - All Audits				
	Total No. of Audits	Time Reduced Audits	Time Increased Audits	No Reduction or Increase Audits	% of Audits with Reduced Time
National	29	21	8		73%
Regional	12	5	6	1	42%
Local	61	37	24	_	60%
Totals	102	63	38	1	
	Year 3 - All Audits				
National	23	14	8	1	60%
Regional	7	2	4	1	30%
Local	43	25	17	1	60%
Totals	73	41	29	3	

Based on the table above, national and local firms did equally well in year three on the percentage of number of audits with reduced time. Each reduced time on 60% of all audits. Apparently local firms were able to exceed national firms in time reduction on a total percentage of hours basis (as in Table 8) because national firms had five audits on which year three time increase was over 20% of year two hours.

Audit stability again emerges as a factor in the comparison of

national and local firm time performances. Unstable audits may be cancelling some of the gains accrued on stable audits thereby reducing the overall time reduction on the total of national firm audits. A comparison of stability ratings of national versus local firm audits is presented in the following table.

TABLE 11

AUDIT STABILITY RATINGS BY TYPE OF C.P.A. FIRM

		Year 2				
		Category 5	Category 4	Category 3	Category 2	Category 1
	Total Audits	% of Audits	% of Audits	% of Audits	% of Audits	% of Audits
National	29	7.0%	0%	76.0%	10.3%	13.7%
Local	61	4.9%	11.5%	72.1%	3.3%	8.2%
Total	90					
		Year 3				
National	23	7.4%	15.8%	55.6%	18.5%	3.7%
Local	43	18.7%	11.8%	65.1%	2.2%	2.2%
Total	66					

Stability Categories:

1. Substantially fewer problems and/or reduced amount of work
2. Mild reduction in problems and/or required amount of work
3. Substantially the same as in prior years
4. Mild increase in problems and/or required amount of work
5. Substantially increased problems and/or increased amount of work.

Combining both years in Table 11, it appears that the local firms had a higher percentage of audits in both Category 4 (Mild increase in problems and/or required amount of work) and Category 5 (Substantially increased problems and/or increased amount of work).

For years two and three, local firms indicated 11.5% and 11.8% in Category 4 while national firms rated 0% and 15.8%. Thus, locals had a higher percentage of unstable audits than did national firms, while nationals had a much greater percentage of audits in the two categories of reduced work on successive audits. Therefore, it appears that stability may not be the main factor promoting time reduction differences between national and local firms as stability favors greater national time reduction in year three and this greater reduction did not occur.

In order to focus attention on the degree of repetition of auditors on successive audit assignments as a factor promoting time reduction, the following comparison is presented.

TABLE 12

PERCENTAGE OF AUDIT TIME BY AUDITORS REPEATING ON SUCCESSIVE AUDITS

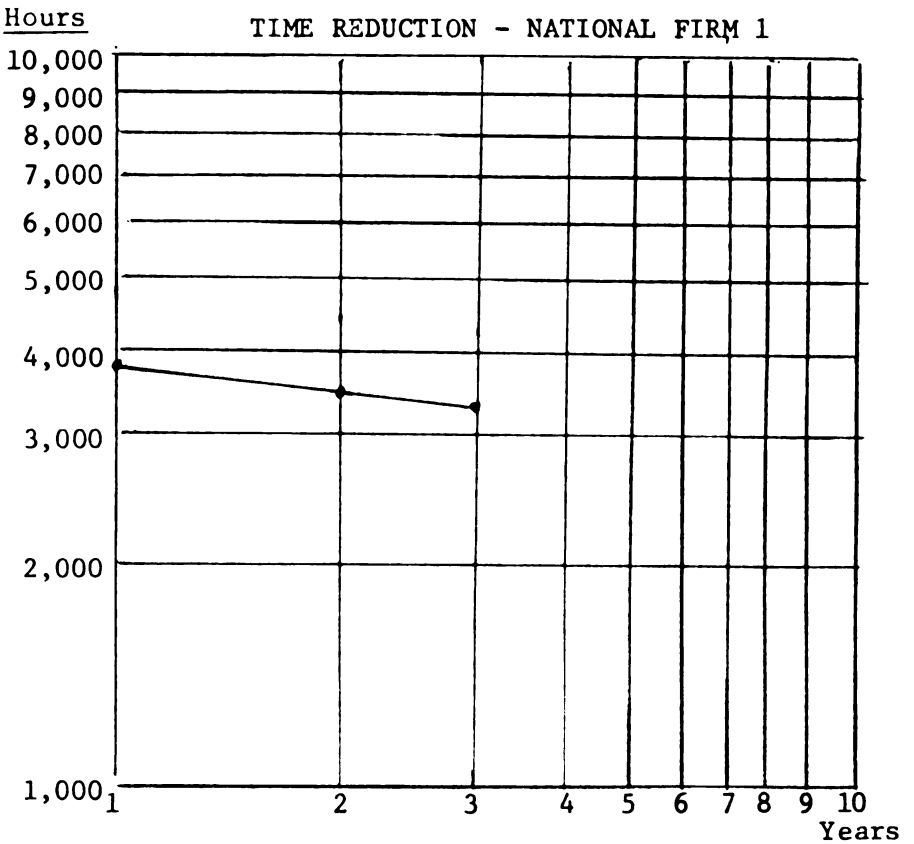
	Year 2		
	Audits by National Firms	Audits by Local Firms	Total
1 - 20% Repeat Hours	5	9	14
20 - 40% " "	7	4	11
40 - 60% " "	6	12	18
60 - 80% " "	4	11	15
80 - 100% " "	6	25	31
	28	61	89
	Year 3		
1 - 20% Repeat Hours	6	1	7
20 - 40% " "	5	2	7
40 - 60% " "	7	0	7
60 - 80% " "	2	11	13
80 - 100% " "	2	29	31
	22	43	65

As the preceding table indicates, local firms appear to exhibit more repetition of auditors on successive audits than national firms. In year two, local firms showed 48 audits, or 80% of total audits, with repetition rates of 40% or more, i.e., 40% or more of the audit staff repeated from the prior year's audit. In year two, national firms had 16 audits with a 40% or above rate of repetition, which represented 57% of all audits observed. In year three, local firms indicated 38 audits, or 90% of total audits, conducted by staff of which 40% or more were repeating from the prior year while national firms indicated 13 audits, or 54% of total audits, were repeated by 40% or more of the audit staff. Since the comparison in Table 7 shows that local firms increased their performance in year three, the higher rate of repetition by local firms reinforces the time reduction theory that repetition is a factor promoting time reduction.

Analysis of time reduction by individual C.P.A. firm

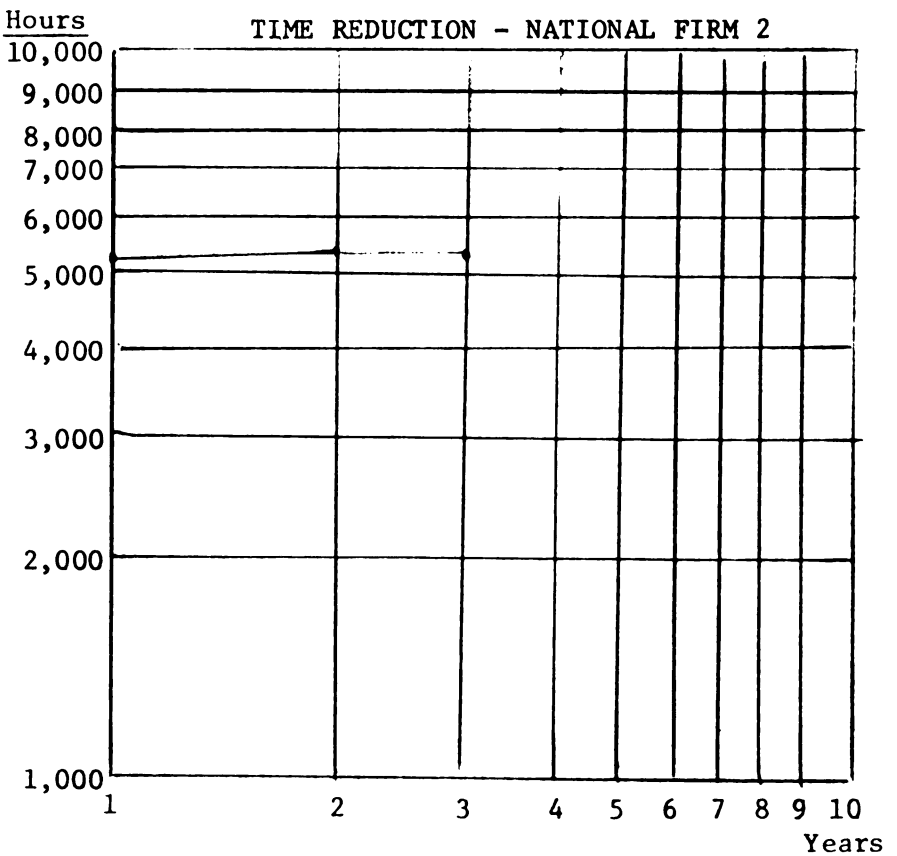
Time reduction curves for the individual public accounting firms cooperating in this study are graphically portrayed in Figures 15 through 28 on the following pages.

FIGURE 15



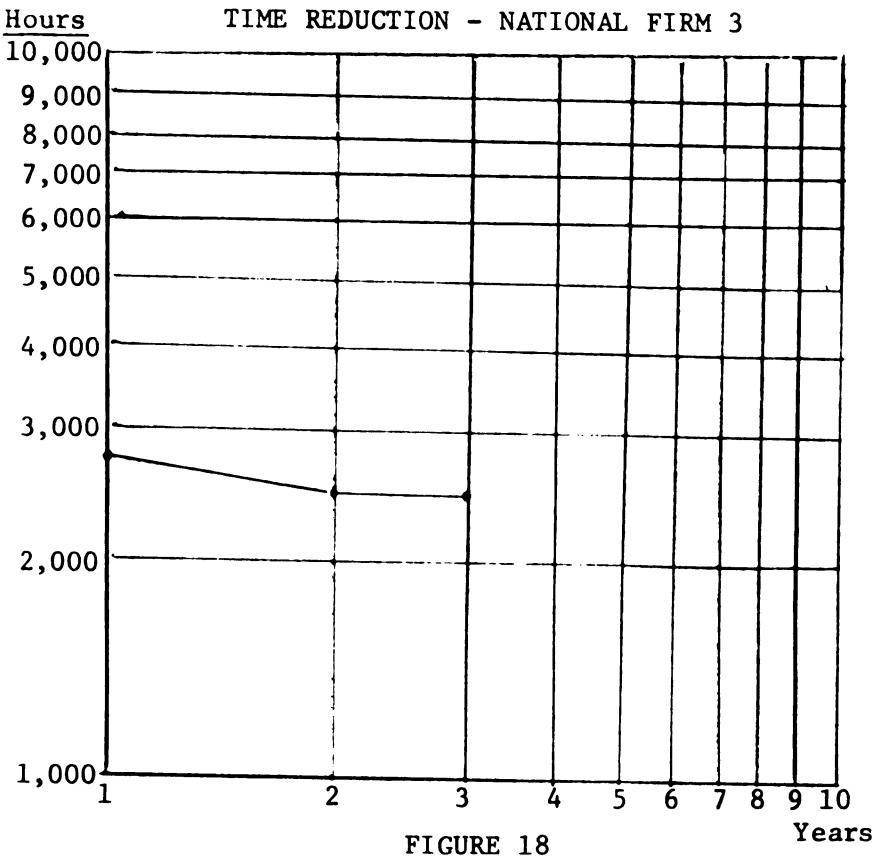
Year	Time
1	3,857
2	3,504
3	3,292

FIGURE 16



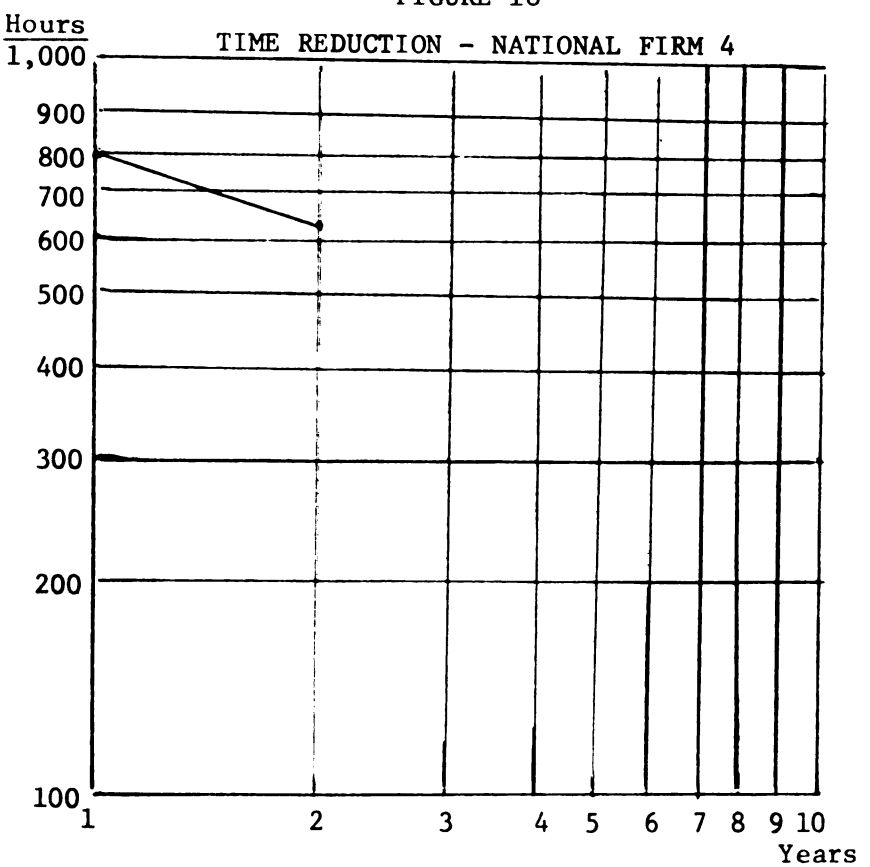
Year	Time
1	5,131
2	5,326
3	5,339

FIGURE 17



Year	Time
1	2,729
2	2,481
3	2,454

FIGURE 18



Year	Time
1	789
2	635

FIGURE 19

TIME REDUCTION - REGIONAL FIRM

Year	Time
1	1,195
2	1,135
3	983

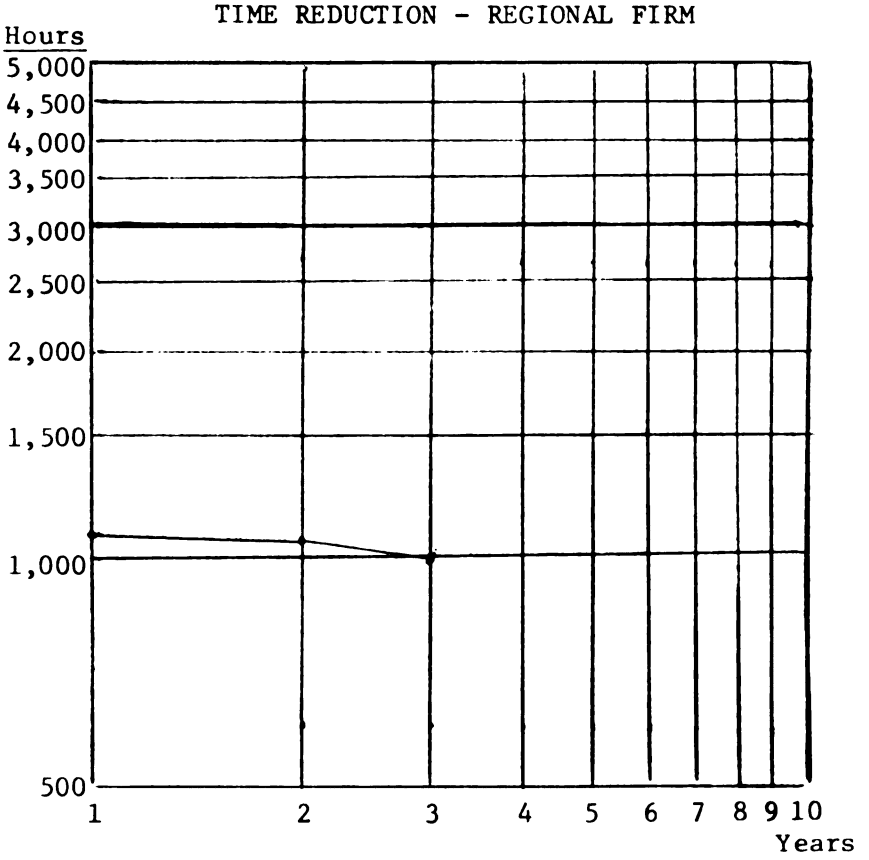


FIGURE 20

Year	Time
1	1,312
2	1,524
3	1,310

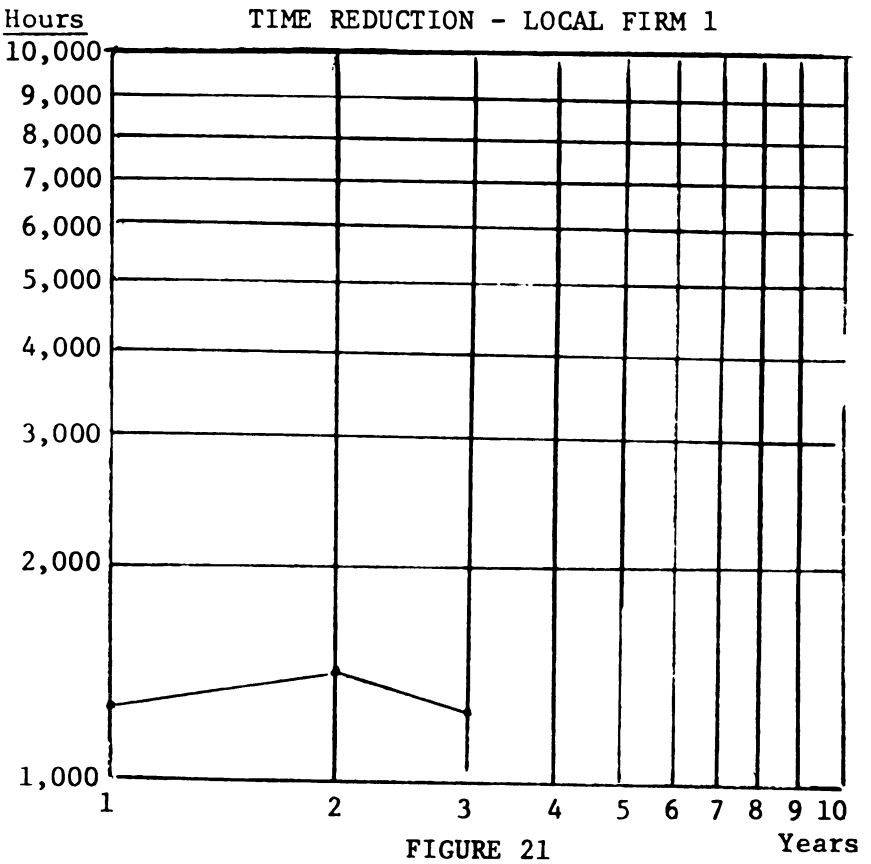


FIGURE 21

Year	Time
1	756
2	699

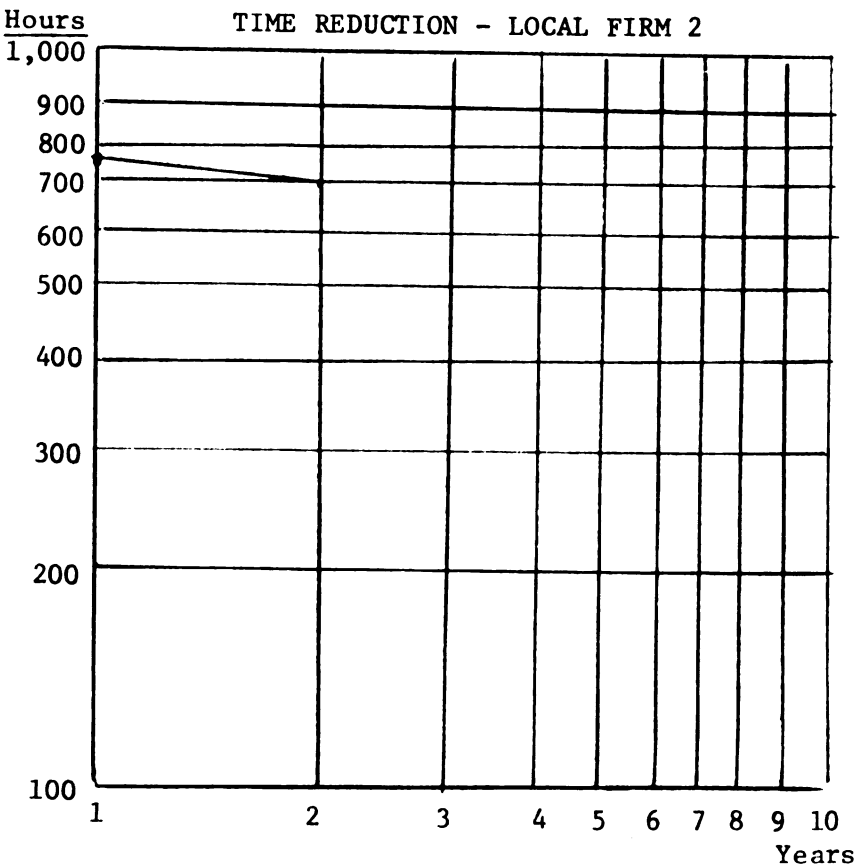


FIGURE 22

TIME REDUCTION - LOCAL FIRM 3

Year	Time
1	210
2	194
3	260

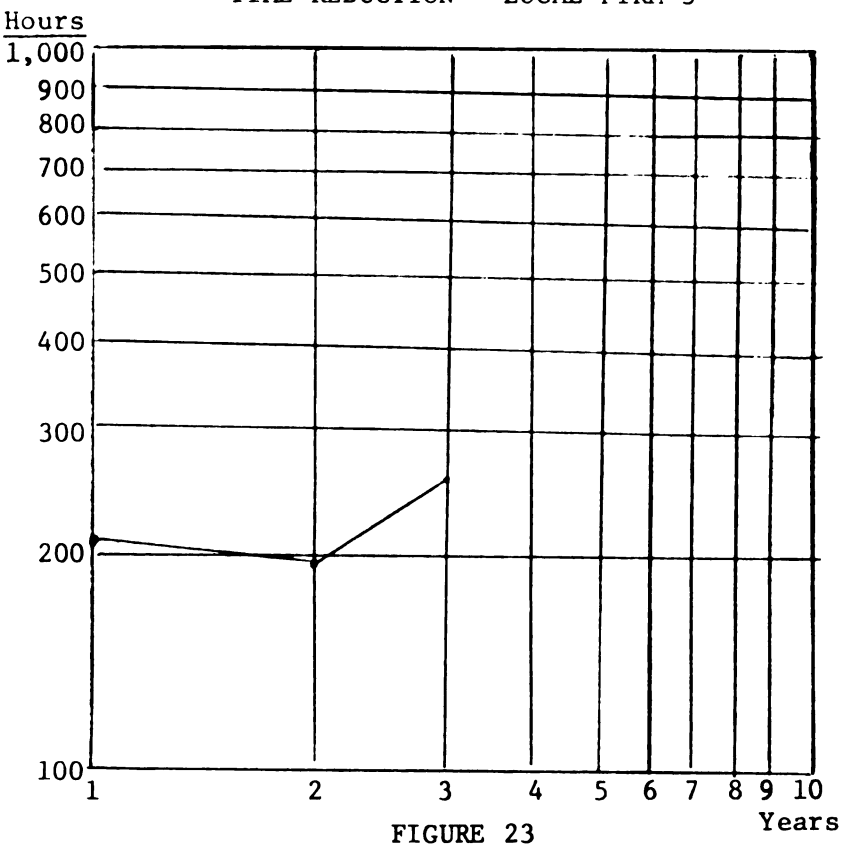


FIGURE 23

TIME REDUCTION - LOCAL FIRM 4

Year	Time
1	1,019
2	1,524
3	1,098

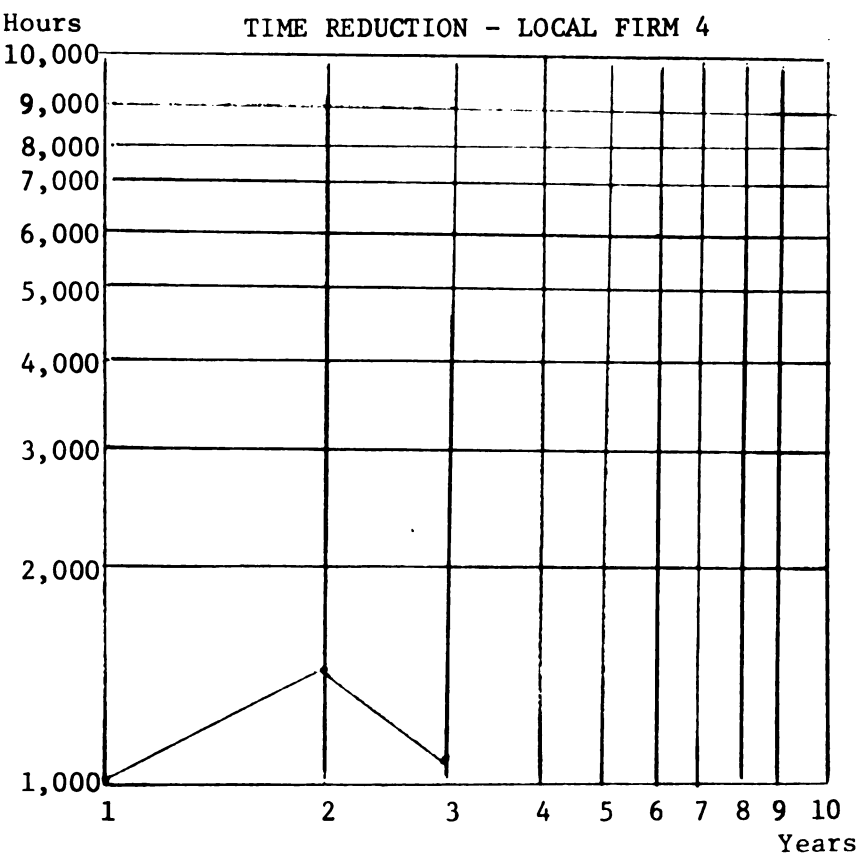


FIGURE 24

TIME REDUCTION - LOCAL FIRM 5

Year	Time
1	1,002
2	898
3	1,022

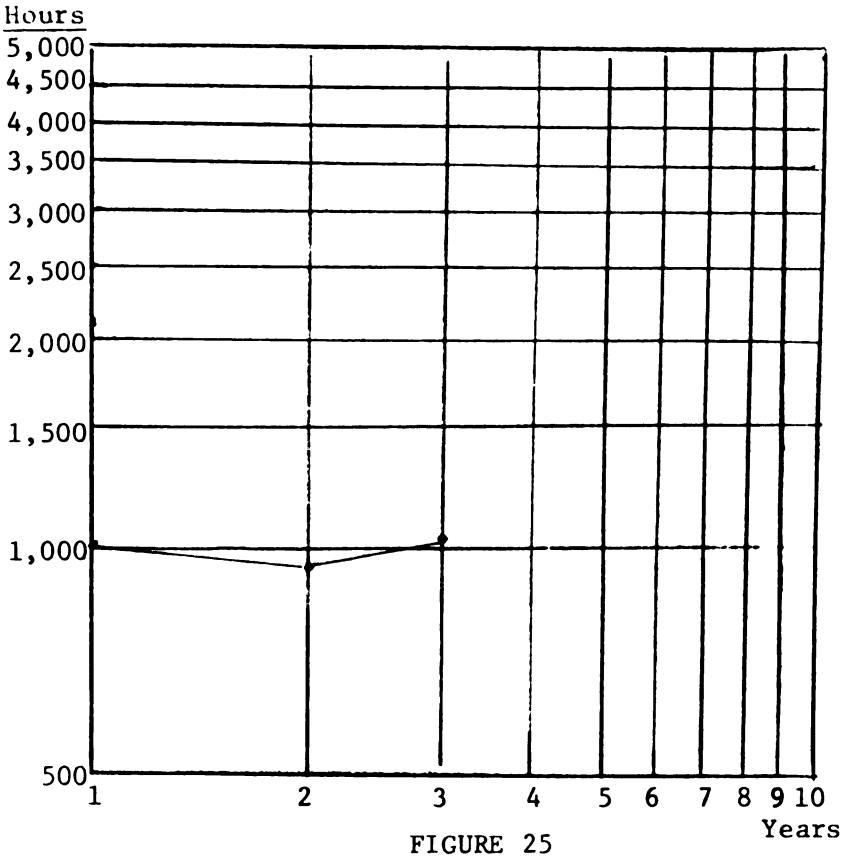


FIGURE 25

TIME REDUCTION - LOCAL FIRM 6

Year	Time
1	1,217
2	910
3	676

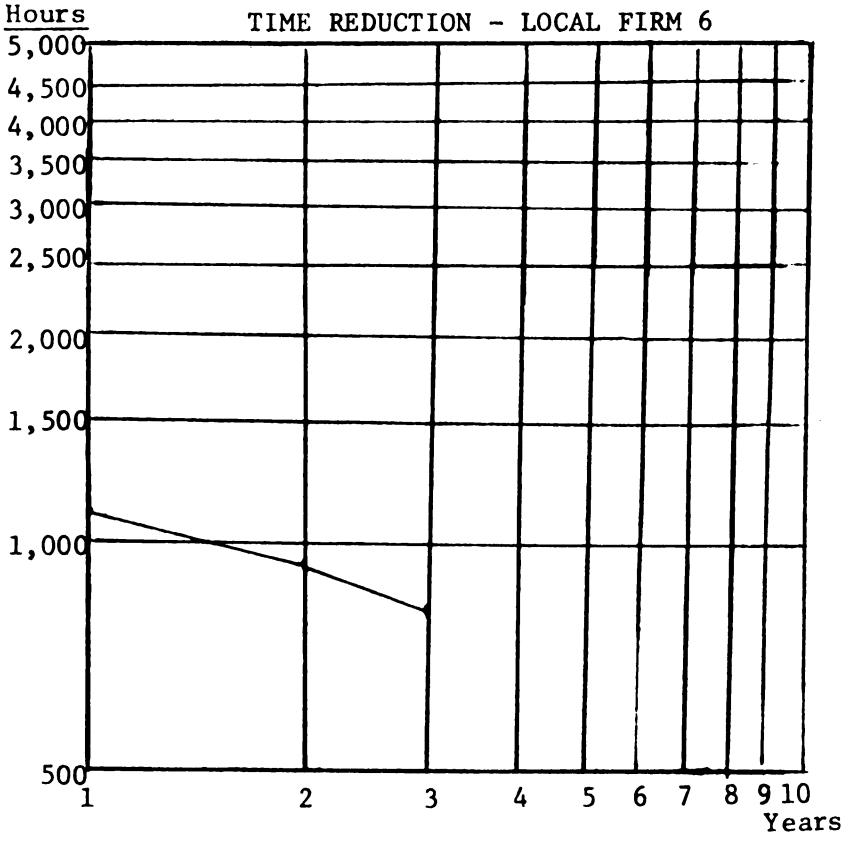


FIGURE 26

Year	Time
1	1,667
2	1,507
3	1,497

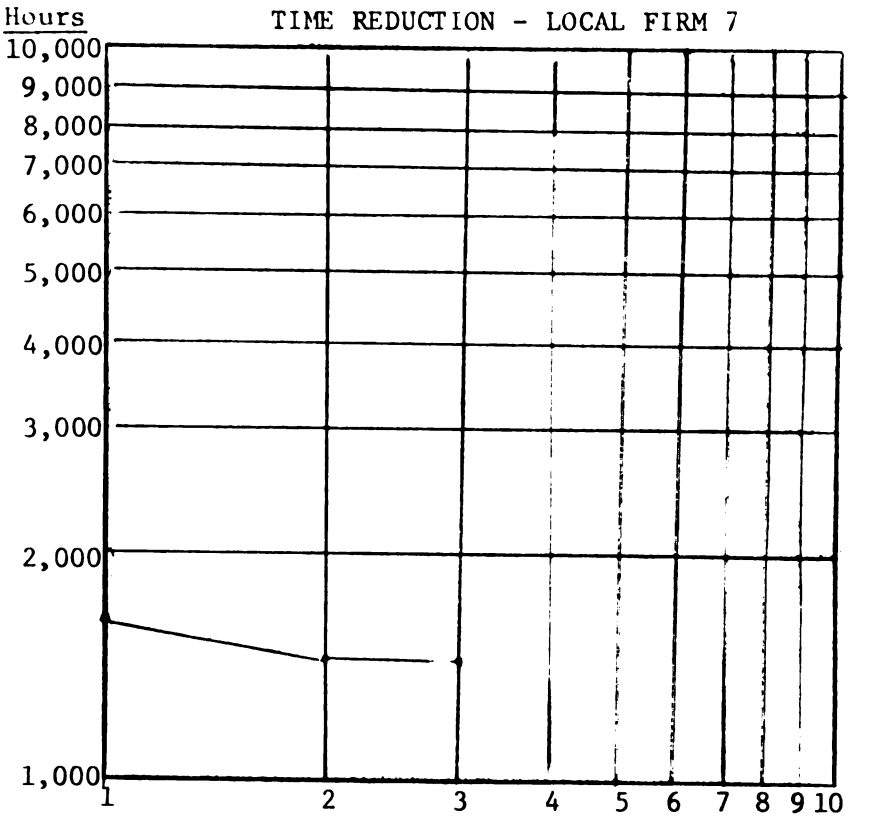


FIGURE 27

Year	Time
1	1,498
2	1,575
3	1,872

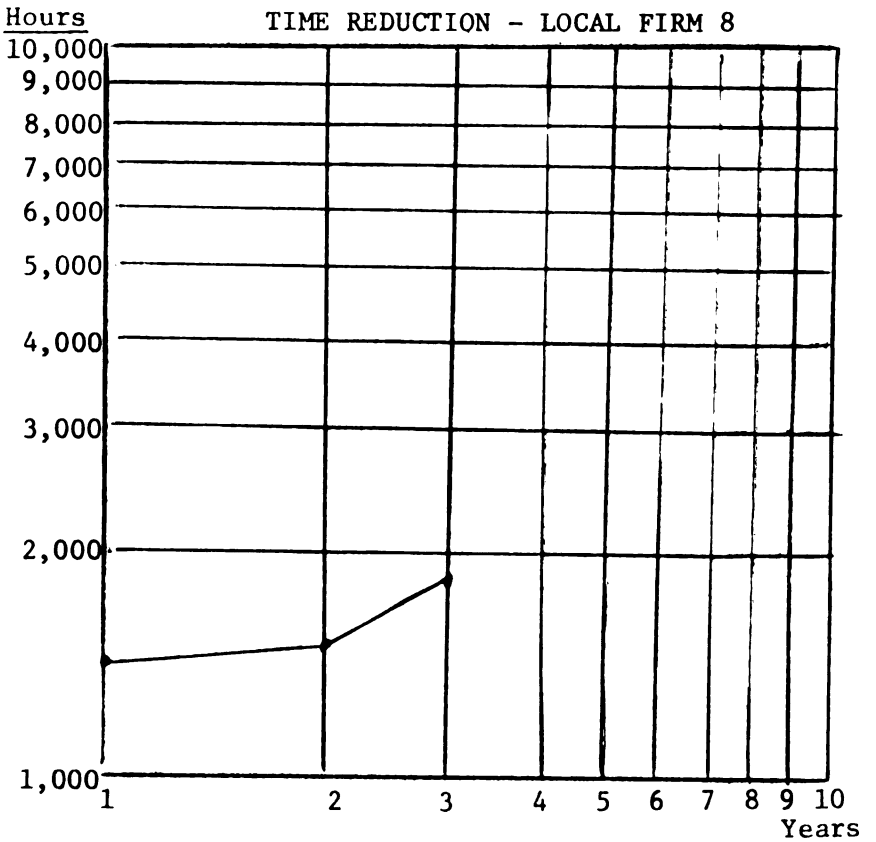
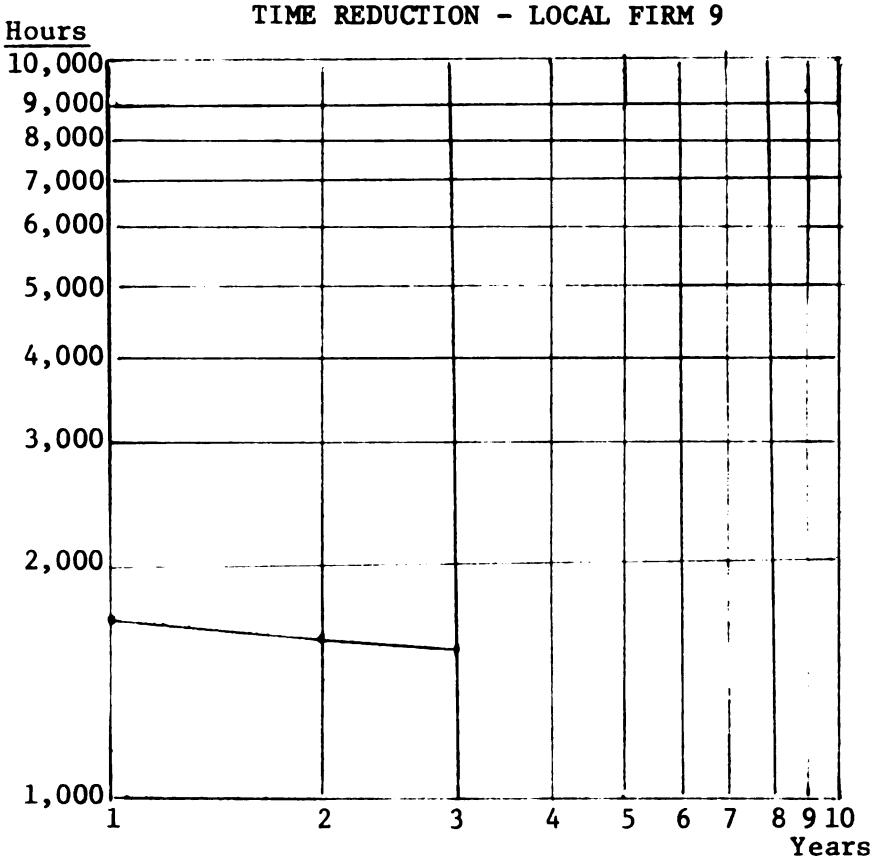


FIGURE 28

TIME REDUCTION - LOCAL FIRM 9

Year	Time
1	1,761
2	1,671
3	1,590



In isolating the reasons for the wide variations in observed time reduction, it appears that time reduction is affected by the type of client being audited. The examination of time reduction by type of industry indicated different rates of time reduction for the various industries, so perhaps the reason for varying time reduction lies in different mixes of client firms. The possibility exists, however, that reduction by client industry may be due to some quality within those particular audit firms who performed the audit rather than being a phenomenon of the audit or client firm. While the variations in time reduction by individual C.P.A. firms are subjected to multiple regression analysis later in this chapter, the variations due to client mix may also be compared in the following manner. In Table 13, the client industries are listed in order of percentage time reduction by industry as based on data from page 86 and they are assigned weights from one through eight so that the highest weights present among audits of a given C.P.A. firm should be conducive to the greatest time reduction. This is due to these C.P.A. firms having a favorable mix of clients from industries which are quite stable.

TABLE 13

AUDIT TIME REDUCTION BY TYPE OF CLIENT INDUSTRY

Rank of Observed Time Reduction	Industry	Weight	Total Observed Industry Time Reduction % Decrease (Increase)
1	Miscellaneous Firms	8	51.3%
2	Banks, Savings & Loan Assns.	7	41.5%
3	Cities, Villages, Townships	6	27.0%
4	Manufacturing	5	18.7%
5	Schools and Colleges	4	9.3%
6	Retailing	3	7.6%
7	Non-Profit Assns.	2	(22.0%)
8	Churches, Hospitals, Country Clubs	1	(50.2%)

Applying these weights to the client industry mix of national firms results in the calculations below. % reduction (increase) is the reduction in hours divided by the prior year's time in hours.

Firm 1	No. of Audits		Time Reduction Points		
Miscellaneous	3	x	8	=	24
Manufacturing	3	x	5	=	15
Schools etc.	1	x	4	=	4
Retailing	2	x	3	=	27
	9				70

Average time reduction points per audit = 7.7

Time Year 1 -- 3857
Time Year 2 -- 3504 Reduction: 353 % Reduction: 9.1%
Time Year 3 -- 3292 Reduction: 212 % Reduction: 6.0%

Firm 2	No. of Audits		Time Reduction Points		
Miscellaneous	1	x	8	=	8
Banks etc.	1	x	7	=	7
Manufacturing	8	x	5	=	40
	10				55

Average time reduction points per audit = 5.5

Time Year 1 -- 5131
Time Year 2 -- 5326 Reduction: (195) % Reduction: (3.8%)
Time Year 3 -- 5339 Reduction: (13) % Reduction: (.2%)

TABLE 13--Continued

Firm 3	No. of Audits		Time Reduction Points		
Miscellaneous	3	x	8	=	24
Manufacturing	1	x	5	=	5
	4				29

Average time reduction points per audit = 9.8

Time Year 1 -- 789
Time Year 2 -- 635 Reduction: 154 % Reduction: 25%

Firm 4	No. of Audits		Time Reduction Points		
Banks etc	1	x	7	=	7
Manufacturing	3	x	5	=	15
Churches etc.	1	x	1	=	1
	5				23

Average time reduction points per audit = 4.6

Time Year 1 -- 2290
Time Year 2 -- 2219 Reduction: 71 % Reduction: 3.1%
Time Year 3 -- 2454 Reduction: (235) % Reduction: (10.6%)

The above data produces the following correlation analysis:

Firm	Total Audit Time Reduction % Year 2	Year 3	Total	Average Time Reduction % Total/2	Average Time Reduction Points
1	10.4%	6.4%	16.8%	8.4	7.7
2	3.8	.002%	3.8	1.9	5.5
3	25.0%		25.0%	25.0	9.8
4	3.1%	(10.6%)	(7.5%)	(3.75)	4.6

Among the four national firms there appears to be a good relationship between time reduction and the type of client industry being audited. The more time reduction points indicating the presence of a favorable client mix, the more time reduction occurred.

Applying the same type of analysis to local firms produces Tables 14 and 15.

TABLE 14

AUDIT TIME REDUCTION BY INDIVIDUAL LOCAL C.P.A. FIRMS

Local Firms Firm No.	Industry	Number of Audits		Time Reduction Points	Average Time Red. Points	Time Year 1	Time Year 2	Time Year 3	Hours and % Time Red. Yr.2 (Incr)	Hours and % Time Red. Yr.3 (Incr)	Total % Time Red. (Incr)
1	Manufacturing	1	x 5 =	5		1108	1133		(25)		
	Retailing	3	x 3 =	9							
	2 Year Audits	4		14					(0.2%)		
	Manufacturing	2	x 5 =	10		1312	1524	1310	(212)	214	
	Retailing	3	x 3 =	9							
	3 Year Audits	5		19					(16%)	14%	
	Totals	9		33	3.67				(16.2)	14%	(2.27%)
2	Miscellaneous	2	x 8 =	16		756	699		57		
	Cities etc.	1	x 6 =	6							
	Schools etc.	1	x 4 =	4							
	Retailing	1	x 3 =	3							
	2 Year Audits	5		29							
	Totals	5		29	5.8				7.5%		7.5%
3	Manufacturing	1	x 7 =	7		1168	1079				
	Retailing	1	x 3 =	3							
	Non-Profit Assns.	6	x 2 =	12					89		
	2 Year Audits	8		22	2.7				7.6%		
	Non-Profit Assns.	3	x 2 =	6		210	194	260	16	(66)	
	3 Year Audits	3		6					7.6%	(34%)	
	Totals	11		28	2.5				15.2%	(34%)	(18.8%)

TABLE 14--Continued

Local Firm No.	Industry	Number of Audits			Time Reduction Points	Average Time Red. Points	Time Year 1	Time Year 2	Time Year 3	Hours and % Time Red. Yr.2 (Incr)	Hours and % Time Red. Yr.3 (Incr)	Total % Time Red. (Incr)
4	Retailing	2	x	3 =	6		1019	1524	1098	(505)	426	
	Non-Profit Assns.	1	x	2 =	2							
	3 Year Audits	3			8							
	Totals	3			8	2.67				(49.5%)	28%	(21.5%)
5	Miscellaneous	1	x	8 =	8		1002	898	1022	104	(124)	
	Banks etc.	1	x	7 =	7							
	Schools etc.	2	x	4 =	8							
	Retailing	2	x	3 =	6							
	3 Year Audits	6			29					10.4%	(13.8%)	(3.4%)
	Totals	6			29	4.8				10.4%	(13.8%)	(3.4%)
6	Manufacturing	1	x	5 =	5		1217	910	676	307	234	
	Schools etc.	2	x	4 =	8							
	3 Year Audits	3			13							
	Totals	3			13	4.3				25.2%	25.2%	50.9%
7	Manufacturing	1	x	5 =	5		168	173		(5)		
	2 Year Audits	1			5	5				(.3%)		
	Miscellaneous	1	x	8 =	8		1667	1507	1497	160	10	
	Manufacturing	2	x	5 =	10							
	Schools etc.	1	x	4 =	4							
	Retailing	2	x	3 =	6							
	Churches etc.	1	x	1 =	1							
	3 Year Audits	7			29	4.2				9.6%	.7	
	Totals	8			34	4.25				9.3%	.7	10.0%

TABLE 14--Continued

Local Firm No.	Firms Industry	Number of Audits		Time Reduction Points	Average Time Red. Points	Time Year 1	Time Year 2	Time Year 3	Hours and % Time Red. Yr.2 (Incr)	Hours and % Time Red. Yr.3 (Incr)	Total % Time Red. (Incr)
8	Miscellaneous	1	x	8 = 8		1498	1575	1822	(77)	(297)	
	Cities, etc.	1	x	6 = 6							
	Manufacturing	2	x	5 = 10							
	Schools etc.	1	x	4 = 4							
	Retailing	4	x	3 = 12							
	Churches etc.	1	x	1 = 1							
	3 Year Audits	10		41	4.1				(5.1)	(19%)	
	Totals	10		41	4.1				(5.1)	(19%)	(24.1%)
9	Manufacturing	1	x	5 = 5		1761	1671	1590	90	81	
	Cities etc	3	x	6 = 18							
	Retailing	2	x	3 = 6							
	3 Year Audits	6		29					5.1%	4.8%	
	Totals	6		29					5.1%	4.8%	9.9%

Summarizing Table 14 would produce the following table for local firms:

TABLE 15

CORRELATION OF OBSERVED AND EXPECTED TIME REDUCTION AS BASED ON CLIENT MIX OF LOCAL FIRMS

Firm No.	Time Reduction Percentage (Incr) Year 2	Year 3	Total	Average	Ave. Time* Reduction Points	Actual Rank	Expected Rank
6	25.2%	25.7%	50.9%	25.45%	4.3	1	4
7	9.3%	.7%	10.0%	5.0 %	4.2	3	5
9	5.1%	4.8%	9.9%	4.95%	4.8	4	2
2	7.5%		7.5%	7.5 %	5.8	2	1
1	(16.2%)	14.0%	(2.27%)	1.13%	3.7	5	7
5	10.4%	13.8%	(3.4%)	(1.7%)	4.8	6	3**
3	15.2%	(34.0%)	(18.8%)	(9.4%)	2.5	7	9
4	(49.5%)	28.0%	(21.5%)	(10.75%)	2.67	8	8
8	(5.1%)	(19.0%)	(24.1%)	(12.05%)	4.1	9	6

*Computed in the same manner as on pages 114 and 115 for national firms.
**Same value as second ranked firm.

Expected rank is based on the average time reduction points present. Actual rank is by observed average time reduction percentage.

The correlation between time reduction and client mix of local firms is not as favorable as that observed between time reduction and client mix of national firms. It is rather surprising that Firm 2 did not rank higher based on high time reduction points, however this may result from one of two causes. Since only two year audits were provided for this firm, any third year time reduction was not included which would raise its correlation with client mix. Also, Firm 2 had a rather small percentage of repetition of auditors in the second year (64%) compared to an average of 78% repeat hours for all local

firms, as indicated in Table 16. It is difficult to account for the success of Firm 6 which had only a fair mix of client firms and an average degree of repetition, but possibly this is a reflection of very competent audit personnel or firm management. Also, this firm provided only three audits which may not be an representative a sample as provided by other firms. Firm 7 was fourth in repetitive hours which may help explain its high time reduction performance.

TABLE 16

LOCAL FIRMS - PERCENTAGE OF REPEAT HOURS CALCULATION

Firm No.	Repeat Hours Year 2	Repeat Hours Year 3	Repeat Hours Total	Total Hours Year 2	Total Hours Year 3	Total Hours Total	% of Total Hours Representing Repeat Hours
1	2,291	1,187	3,478	2,657	1,310	3,967	87.6%
2	491	---	491	699	---	756	64.0%
3	719	157	876	1,273	260	1,638	53.4%
4	1,369	1,021	2,390	1,524	1,098	2,622	91.1%
5	803	825	1,628	898	1,022	1,920	84.7%
6	712	518	1,230	910	676	1,586	77.5%
7	1,255	1,175	2,430	1,680	1,497	3,177	76.4%
8	858	1,019	1,877	1,575	1,872	3,447	54.4%
9	1,671	1,050	2,721	1,671	1,590	3,261	83.4%
	10,169	6,952		12,887	9,325		

$$\frac{\text{Total Year 2 Repeat Hours}}{\text{Total Year 2 Hours}} = \frac{10,169}{12,887} = 78\% \text{ Average Repeat Hours}$$

$$\frac{\text{Total Year 3 Repeat Hours}}{\text{Total Year 3 Hours}} = \frac{6,952}{9,325} = 74.5\% \text{ Average Repeat Hours}$$

Firm 5 ranked low in time reduction although the degree of repeat hours was high at 84.7%. Since the data for this firm included one large audit which required five times the average hours of the other audits of this firm, time was thus raised 18% which perhaps biased time reduction downward.

Analysis of time reduction by detailed audit function

It is difficult to develop firm conclusions about time reduction by detailed audit function due to the small sample obtained. Detailed data by audit function was available for only seventeen audits from three public accounting firms although a wide variety of industries was represented. The functions are listed in the following table in the order of percentage of time reduction accomplished.

TABLE 17

TIME REDUCTION BY DETAILED AUDIT FUNCTION

Function	Time Year 1	Time Year 2	Time Reduction (Incr) Hours	%
1. Officers & Directors Accts.	3	1	2	66.6%
2. Internal Control	103	43	60	58.2%
3. Tests (of transactions, etc.)	135	94	41	30.4%
4. General Ledger Trial Balance	451	321	130	29.0%
5. Payroll and Liabilities	98	73	25	25.5%
6. Cash	293	225	68	23.2%
7. Prepaid & Deferred Charges	79	62	17	21.5%
8. Inventory Observation	108	85	23	21.3%
9. Accounts Payable & Accrued Liabilities	198	157	41	20.7%
10. Inventory (planning, extn. etc.)	239	211	28	11.7%
11. Planning & Supervision	62	55	7	11.1%
12. Reports	90	80	10	11.1%
13. Notes & Accounts Receivable	152	142	10	6.6%
14. Marketable Securities	7	3	4	5.7%
15. Intangibles & Other Assets	8	8	0	---
16. Journal Entries & Minutes	19	22	(3)	(15.9%)
17. Other Hours	147	172	(25)	(17.0%)
18. Income & Expense	183	218	(35)	(19.1%)
19. Notes Payable & Long Term Liabilities	20	25	(5)	(25.0%)
20. Notes & Accounts Receivable Confirmations	82	106	(24)	(29.3%)
21. Other Assets	4	6	(2)	(33.3%)
22. Property, Plant & Equipment	99	142	(43)	(43.4%)
23. Other Liabilities	20	30	(10)	(50.0%)
24. Analytic Review	14	24	(10)	(71.4%)
25. Capital Stock & Net Worth	12	24	(12)	(100.0%)
Totals	2,629	2,329	300	11.4%

The detailed functions showing the greatest decrease in time, when a significant amount of audit time was involved, are: internal control, tests, general ledger trial balance, payroll and liabilities, cash, prepaid and deferred charges, accounts payable and accrued liabilities, and inventory observation. All of these showed a time reduction of over 20% on successive audits.

The functions showing the greatest time reduction might be grouped under two headings: routine and preventative tasks. Routine tasks would include: general ledger trial balance, cash, prepaid and deferred charges, accounts payable and accrued liabilities, payroll and liabilities, and to an extent, inventory observation. The preventative task group would include internal control and tests. Routine task performance should improve on successive audits with experience of the auditors (and the firms involved had a fair degree of repetition of men on audits) and as problem areas are resolved on each successive audit. The preventative group should also show time improvement for similar reasons as well as from general stability of the client firm, from a reasonable level of personnel turnover, and from development of improved systems and procedures over the years. Testing and internal control efforts by the public accountant can be diminished in years when the potential to supply accounting information and demand for that information are in relative balance.

Those functions showing the greatest increase or smallest reduction in time were: property, plant and equipment, notes and accounts receivable confirmation, notes and accounts receivable, and income and expense. It is difficult to account for the lack of greater time reduction since most of these functions are fairly routine.

However, these functions require a considerable amount of detailed checking and, if a control account and subsidiary ledger become out of balance in the accounts receivable or property, plant and equipment areas, much time may be required to correct the problem. Also, in expansionary years such as two years of this study, 1968 and 1969, equipment acquisition and disposition verification can be quite time consuming. Perhaps expansion affects all areas as an expanding accounting force in the client's office may lead to turnover of duties in the accounts receivable and property accounting areas and perhaps to errors in the associated record keeping in these areas.

In conclusion, the results of the study in the detailed audit function area must be qualified in view of the small sample size. A deeper study should be undertaken over a longer period of years and from more public accounting firms. It should also be noted that the foregoing results are presented as a general description of what happened in the sample and are not suggested in an inferential manner.

Multiple regression and correlation analysis for eight time reduction related variables

The part of the study was concerned with determining the association of certain factors selected for examination with observed time reduction. Correlation and regression analysis were employed for this purpose. The method used for this section consisted of a computer aided analysis employing the program entitled "Multi-variate Analysis of Variance". This program was developed by Jeremy Finn of the State University of New York at Buffalo.

The eight factors believed to be associated with time reduction were expanded to eleven factors for a year one to year two time

reduction comparison by the addition of year two data for: number of men on the audit, years of experience of men, and number of hours by men new to the audit. Of the one hundred and two audits originally examined, twelve audits from the regional firm were excluded since data on two variables was lacking. One unusual audit was deleted for this analysis since it did not represent a typical audit and its inclusion, as noted previously, would have unduly biased time reduction downward. Thus, eighty-nine audits were evaluated statistically for a two-year sequence and, of these, sixty-five were also examined over a three-year sequence.

Key figures developed from this analysis for the series of audits from year one to year two are presented below:

Multiple R^2	= 0.5177	Standard Deviation	= 74.9805
Multiple R	= 0.7195	Degrees of Freedom (For Hypothesis)	= 11
F value	= 7.5127	Degrees of Freedom (For Error)	= 77
		Probability Level	= Less than .0001

In addition to the above statistics, the average hours per audit were 268.7978 in year one and 257.1573 in year two. The time reduction in hours per audit would be 11.6404 or an overall time reduction rate from year one to year two of 4.32%. The multiple R^2 figure represents the coefficient of determination for year two. It indicates that 51.77% of the observed time reduction is explained by the presence of the factors (independent variables) which were included in the regression analysis. This is not a particularly high correlation but, in view of the small selection of variables from a list of many possible time reduction variables as discussed in Chapter VI, the correlation is

meaningful. The standard deviation of 74.9805 seems extremely high but this was not surprising as the average time reduction for year two was 11.64 hours, and this was derived from time reduction per individual audits ranging from a 399 hour reduction in one case to an increase in time of 393 hours in another.

Stepwise regression analysis, chi-square, and probability levels for the variables are presented in the following table:

TABLE 18

YEAR 1 - YEAR 2 CHI-SQUARE VALUES AND PROBABILITY LEVELS

Variable	Chi-square Value	Probability Level
Repeat Hours, Year 2	17.8985	.0001
Stability, Year 2	26.0113	.0001
Hours by Men, New Year 2	7.1571	.0075
Years Experience, Year 1	3.3784	0.0661
Years Experience, Year 2	0.5196	0.4711
Firm Experience	0.0935	0.7599
Industrial Experience	0.7196	0.3963
Men, Year 1	1.1560	0.2824
Men, Year 2	0.2454	0.6203
Size	0.0277	0.8679
Training	4.2680	0.0389

(Explanation of the above variables follows Table 20.)

The first two variables, Repeat Hours, Year 2, and Stability, Year 2, were deemed significant in predicting time reduction and were significant at the .0001 level. The third variable, Hours by Men, New Year 2, was significant in predicting time reduction also at a probability level less than .0075.

Correlation coefficients were computed for each of the variables and the time reduction from year 1 to year 2. These results are presented in Table 19. Only two variables, Repeat Hours, Year 2, and

Stability, Year 2, were significantly correlated with time reduction. The partial correlation coefficients for Repeat Hours, Year 2 (-0.432337) and for Stability, Year 2 (-0.604080) were above the value needed for a significant correlation at the 99% confidence level. Thus, there is a significant relationship between the presence of these two variables and observed time reduction. The variable, Hours by Men, New Year 2, would be significant at the 95% confidence level. These correlations appear to bear out the regression findings, i.e., Repetition, Stability, and New Men seem to be closely associated with time reduction.

An apparent contradiction exists between the factor of Repetition and that of Hours by New Men in promoting time reduction. The concepts seem opposite in nature and yet both serve to reduce time. Figures 31 and 32 present an analysis of this phenomena. National firms utilized the services of new men much more than local firms as shown in the following comparison.

% Hours by New Men

	By National Firms				By Local Firms			
	Year 2		Year 3		Year 2		Year 3*	
Repeat Hours / Total Hours	5,818 / 10,000	= 58%	5,522 / 8,671	= 64%	2,701 / 12,887	= 21%	2,307 / 9,325	= 25%

*Year 3 data is introduced at this point for clarification of stability factor only.

For national firms (Figure 31) time reduction and hours by new men were closely associated. For local firms (Figure 32) time reduction was not associated closely with hours by new men. Apparently national firms expect this rapid rotation of new men through audits, and plan and train for it while local firms rely on a greater degree of repetition to reduce time. However, in a statistical sense, national firms' volume of hours by new men was so great (of 16,348 total new hours,

national firms had 11,340 or 70% of all new hours) and so effective that the result dominates that of new hours by local firms and thus causes a favorable overall correlation with time reduction. This is despite the fact that local firms do not have a favorable relationship with new hours in the audits sampled.

Table 20 presents a summary of key data from the regression and correlation analysis. Figures 29 and 30 show the nature of the negative correlation of many of the variables examined. Since a stability rating of 5 represented great instability and a number 1, greatly improved stability, the correlation is a negative one. Men Year 2 represented a negative correlation in the normal sense (Figure 30) in that the more men on an audit, the less time reduction is expected. (Negative correlation implies that as an independent variable increases, the dependent variable decreases.) The pattern of negative correlation is apparent in Figure 30.

Additional graphs are presented in Appendix E showing the relationship of time reduction with: firm auditing experience, experience in auditing client industry, and audit size. The trend lines in Figure 38 show typical time reduction behavior as firm time reduction stabilizes over a period of time. Figure 39 shows very poor correlation between industry experience and time reduction. There is also a poor correlation of time reduction and audit size as indicated in Figure 40. This was unexpected as some economies of scale from large audits may be contemplated. Apparently these economies were weak in the audits observed, and audit size does not necessarily promote time reduction.

From discussions with C.P.A. firms, audit stability was expected to be a powerful variable influencing time reduction, and this

TABLE 19

COMPARISON OF VALUES OF SIMPLE LINEAR COEFFICIENTS NEEDED FOR SIGNIFICANCE FOR OBSERVED CORRELATION COEFFICIENTS

Sample Size 89, Year 1 to Year 2 Time,
Degrees of Freedom Used: 80, Confidence Level .01

	Variable	Correlation Coefficient	Value Needed for Significance	Correlation Coefficient Is Significant
1.	Repeat Hours Year 2	-0.432377	.283	Yes
2.	New Men Year 2	0.242463	.283	No
3.	Stability Year 2	-0.604080	.282	Yes
4.	Years Experience, Year 1	0.031133	.283	No
5.	Years Experience, Year 2	-0.003223	.283	No
6.	Firm Experience	0.026508	.283	No
7.	Industrial Experience	0.040805	.283	No
8.	Men Year 1	-0.071742	.283	No
9.	Men Year 2	-0.099530	.283	No
10.	Size	-0.095029	.283	No
11.	Training	-0.092136	.283	No

TABLE 20

YEAR 1 - YEAR 2 RESULTS OF THE CORRELATION AND REGRESSION ANALYSIS

Factor	Partial Correlation Coefficient	Raw Regression Coefficient	Standardized Regression Coefficient	Standard Error of Raw Regression Coefficients
Size	0.095029	0.28025	0.082861	0.39700
Training	-0.092136	46.36683	0.229679	22.05945
Repeat 2	-0.432337	-0.15088	-0.255765	0.05872
New 2	0.242463	0.17208	0.250501	0.07425
Firm Exp.	0.026508	0.49898	0.053229	0.81253
Ind. Exp.	0.040805	-0.68793	-0.093990	0.69636
Men 1	-0.071742	-10.65915	-0.258277	8.73679
Men 2	-0.899530	4.21749	0.105165	7.84567
Yrs. Exp. 1	0.031133	1.84406	0.372923	0.99523
Yrs. Exp. 2	-0.003223	-1.25998	-0.203895	1.09123
Stab. 2	-0.604080	-62.67306	-0.565706	10.34037

(Size refers to size of the C.P.A. firm in employees; Training: presence of company training program; Repeat 2: hours on audit by men there in prior year; New 2: hours by men new to audit this year; Firm Exp.: experience of the C.P.A. firm in auditing this firm in prior years; Ind. Exp.: number of prior years the C.P.A. firm has audited firms in this industry; Men 1: number of men on the audit in year 1; Men 2: number of men on the audit in year 2; Yrs. Exp. 1: cumulative years of experience of all auditors on the audit in year 1 and similarly for year 2; Stab. 2: the degree of audit stability compared to that of the prior year's audit.)

FIGURE 29

RELATION OF STABILITY AND TIME REDUCTION

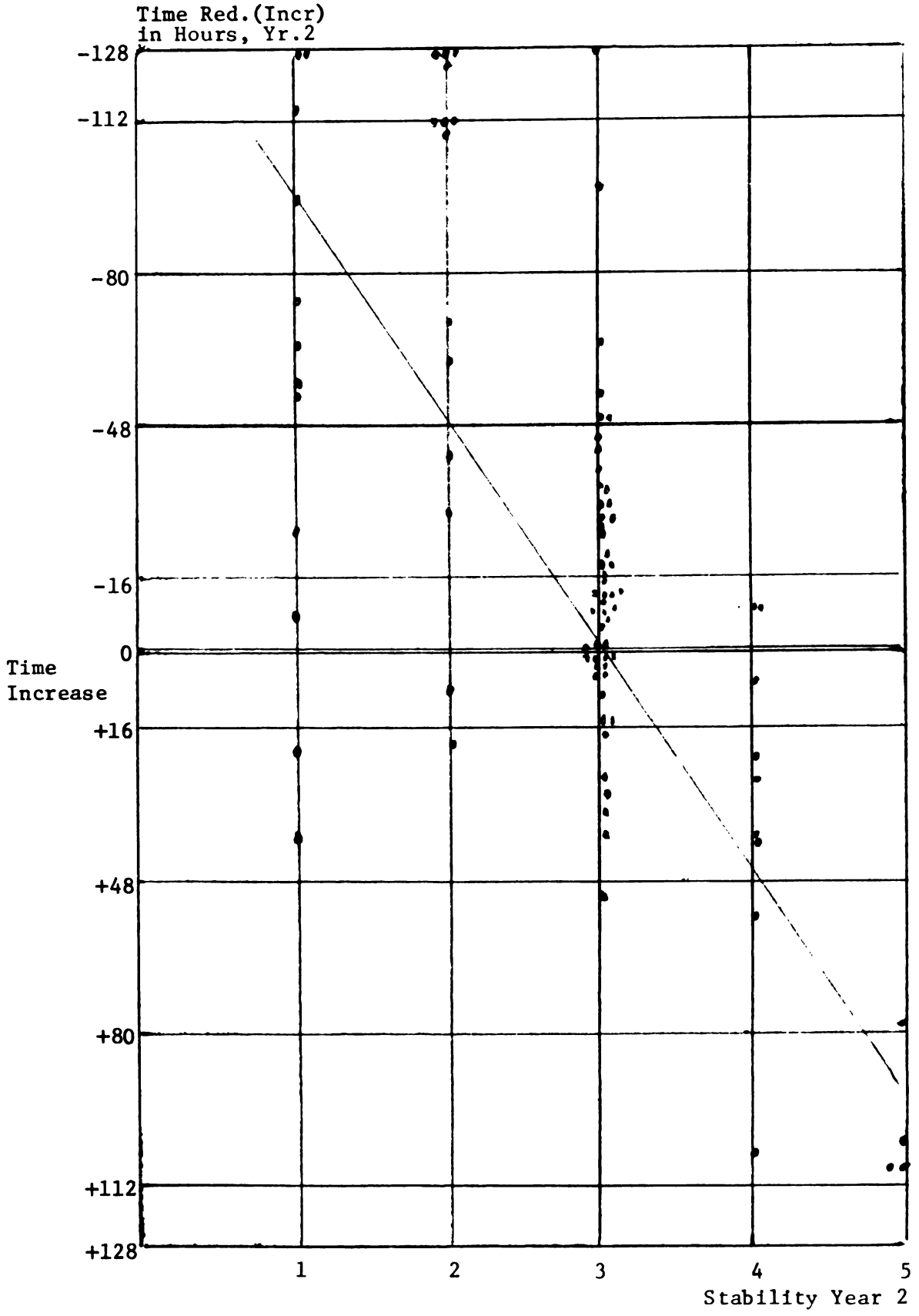


FIGURE 30

RELATION OF NUMBER OF MEN AND TIME REDUCTION

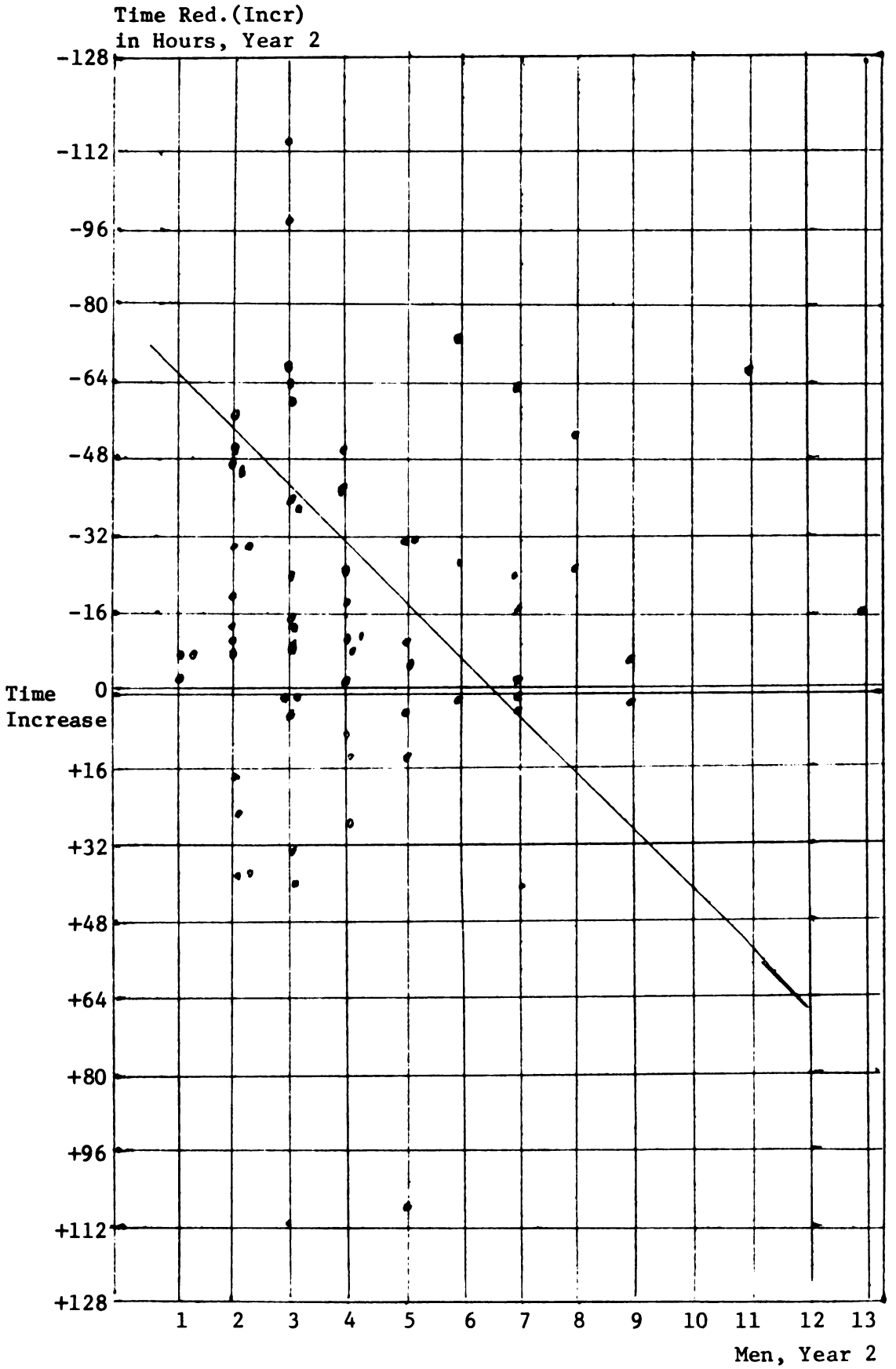


FIGURE 31

RELATION OF NEW MEN TO TIME REDUCTION
(National Firms)

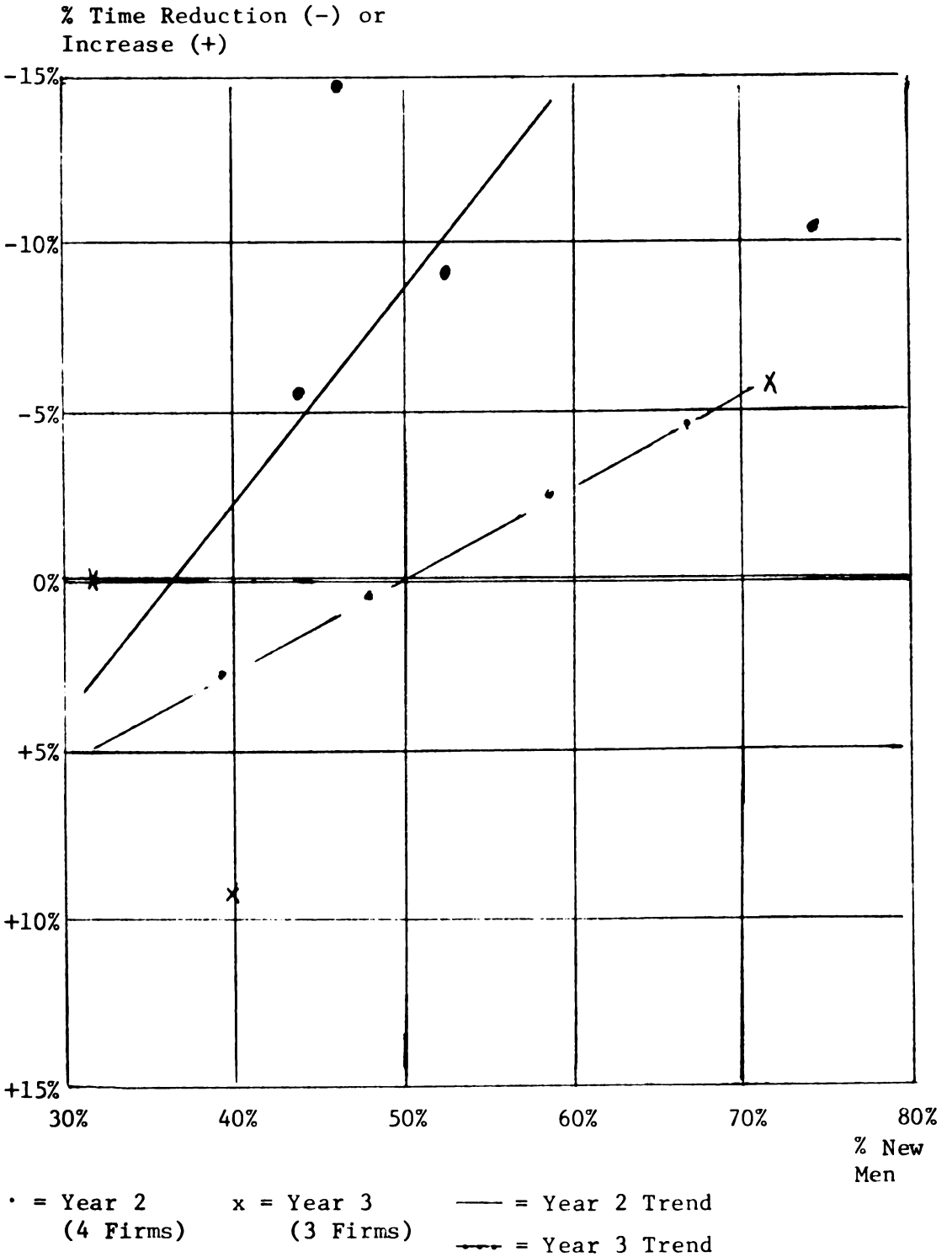
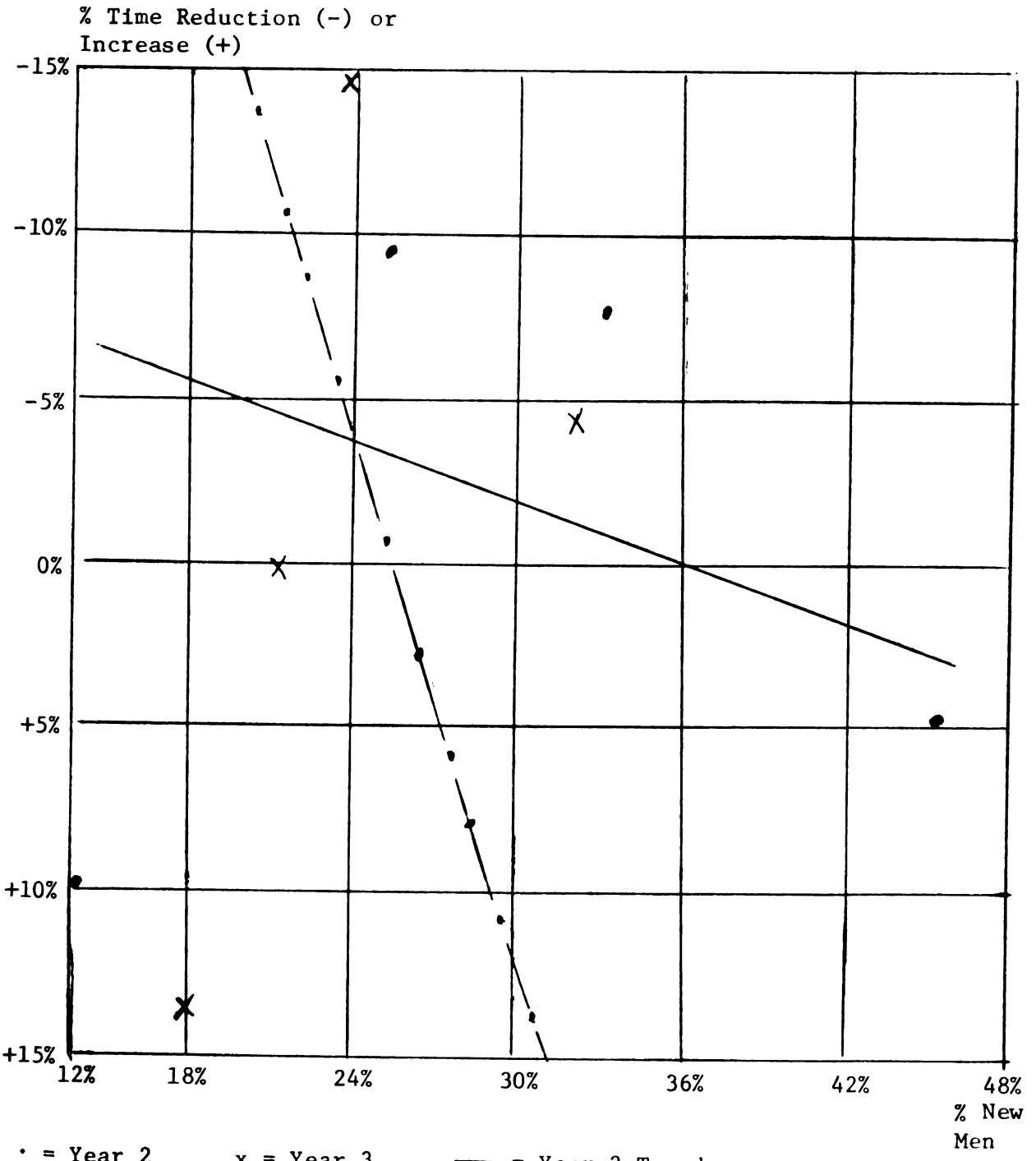


FIGURE 32

RELATION OF NEW MEN TO TIME REDUCTION
(Local Firms)



was confirmed in the correlation and regression analyses in the year 1 to year 2 study. Although stability has been assumed to be contained within the audit itself, it may also be controllable, to an extent, by the C.P.A. firm, and thus it is a complex factor to appraise. Perhaps this is the explanation for the earlier observation that national C.P.A. firms seemed to have more stable audits than local firms. This fact, would, of course, affect potential for time reduction. The probability of repetition promoting time reduction accurately was the same for that of stability, 99.9% accurate or having a .1% possibility of error. The correlation coefficient of repetition of -0.432337 was less than that of stability (-0.604080) as noted in Table 20. Thus, a time reduction pattern does seem to exist with repetition and the basic time reduction curve may prove applicable to public accounting.

Summarizing the year one to year two analysis, it would seem that two separate forces are operating to reduce audit time; the B factor and slope of the time reduction curve. The B factor would include the variables of Training, Stability, Years of Experience, Year 1, and Hours by Men, Year 2. The slope would result from repetition. The B factor would relate, then, to the basic ability of the firm to reduce time, irrespective of knowledge gained of the specific client's operation. Repetition would relate to improvement from knowledge of the specific client operation.

Regression and correlation analysis - Year 2 - Year 3

The analysis of year two to year three time reduction included data from 65 audits. In addition to the eight basic factors examined in the year one to year two study, the following five additional factors

or variables were included: hours by men repeating on the audit for the third year; hours by mean repeating in the last year from the prior year of a three year audit sequence; men repeating in year three after a one year lapse; number of men on the audit, year three; and years of experience of men on the audit, year three.

Key figures developed from this analysis of audits from year two to year three are presented below:

Multiple R^2 = 0.6074	Standard Deviation = 51.5876
Multiple R = 0.7794	Degrees of Freedom = 13 (For Hypothesis)
F value = 6.0705	Degrees of Freedom = 51 (For Error)
	Probability level = Less than .0001

The average hours per audit were 288.6 in year 2 and 276.9 in year 3, and the average hours time reduction per audit was 11.7 hours. Thus the overall time reduction rate from year 2 to year 3 was 4.05%.

The coefficient of determination of 0.6074 represents an explanation of almost 61% of the time reduction due to the variables present. This is a higher degree of explained time reduction compared to that of the year 1 to year 2 series. Possibly this is due to more repetition being allowed to develop, with some men repeating on audits for the third consecutive year. This possibility, and the effect of less stability in year 3 will be considered in more depth later in the analysis. At any rate, an explanation of nearly 61% of the time reduction as being associated with the selected variables and at a probability level of .0001 was felt to be a meaningful correlation of all variables with time reduction, year 3.

Stepwise regression analysis, chi-squares, and probability levels for the variables are presented in the following table:

TABLE 21

YEAR 2 - YEAR 3 CHI-SQUARE VALUES
AND PROBABILITY LEVELS

Variable	Chi-square Value	Probability Level
Repeat Hours, Year 3	13.4837	0.0003
Stability, Year 3	9.2997	0.0023
Hours by Men, New Year 3	10.0841	0.0015
Years Experience, Year 2	2.6706	0.1023
Years Experience, Year 3	6.3211	0.0120
Firm Experience	0.0111	0.9163
Industrial Experience	0.6183	0.4317
Men, Year 2	0.0470	0.8283
Men, Year 3	0.0001	0.9910
Size	2.8284	0.0927
Training	4.8416	0.0278
Hours by Men in Year 3 Repeat from Year 1	2.8069	0.0939
Hours by Men in Year 3 Repeat from Year 2	2.1278	0.1447

The first three variables were significant in predicting time reduction, repeating the pattern from years 1 to 2. For the first two variables, Repeat Hours, Year 3, and Stability, Year 3, there is an ability to predict time reduction at the .003 and .0023 confidence levels. This predictive ability must be due to an actual correlation between observed time reduction and presence of the variables rather than time reduction being due to other unmeasured variables. Hours by Men, New Year 3 was a slightly better predictor of time reduction than was Stability, predicting time reduction at the .0015 confidence level.

Correlation coefficients were computed for each of the variables and the time reduction from year 2 to year 3. These results are presented in Table 22. Repeat Hours, Years 1, 2, and 3 was the only variable significantly correlated with time reduction, having

TABLE 22

COMPARISON OF VALUES OF SIMPLE LINEAR COEFFICIENTS NEEDED FOR SIGNIFICANCE FOR OBSERVED CORRELATION COEFFICIENTS

Sample Size 65, Year 2 to Year 3 Time,
Degrees of Freedom Used: 60, Confidence Level .01

Variable	Correlation Coefficient	Value Needed for Significance	Correlation Coefficient Is Significant
1. Repeat Hours Year 1, 2 & 3	0.440516	.325	Yes
2. Repeat Hours Year 3 from Year 2	-0.020468	.325	No
3. Repeat Hours Year 3 from Year 1	-0.114557	.325	No
4. Hours by Men New Year 3	-0.183538	.325	No
5. Stability Year 3	-0.195465	.325	No
6. Years Experience, Year 2	0.114071	.325	No
7. Years Experience, Year 3	0.056426	.325	No
8. Firm Experience	-0.003910	.325	No
9. Industrial Experience	0.085906	.325	No
10. Men Year 2	0.229835	.325	No
11. Men Year 3	0.087076	.325	No
12. Size	0.137285	.325	No
13. Training	-0.009096	.325	No

sufficient value for correlation at the 99% confidence level. Significant at the 90% confidence level were: Men, Year 2, Stability, Year 3, and Hours by Men, New Year 3. As in year one, correlation and regression analysis both indicate Stability, Repetition, and New Men as the variables most associated with time reduction.

Table 23 on the following page summarizes key data from the regression and correlation analysis.

The factors, Repeat Hours Year 1, 2, and 3 and Repeat Year 3 from Year 2, displayed correlation coefficients of 0.440516 and -0.020468 respectively. These factors together indicated a strong correlation of repetition with observed time reduction. Repetition then, appeared as the major cause of time reduction in the Year 2 - Year 3 study. Thus, the earlier statement that repetition is the major cause of slope in the time reduction curve seems supported by the analysis above.

Factors which may be associated with the B factor, or basic ability to perform an audit in a minimum time the first year may include the following factors shown with their respective correlation coefficients:

Size	0.137285
Training	-0.009096
New Year 3 (Hours by men New Year 3	-0.183538
Firm Experience	-0.003910
Ind. Experience	-0.085906
Men, Year 2	0.229835
Men, Year 3	0.087076
Years Experience, Year 2	-0.114071
Years Experience, Year 3	0.056426

TABLE 23

YEAR 2 - YEAR 3 RESULTS OF THE CORRELATION AND REGRESSION ANALYSIS

Factor	Correlation Coefficient	Raw Regression Coefficient	Standardized Regression Coefficient	Standard Error of Raw Regression Coefficients
Size	0.137285	1.36065	0.607991	0.33857
Train	-0.009096	42.60932	0.291803	20.20681
Repeat 1,2,3	0.440516	0.37999	0.757821	0.06806
Repeat Yr. 3 from Yr. 2	-0.020468	0.17910	0.147423	0.12089
Repeat Yr. 3 from Yr. 1	-0.114557	-0.49827	-0.161256	0.29899
New, Yr. 3	-0.183538	-0.14847	-0.352849	0.05391
Firm Exp.	-0.003910	-0.34307	-0.056077	0.63522
Ind. Exp.	-0.085906	-0.06076	-0.012536	0.54589
Men 2	0.229835	-0.58938	-0.020458	4.91665
Men 3	0.087076	0.64530	0.023662	4.45344
Yrs. Exp. 2	0.114071	2.19686	0.499687	0.74550
Yrs. Exp. 3	0.056426	-1.95309	-0.456911	0.70626
Stability 3	-0.195465	-26.18997	-0.423127	6.50393

Summary of the Empirical Study

Concepts which were developed	Usefulness of the concept for C.P.A. firms
Client industries exhibit widely varying time reduction patterns	Time data may be accumulated by client industry from which time reduction guide figures may be developed.
Repetition of auditors is associated with time reduction. Local firms practice more repetition than national firms.	Accumulate data on the percentage of repeat hours per audit from which guide figures for expected time reduction, as associated with repetition, may be established.
The number of hours by new men promote time reduction. New men on audits were used more by national than by local C.P.A. firms. Associated with this finding, it was noted that time reduction rate of national firms in the third year was less than that of local firms.	National firms may need to examine auditor rotation policy benefits vs the benefits from more repetition in subsequent years of an audit.
Stability of client industry tends to affect time reduction by industry.	Establish stability ratings for each audit and determine cause of instability as: (1) Client firm related (2) C.P.A. firm related Follow up on possible correction of causes.

Summary of the Empirical Study (continued)

Concepts which were developed	Usefulness of the concept for C.P.A. firms
Local firms experienced more audit instability than national firms.	Establish stability ratings for each audit. Local firms should check the mix of repetitive and new hours on each audit. A limited rotation policy for development of broad audit and audit management skills may be considered by local firms.
Time reduction by detailed audit function varied widely by function.	Maintain detailed audit records to accumulate time data by audit function. Eventually, standards or guides for time reduction by function may be developed.
On a firm to firm comparison of C.P.A. firms, not all variations in time reduction could be explained by stability, by repetition, or by hours of new men. A residual variation in time reduction exists which may relate to management competence in the C.P.A. firm or to individual auditor competence.	After applying all useful criteria discussed above, examine those subjective measures not examined in this study, such as: (1) Degree of client preparation (2) Client personnel turnover (3) Client cooperation (4) Presence of uninterrupted audit time (5) Adequacy of pre-audit conference (6) Adequacy of post-audit working paper review (7) Education of auditors assigned

CHAPTER VIII

POSSIBLE FUTURE USES OF TIME REDUCTION CURVES BY CERTIFIED PUBLIC ACCOUNTING FIRMS

The time reduction curve may serve as a basis for future analyses of time requirements by public accounting firms. Several possible applications of time reduction curves are suggested and include the following:

1. Evaluation of the "trade-off" between balanced experience and time reduction potential. Discussion includes re-examination of the B factor, combined consideration of slope and B factor, graphical portrayal of trade-off, hypothetical analysis in hours and in cost terms, and limitations of a hypothetical approach.
2. Determination of year one audit time
3. Determination of years needed to reduce audit time
4. Evaluation of cost of changes in audits

Evaluation of the "trade-off" between balanced experience and time reduction potential

Consistent with the principles of the time reduction curve, it appears that a "trade-off" is possible between a minimum time on first year audits and rapid time reduction on subsequent years' audits. In time reduction curve analysis, the basic ability to perform on a new product, model, etc. is known as the "B" factor. On page 58 it was

noted that some eventual minimal time to complete a job depends on the time required to produce the first unit (B factor) and the rate of improvement (slope of the curve). The more ability and experience individuals have with similar jobs, the less time will be required for the first performance on a new job. Accordingly, with a low first unit time, less improvement will be possible on successive units as repetition will not bring great time reduction. Conversely, an inexperienced group may require more time to complete the first unit but will effect more time reduction in repeating the task over several time periods. Thus, the public accountant may possibly make a trade-off of experienced men for inexperienced men on the first year of an audit, thereby incurring a minimum audit time for the first year and less time reduction in successive years.

Since the B factor is a useful concept for industry in estimating time reduction, it could have the same use for public accounting. For example, in World War II aircraft procurement, the government recognized varying B factors for aircraft manufacturers who possessed differing degrees of production experience and competence. Both the government and the manufacturers, knowing the first unit time (B factor) and time reduction potential (slope or degree of learning), could quite accurately predict time requirements over the months or years of a government contract. As the more experienced aircraft firms require less time on the first production run of new aircraft, so the more experienced public accounting firms may require less time on a first year's audit than the less experienced may require. Nicholas Baloff has commented on this variability of B factors from firm to firm and from product to product.[76] Furthermore, public accountants

might also utilize the B factor and thus have a powerful tool not only for forecasting annual audit time budgets but also for setting fees, for manpower scheduling, etc. Indeed, the B factor itself could be measured by public accounting firms in order to examine its improvement or deterioration, as such knowledge would be useful in overall time reduction. Undoubtedly, their findings would corroborate the Boeing Company's studies which stated: "In other words, the 'B factor' is a mathematical value which shows the skill level of a certain company's organization. How much is the experience of the Green Company worth?"[77] Lastly, and particularly applicable to public accounting, are the other specific B factor determinants proposed by Yezdi Bhada in his discussion of pre-product planning: "The better the pre-product planning.... the labor time for the first completed unit is likely to be lower than without such extra care."[78] Bhada seems almost to be making particular reference to public accounting when he states: "...Also proper planning at the initial stage lessens the scope for improvement during the course of production which results in a flatter function, lying considerably below one which depicts a smaller amount of pre-production planning."[79]

Attention focused on the B factor in this study as a result of conversations with the public accounting firms in which the desire to develop rapid competence and varied experience was stressed. It appeared that the firms were attempting to develop the B factor by a policy of rapid rotation of personnel on audits. Such rotation was more prevalent in national CPA firms than in the smaller local firms largely because in the national firms the auditors themselves sought rotation in order to have more challenging assignments. The policies

followed in assigning auditors may range from a completely new audit team each year to a repetition of all auditors from the prior year engagement. The advantages of a completely new team may lie in the rapid training, flexibility, and challenge presented to the auditor. The disadvantage would be primarily the sacrifice of maximum second, third, and subsequent years' audit time reduction. This reduction would be based on the acquisition of general organizational familiarity with the client. The advantages of repetition of the entire staff from the prior year's audit would lie in the development of organizational familiarity leading to time reduction, in developing client confidence and harmony with the public accounting firm staff, and possibly in a more coordinated team effort by the audit group. The disadvantages of this approach could be the loss of rapid training, flexibility, and challenge for the individual auditors, and also pure boredom from a repetitive task. This boredom could lead either to the plateau of no further time reduction or to possible time increase as incentive for reduction is not created.

To exploit the maximum possible advantages of these two extreme positions of complete rotation as opposed to complete repetition of staff on an audit, some intermediate assignment policy should be considered. Such a policy was followed by some firms who reassigned some auditors to the same audit but in more responsible positions than in prior years. This policy seems to offer two advantages. There is some continuity on the audit so that knowledge of client procedures, personnel, and a host of organizational factors are handled smoothly. The client does not feel that he is providing a training ground for new auditors. Thus, it would appear that there is a median point

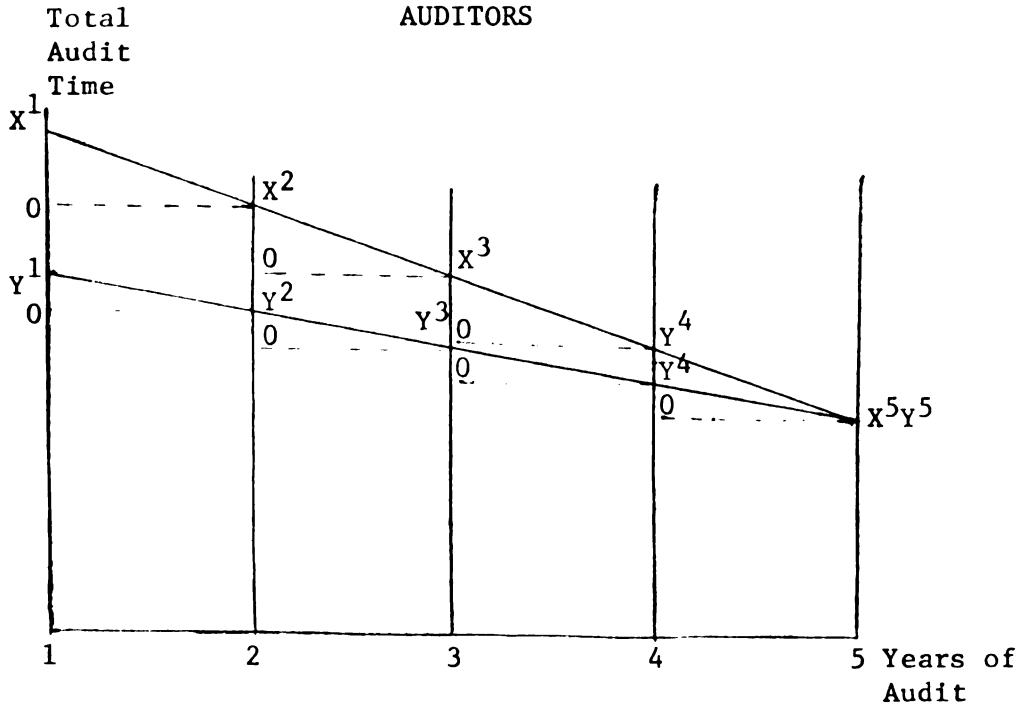
between nearly complete rotation and nearly complete repetition. Efforts should be made to determine the approximate degree of repetition and rotation most conducive to time reduction, auditor satisfaction, and client satisfaction. To determine the cost of a company policy of rotation versus the cost of great repetition in audits, a mathematical approach could be attempted. A mathematical approach has some weakness due to the difficulty of quantifying such audit assignment goals as client and auditor satisfaction, and a competent and versatile staff capable of handling new and unusual situations. However, if some basic quantification were accomplished, a decision of rotation versus repetition, or an intermediate position between the two extremes, can be made with those non-mathematical variables considered as a last step in the analysis. This is a method long practiced in most business decisions. Quantification will help focus attention on other non-measurable factors.

Any analysis undertaken to determine the costs of a trade-off between rotation and repetition should determine B factor changes and subsequent years' time changes. Any loss of potential time reduction of a subsequent audit by not incurring normal time reduction with repetition should be made up in a general gain of the B factor. That is, the rotation policy must result in an enhanced ability to perform first year audits in a minimum amount of audit time. For example, a firm embarking on a policy of rotation after years of allowing substantial repetition on audits should observe increased ability to perform new audits rapdily. This improvement must compensate for the decreased time reduction on subsequent years of a client's audit through not having sufficient repetition of the audit force. Graphically the

trade-off can be described in the following manner:

FIGURE 33

TRADE-OFF IN AUDIT TIME REDUCTION
EXPERIENCED vs INEXPERIENCED
AUDITORS



The trade-off is represented by the vertical distance between curve X^1-X^5, audit time for inexperienced men, and Y^1-Y^5, audit time for experienced men. The smaller yearly time reductions by the experienced men are represented by the areas $Y^1 0\ Y^2$, $Y^2 0\ Y^3$, $Y^3 0\ Y^4$, and $Y^4\ 0\ Y^5$. The larger time reduction for the inexperienced men is in the areas $X^1\ 0\ X^2$, $X^2\ 0\ X^3$, $X^3\ 0\ X^4$, and $X^4\ 0\ X^5$. A minimum time on the first year's audit must compensate for the more rapid reduction obtained by inexperienced men. These two alternative policies are described in the following plans.

Plan A: Average ability accountants repeating on the same audit.

First year time is high with rapid time reduction occurring in successive years. "Learning" or time reduction is due both to individual and organizational causes.

Plan B: More competent accountants assigned to responsible audit positions quickly and rotated frequently. First year time is low because of auditor efficiency. "Learning" or time reduction is difficult to describe because of rotation, sometimes annually, but the minimum time on the first year must come from the basic skill of the auditor, an individual cause. Plan B at all points takes less time but time and pay for each type of auditor must be factored in to derive total job cost. Gain in the B factor should insure minimum initial time on new audits as well as the ability to deal with unusual situations more efficiently.

The preceding analysis portrays verbally and graphically the need for and a method for determining the costs and benefits of a trade-off between the rapid rotation and repetitive policies of auditor assignment. The problem may also be approached in a mathematical context. For example, a determination of the time reduction rate needed by experienced men to attain, in a given period, the time per audit attained by inexperienced men may be made by using the following two formulas. The formula for unit time is:

$y = ax^m$ Where y = total time per unit (or per audit)
a = initial time to perform first unit (or audit)
x = number of units (or number of year's audit)
m = rate of time reduction per unit (or per audit) The rate assumes a negative sign when dealing with time reduction.

If the letter I is used to represent time per audit for inexperienced men, then their audit time formula may be stated as:

$I = ax^m$ (I is substituted for Y, or total time per audit)

Similarly, the letter E may be used to represent total time per audit for experienced men, resulting in the following formula:

$E = a_1x_1^{m_1}$ (E is substituted for Y, or total time per audit)

To calculate the time reduction rate needed by experienced men, the following assumptions are made: time for the first unit for inexperienced men, 1200 hours; time for experienced men, 1000 hours, and that the term units denotes completed audits. The slope of the curve or rate of learning for experienced men is assumed to be less than the rate of learning for inexperienced men (m_1 is less than m). The given period of time, or x, is four years, assuming that in four years the two groups will have identical audit time.

Since x equals years of audits performed, and since on the fourth year, time of both groups is identical, at four years:

$x = x_1 = 4$ (Number of years of audits by each group of men is identical)

Since audit time for the fourth year is identical for both groups of men:

$I = E$

Also, since over the four year audit period, both groups attain the same audit time in the fourth year, the slope needed by the experienced group to attain the same audit time in four years as that attained by the inexperienced group is the observed slope for an 80% time reduction curve of the inexperienced group compared to that

needed by the experienced group:

$$1200\ x^{-.322} = 1{,}000\ x_1 m_1$$

The slope equation may be solved as:

$$1200(4)^{-.322} = 1{,}000(4)^{m_1}$$

$$\text{Log } 1200(-.322)(\text{Log } 4) = \text{Log } 1{,}000 + m_1 \text{ Log } 4$$

$$3.0792\ (-.322)(0.6021) = 3.0000 + m_1\ (0.6021)$$

$$.6021m_1 = 3.0792 - 3.0000 + (-.322 \times 0.6021)$$

$$.6021m_1 = .0792 + (-.322 \times .6021)$$

$$.6021m_1 = -.1147$$

$$m_1 = \frac{-.1147}{.6021}$$

$$m_1 = -.190$$

Thus the slope of the time reduction curve needed for the experienced men in order to equal in four years the time of the inexperienced men is -.190. This will represent an 87.66% time reduction curve as calculated below.

Applying this rate of time reduction or slope to determine the time required by the experienced men, the following result is obtained:

$$\text{Log } y = (1{,}000) + (2^{-.190})$$

$$= \text{Log } 1{,}000 + (-.190) \text{ Log } 2$$

$$\text{Log } y = \text{Log } 1{,}000 - .190 \text{ Log } 2$$

$$= 3{,}000 - .190 \times .30103$$

$$= 3{,}000 - .0571957$$

$$= 2.9428 \text{ (rounding)(in logs)}$$

$$= 876.6 \text{ (antilog of 2.9428 and the second year audit time)}$$

$$\text{Log } y = (1{,}000) + (3^{-.190})$$

$$= \text{Log } 1{,}000 + (.190) \text{ Log } 3$$

$$\text{Log } y = \text{Log } 1{,}000 - .190 \text{ Log } 3$$

$$= 3{,}000 - .190 \times .4771$$

$$= 3{,}000 - .090649$$

$$= 2.909351 \text{ or } 2.90935$$

$$= 812 \text{ (antilog of 2.90935 and the third year audit time)}$$

Applying the same slope to the fourth year would produce 768.4 hours as the time requirement for that year. Calculations would be:

$$\text{Log } y = (1{,}000) + (4^{-.190})$$

$$= \text{Log } 1{,}000 + (-.190) \text{ Log } 4$$

$$\text{Log } y = \text{Log } 1{,}000 - .190 \text{ Log } 4$$

$$= 3{,}000 - .190 \times .6021$$

$$= 3{,}000 - .11444$$

$$= 2.88556$$

$$= 768.4 \text{ (antilog of } 2.88556 \text{ and fourth year audit time)}$$

A comparison of the times of the two groups, experienced and inexperienced, yields the following results:

TABLE 24

HOURS REQUIRED BY EXPERIENCED AND INEXPERIENCED MEN

Experienced Men 87.6% Time Reduction Curve		Inexperienced Men 80.0% Time Reduction Curve	
(Years) Units	Hours required per Unit(audit)	(Years) Units	Hours required per Unit(audit)
1	1,000.0	1	1,200
2	876.6	2	960
3	812.0	3	842.5
4	768.4	4	768

To express the above two time reduction potentials in a percentage basis one would follow time reduction curve theory which states that between doubled quantities, a given percentage time reduction will apply. For the inexperienced men, as audit years were doubled, second year's time was 80% of first year's time, and at four

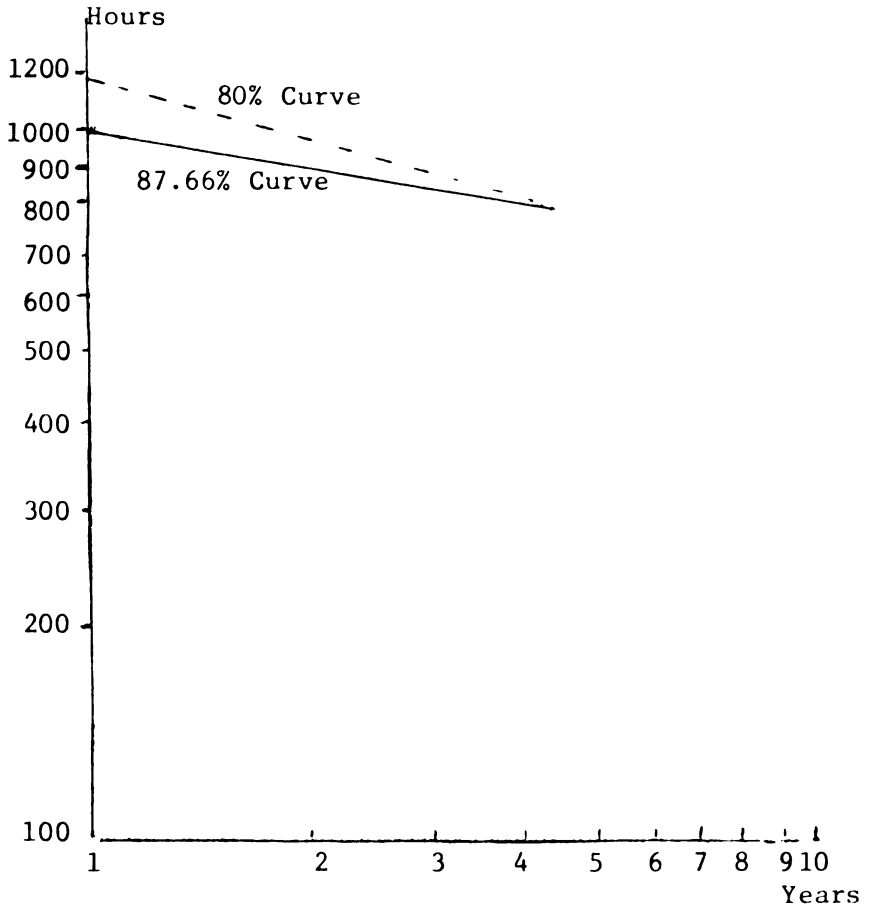
years time was 80% of the time needed in the second year. The slope of the inexperienced men is thus an 80% slope, 960/1,200 and 768/960. The slope for the experienced men is 87.66%, derived as 876.6/1,000 and 768.4/876.6. (For the third year values, Appendix D presents calculations for inexperienced men and calculations for experienced men are shown on page 150-151.) Thus, the experienced men need an 87.66% slope to equal the same time per unit in four years which the inexperienced men will achieve in four years.

If the relative cost of the work force of inexperienced men were compared with that of experienced men, costs of learning can be put on a measurable basis as the comparison in Table 25, given some mix of personnel at various salary levels and performing the same audit for four years, shows.

The following graph sums up on log-log paper the results of the two possible time reduction patterns by experienced and inexperienced personnel.

FIGURE 34

TIME REDUCTION CURVES FOR EXPERIENCED AND INEXPERIENCED MEN



In the curves above, plotted on log-log paper, the upper or 80% curve represents the time reduction behavior for inexperienced men and the lower or 87.66% curve portrays the time reduction achieved by experienced men.

The preceding analysis, however, is not meaningful until the data is converted into cost terms as the following hypothetical example illustrates. The relative cost of audits by a group of experienced auditors is compared to that of a group of less experienced auditors. It may be assumed that the experienced group of auditors would require 1,000 hours for the first year's audit and have an 87.66% time reduction curve and that the inexperienced group would require 1,200 hours for the first year's audit and have an 80% time improvement curve. Thus the difference in time reduction curve slopes would be consistent with the theory that initial time requirements for an experienced group and the degree of time improvement should be less than for an inexperienced group. The assumed composition of the two audit teams and the salary rates per hour are indicated as follows:

Experienced Audit Team (87.66% Time Reduction Assumed)

% of Total Audit Hours Assigned	Rank or Salary Classification	Hourly Rate
20%	Juniors	$5.00
40%	Semi-seniors	7.00
40%	Seniors	10.00

Inexperienced Audit Team (80% Time Reduction Assumed)

% of Total Audit Hours Assigned	Rank or Salary Classification	Hourly Rate
60%	Juniors	$5.00
20%	Semi-seniors	7.00
20%	Seniors	10.00

TABLE 25

COMPARISON OF HOURS AND COST - INEXPERIENCED
vs EXPERIENCED AUDITORS

	Hours required				Audit labor cost			Total Labor	Accumulated Labor
Year	Junior	Semi	Senior	Total	Juniors	Semi	Seniors	Cost	Cost
1	200	400	400	1,000	$1,000	$2,800	$ 4,000	$ 7,800	$ 7,800
2	175	351	351	877	875	2,457	3,510	6,842	14,642
3	160	318	318	796	800	2,226	3,180	6,206	20,848
4	154	307	307	768	770	2,149	3,070	5,989	26,837
	689	1,376	1,376	3,441	$3,440	$9,632	$13,760	$26,837	

Audit team 1 above: Experienced men; 1,000 hours initial time requirement; 87.66% time reduction curve.

	Hours required				Audit labor cost			Total Labor	Accumulated Labor
Year	Junior	Semi	Senior	Total	Juniors	Semi	Seniors	Cost	Cost
1	720	240	240	1,200	$ 3,600	$1,680	$2,400	$ 7,680	$ 7,680
2	576	192	192	960	2,880	1,344	1,920	6,144	13,824
3	506	168	168	842	2,530	1,176	1,680	5,386	19,210
4	460	154	154	768	2,300	1,078	1,540	4,918	24,128
	2,262	754	754	3,770	$11,310	$5,278	$7,540	$24,128	

Audit team 2 above: Inexperienced men, 1,200 hours initial time requirement, 80% time reduction curve.

Experienced			Inexperienced men			Difference: Inex. over Exp.		
Year	Total Hours	Total Cost	Year	Total Hours	Total Cost	Year	Total Hours	Total Cost
1	1,000	$ 7,800	1	1,200	$ 7,680	1	200	($120)
2	877	6,842	2	960	6,144	2	83	(698)
3	796	6,206	3	842	5,386	3	46	(815)
4	768	5,989	4	768	4,918	4	0	(1,071)
	3,441	$26,837		3,770	$24,128		329	($2,704)

The above is a recapitulation of the respective costs of experienced as opposed to inexperienced men.

The preceding example serves to point out that a computational solution to the problem of trade-off evaluation is possible, that relative costs may be and should be measured to determine the fiscal success or shortcomings of a rotation policy. There are some qualifications regarding this evaluation, however. The cost reduction is based on a given mix of accountants at various experience levels and at given pay levels. If either the mix of accountants or the various pay scales is changed, then the outcome of the cost comparison is changed. The results of this example tend to favor the use of inexperienced men as total cost was less over the years. However, this cost conclusion must be rigorously qualified since cost reduction is not the only criteria of audit effectiveness. Other considerations, such as improvement of client's accounting procedures, client retention, etc. may be as important or even more important than cost reductions. Through the use of the foregoing computational approach, attention may be focused on ways to measure achievement of this one criteria of audit effectiveness.

Through the use of mathematics and linear programming, it should be possible to set up a formula which would provide data on cost reduction possibilities with various mixes of experience and pay scales. Developing such formulas would require thorough knowledge of individual firm member productivity which may be difficult for the public accounting firm to determine. It implies that a junior accountant should be expected to perform a given job in a certain amount of time, a semi-senior in a certain amount of time (assumed to be a lesser time), etc. A problem arises in that a senior accountant would normally handle different audit areas than a junior so that some

minimum acceptable mix to allow for needed expertise and experience must be maintained. Beyond this minimum acceptable mix, there should be a possibility for varying the composition of the audit force to allow for special knowledge, skills, etc. to meet the particular demands of a given audit.

Determination of year one audit time

Using the B factor concept, the public accounting firm should be able to determine more accurately the time required for a first year audit. In the aircraft industry, government auditors discovered the B factor, or time required for the first job, and so should a public accounting firm be able to discover the B factor on an audit. If some aircraft firms, in contacting with the government for airplane production, were expected to have a lower first unit time than other firms, this was evidence of knowledge of B factor by firms. The public accounting firm, possessing similar knowledge, should be able to reliably estimate first year audit time.

To determine the first year audit time the public accounting firm might use one of several methods such as:

1. Taking average time for first years of similar audits.
2. Totaling average time for all component parts of an audit. For example, totaling the average or standard time for accounts receivable, plus the average time for inventory observation, etc. Allowance would have to be made for size of audit, etc.
3. Comparing the time required by another public accounting firm for a prior audit and projecting it back to what

the first year's time would be.

If method (3) were to be used, selection of the last year's audit time by the successor firm might be appropriate for several reasons. Rates charged by the public accounting firm taking over the audit probably cannot deviate greatly from those charged by the prior firm. Often last audit time is more readily available and more relevant to current conditions in the client firm than earlier years' audit data. Finally, the last year's audit time may be a present or future target sought by the successor firm. Thus, for the purpose of developing expected first year time, the formula $a = \frac{x}{x^m}$ described below will be useful. Time will be projected backward through the use of this formula, i.e., if the prior audit firm had performed the audit for enough years for the majority of time reduction to occur, the successor firm could estimate first year time as follows:

$$\text{(First year time) } a = \frac{y \text{ (Time prior audit firm required in last year}}{x^m \text{(Successor's slope of time reduction curve)}}$$

(Successor's normal time to reach a minimum time)

It is quite probable that the first year time calculations as suggested in methods (1) and (3) will not agree with the time calculated in method (2). Method (2) would represent total audit time derived by adding the total standard times of the various audit functions based on normal time reduction occurring after several years. Methods (1) and (3) project time back to year one and include all of the factors causing year one to have high time requirements. These factors would include gaining familiarity with the client firm organization, records, personnel, etc., and such organizational factors as scheduling improvements, advance planning, etc. It is this aspect of auditing

which must be isolated in order to determine the added time and cost required for new audits, much of which results from unfamiliarity with the new client. A similar area of considerable interest would be a comparison of first year time by a successor firm with first year time by the prior audit firm. Any observed time difference could reflect differences in the public accounting firm organization, but it could also reflect changes in client, in audit scope, etc.

Eventually the public accounting firm should find that the two main divisions of audit time may be determined as:

1. The period required to become familiar with the client firm, or time required for organizational time improvements to occur, which seems at least partly related to the B factor.
2. The period required to reduce individual task time requirements, or the time needed for individual learning or time improvement to occur, which seems a function of the x factor (years of experience).

Thus, the B factor, or time required for the first audit unit, seems to represent the element of familiarization with a new client firm. The speed of familiarization and time reduction in this division of audit time may depend upon:

1. The unique nature of the client firm, capability of its personnel, condition of records, etc.
2. The audit firm's experience with the type of firm and industry being audited.
3. The skill and experience of the accountants assigned to the audit.

4. The organization of the CPA firm.

5. The pre-audit preparation of the client firm.

Determination of the required first year audit time, based on current time data of a prior audit firm, can be accomplished for a succeeding audit firm through the use of the unit time formula $y = ax^m$. This calculation may be illustrated in the following hypothetical example for which these assumptions are made: a public accounting firm with an 80% time reduction rate normally occurring over a four year period engages a new client; the new client's prior public accounting firm had audited the client for a five year period which is its interval required for normal time reduction to occur, and finally, that the most recent audit required 640 hours. The calculation would be made as follows:

Formulas:

$$y = ax^m$$

$$a = \frac{y}{x^m}$$

Data:

$x = 4$ (Years)

$y = 640$ (Present Hours)

$m = -.322$

Applying the formula:

Let $x^m = R$

$R = x^m$

$\text{Log } R = \log x^m$

$\text{Log } R = -.322\ (.60206)$

$R = -.19306$

$R = \text{antilog } (-.19306)$

$R = .0641$

Then:

$$a = \frac{y}{x^m} \text{ or } a = \frac{640}{0.641} = 1{,}000 \text{ hours}$$

The first year audit by the successor firm would require approximately 1,000 hours.

Some clarification of the assumptions made in the foregoing

example are in order. The time reduction pattern of the prior public accounting firm is not known nor need it be for this analysis. Whereas the prior firm reduced time to 640 hours in five years, the succeeding audit firm contemplates four years only to accomplish this task. It is merely important to assume that the majority of time reduction has occurred for the prior audit firm. Questions may be raised when first year time derived in this manner appears to diverge from first year times developed by the other methods. It may be that the prior audit firm had vastly different competence than the successor firm. In this case, an estimate of first year hours would have to be adjusted to coincide more closely with the estimates based on method (1).

Data of a prior audit firm's billings may not always be available to the successor firm; however, in some instances, it may be obtained when governmental unit or school audit cost is reflected in published or readily available financial reports. A second application of the above procedure would be in determination of first year time which could be allowed for a particular audit. A public accounting firm might have a general idea of the number of hours which could be devoted to the audit yearly over a period of time based on staff size, growth policies of the firm, etc. If the firm could handle the audit at 640 hours yearly over the long term, it would be essential to know the first year time in view of current time pressures and current staff available. The formula above would be useful in this context.

Determination of years needed to reduce audit time

A determination of the number of years required to reduce audit time to some normal, minimum, or long range time requirement may be useful. This determination can be made through a further application of time reduction curve analysis based on a prior firm's experience. A public accounting firm may need to know, given the first year time required on an audit, how quickly they can reduce time to some normal, minimum, or long term average time figure in order to promote long range planning needs in the context of staff time requirements, available personnel, etc. Or, if an audit were taken over from an experienced firm, i.e., one which had performed the audit for several years, the successor firm might wish to know the number of years required to reduce their time to the prior firm's minimum time figure. Again, the assumption is that after several years, significant time reductions will no longer occur. The following hypothetical illustration of this application assumes that the desired audit time is 1,000 hours, after expected time reduction has occurred. It is also assumed that the first year time requirement is 1,500 hours with an 80% time reduction curve.

Formulas:

$$y = ax^m$$

$$\text{Log } y = \log (ax^m)$$

$$\text{Log } y = \log a + \log (x^m)$$

$$\text{Log } y - \log a = m \log x$$

$$m \log x = \log y - \log a$$

$$\log x = \frac{\log y - \log a}{m}$$

$$x = \frac{\text{antilog } (\log 1{,}000 - \log a)}{m}$$

Applying the formulas:

$$\text{Log } 1{,}000 = \log (1{,}500\ x^{-.322})$$

$$\text{Log } 1{,}000 = \log 1{,}500 + \log(x^{-.323})$$

$$\text{Log } 1{,}000 = \log 1{,}500 + (-.322 \log x)$$

$$\text{Log } 1{,}000 - \log 1{,}500 = -.322 \log x$$

$$3 - 3.1761 = -.322 \log x$$

$$.322 \log x = 3 - 3.1761$$

$$\log x = \frac{3 - 3.1761}{-.322}$$

$$x = \text{antilog } .547$$

$$x = \underline{3.52 \text{ years}}$$

Thus, in 3.52 years, audit time can be reduced to 1,000 hours, given the time improvement rate and the initial time requirement. This implies that less than 1,000 hours will be required in the fourth year. To check the accuracy of the foregoing calculation and to illustrate the mathematical application of the time reduction curve, year by year time reduction should proceed as follows:

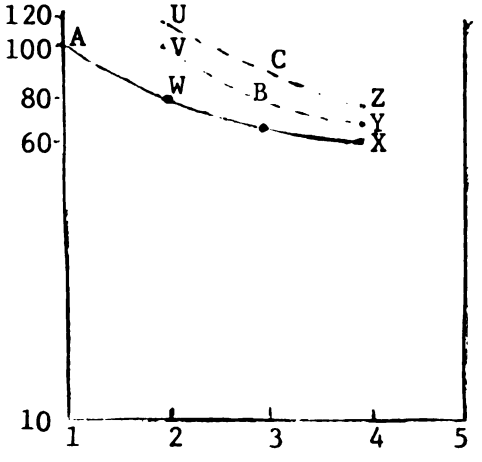
Year	Time required	Time calculations
1	1,500 hours	Given
2	1,200 hours	$y = ax^{m}$ * or $y = ax^{-m}$ $y = (1{,}500)(2^{-.322})$ $\text{Log } y = \text{Log } 1{,}500 + \log(2^{-.322})$ $= \text{Log } 1{,}500 + (-.322) \log 2$ $\text{Log } y = \text{Log } 1{,}500 - .322 \log 2$ $= 3.1761 - (.322 \times .3010)$ $\text{Log } y = 3.1761 - .0969$ $y =$ antilog of 3.0792 $y = 1{,}200$ hours
3	1,052.5 hours	$y = (1{,}500)\ (3^{-.322})$ $\text{Log } y = \text{Log } 1{,}500 + \log(3^{-.322})$ $= \text{Log } 1{,}500 + (-.322) \log 3$ $\text{Log } y = \text{Log } 1{,}500 - .322 \log 3$ $= 3.1761 - (.322 \times .4771)$ $\text{Log } y = 3.1761 - .1536$ $y =$ antilog of 3.0225 $y = 1{,}052.5$ hours
3.52	1,000 hours	$y = (1{,}500)\ (3.52^{-.322})$ $\text{Log } y = \text{Log } 1{,}500 + \log(3.52^{-.322})$ $= \text{Log } 1{,}500 + (-.322) \log 3.52$ $\text{Log } y = \text{Log } 1{,}500 - .322 \log 3.52$ $= 3.1761 - (.322 \times .5453)$ $\text{Log } y = 3.1761 - .1756$ $y =$ antilog of 3.005 $y = 1{,}000$ hours

*The formula $y = ax^{m}$ is the formula for a straight line. If the m in the formula is positive, a positive sloping (upward sloping from the origin or y axis intercept) will result. If the m is negative, the line is negatively sloping or downward from the point of origin. Since time reduction curves imply less time on subsequent units than on the initial unit, the line is downward sloping and the sign preceding m must be negative.

Evaluation of the cost of changes in audit content or client firm induced audit extensions

Time reduction curve analysis may also prove useful to the public accounting firm in evaluating the cost of changes in audit scope. When a client firm merges with another firm, makes any significant change in product line, has turnover of key personnel, converts its accounting system to electronic data processing, etc., an interruption of the normal time reduction process results. This interruption has been observed in industry with a change in tooling, design, specifications, etc. and the time reduction curve then "toes up" or develops "scallops." Graphically, the effect appears as:

Effect of Changes in Audit Content on Audit Hours



Curve A Original Time Requirements	
Units	Time per Unit
1	100
2	80
3	70
4	64

Curve B Time Requirements After Change	
Units	Time per Unit
2	100
3	80
4	70

Curve A represents the original time reduction curve with an 80% slope. Curve B represents a time reduction curve after tooling or other basic change in the item being produced. The toeing up or scallop is the vertical distance from W to V. The time in the second year returned to the same level as achieved in the first year (100 hours per unit.) The result of the change is to cause the time reduction curve to start at the

beginning, as though no prior experience had occurred. The cause of the increased time seems rooted in a need for refamiliarization with the new process.

When audit content changes markedly, or when the audit is extended, a toeing up or scallop effect in audit time may result. There is no assurance that time will return to the time required in a prior audit. Time could well exceed the time required on a prior audit. Thus, a movement to point U on the foregoing graph could occur.

In an industrial situation, a change in any of the factors affecting speed of familiarization with the product manufacturing process can be quite serious. A movement to curve C on the graph would cause the anticipated minimum time or cost per unit (y in the $y = ax^m$ formula) to be either postponed to a later unit in process, or possibly cause the firm never to achieve this minimum cost. The government, in contracting for production, is aware of the time reduction behavior in the contracted firm, and it is normal process for the government to pay for the added cost caused by the increase in unit time.

Public accountants should also be reimbursed for any added time caused by audit content of extension changes. Conceptually, the added fee over the years should be based on the area V W X Y, if the second year audit required the same time as the first year. The total hours contained in this area multiplied by the average charging rate per hour would be the additional fee needed. (This assumes that fees were allowed to drop as time was reduced. In this case, after a change in audit content, fees would have to increase.) Movement in time requirements to a point such as U could cause the public accounting firm confusion in charging policy and also in scheduling manpower needs. When a time

reduction should occur, but in fact an increase in time occurs, there is actually a double loss to the firm. Normal time reduction from A to W should be contemplated if the audit is stable, and if all factors promoting time reduction are operative on the audit. Thus, the fact that audit time remains constant in year two is one loss, and the fact that audit time increased beyond the year one time is a second loss. Thus, the total additional fee needed over the years is the result of the hours contained in the area U W X Z multiplied by the average charging rate per hour.

Cost control sheet embodying time improvement analysis

A cost control sheet can serve many purposes for the CPA firm. It can serve as a basis for billing the client and for a comparison of actual versus budgeted time. It can also serve as an aid in determining the behavior of time expended when certain variables are present on the audit. These variables are the factors influencing time reduction, and so the cost control sheet should provide columns for all of the time reduction variables and a scale to rate the degree of presence or absence of these variables on the audit. With more time reduction variables present, more time reduction is to be anticipated.

Time records examined during this study presented a broad spectrum of data accumulation from the very basic to the very detailed. Those embodying very basic data were insufficient for time control; those containing very detailed data were time consuming for auditors to compile during the audit. One firm's control sheet represented a good minimum standard for a cost control sheet and was not prohibitive in time required for its compilation. An abbreviated format of this sheet is

presented on the following page. The addition of a section for those factors promoting time reduction would increase its potential for time control. Data for two prior years of a firm's audit is presented in detail by audit function. Improvement or lack of improvement in total audit time as well as individual function time is thus made visible. When actual time for individual audit function departs from estimated time, it is possible to accumulate these deviations by function over a large number of audits and thus ability for time estimating could be improved. It should be evident that for functions of a more routine and repetitive nature actual and estimated time would be fairly similar. When actual and estimated time consistently do not agree, these functions would appear to be the more non-repetitive functions. Perhaps the most important advantage then of this time control sheet is its tendency to isolate the non-repetitive aspects of the audit, which should lead to an analysis of the causes of the non-repetitive aspects and possible ways of eliminating them in the future. Certainly not all non-repetitive aspects can be avoided but those which rest with the audit firm should be minimized wherever possible.

The analysis form accompanying the time control sheet might serve as the means for analyzing the non-repetitive area developed from the sample time control sheet. The first step would be a separation of the variance in actual time over estimated time into two components: audit firm related time variances and client related time variances. The audit firm related variances should pertain to time which is absorbed and not charged to the client because of some fault in the firm's audit method. The client billed item would normally cover the client related time variances. Each type of variance would then be analyzed according

FIGURE 36

Sample Time Control Sheet

Auditor

HOURS BY FUNCTION

Date	ESTIMATED HOURS	Total Hours	Cash	A/C. Rec.	Invy.	Invy. Obsv.	Gen. Plan. & Superv.	Gen. Ledg. Trial Bal.	Prepaid & Def. Exp.	N. Pay & L. Term D.	Anal. & Tests	Cap. Stock & Surplus
Total												
Actual over(under) est.												
Act. Hours. Prior Audit												
Act.Hrs.2nd.Prior Audit												

FIGURE 37

Analysis Form
To Accompany
Sample Time Control Sheets

Firm Audited _____

Year	Est. Hours	Actual Hours	Disposition of Difference		Firm Related Time Variance						
			Billed	Absorbed	Years Prior Audits	% of repeat Hours	Total audit experience	% of men co. trained	Uninterrupted Audit Time	Firm staff Coordinate	Pre-Audit Conference

Explanation:

Years prior audits---number of prior years auditing this firm prior to this year's audit.
% of repeat hours----hours performed by men who worked on job in 2 prior years, 1 year or both years/total audit hours.
Total audit exper.---total years public accounting experience brought to bear on this audit. (No. of Menxyrs. exp. per man)
% of men co. trained-if 4 out of 5 men on audit are company trained, then 4/5 = 80% company trained.
Unint. work time-----Rate from 5 (uninterrupted time) to 1 (very interrupted time to work on other audits, taxes, etc.)
Firm staff coord.----Rate from 5 (excellent cooperation in providing tech. aid, computer time, etc. also clerical help when required) to 1 (Poor) (Scheduling quality could be included under this caption).
Pre audit conference-Rate from 5 to 1 (5 excellent, 1 poor) for degree of problem prevention by pre-audit conf.

Client Related Time Variances

Year	Change in Audit Scope	Internal Control Changes	Personnel Changes	Special Studies Required	Computer Related Problems	Degree of Client Cooperation

Explanation:
Change in audit scope--rate 5 for same of smaller scope, 1 for great increase.
Internal Control changes--rate 5 for no. int. control problems
Personnel changes-rate 5 for stable personnel at client's office.
Special studies--rate 5 for none required.
Computer related problems--rate 5 if none.
Degree of client cooperation--5 for excellent cooperation, adequate record availability, scheduling prep. aid, etc.

to possible causes. While this judgment would be subjective, experience should effect some degree of facility in estimating the causes of time variance. An important by-product of the analysis of audit time behavior would be the rigorous examination of the "anatomy of an audit." In the larger firms, there may emerge a need for an "audit time specialist" similar to the methods department of an industrial firm.

Use of a specialist in time reduction

In larger public accounting firms, it might be advantageous to assign a man or a section of the firm to work exclusively on time reduction and time control on audits. This function is performed either formally or informally in national companies at present, however a specialist might use such tools as the analysis form and time control sheet to analyze time variances more carefully. Only by pinpointing the cause of variances can these either be prevented when the fault lies with the public accounting firm, or charged to clients when they have caused the variance.

Points may be assigned to the audit as suggested on the time analysis sheet and eventually a pattern of time reduction and points assigned established. Thus, the more points assigned to an audit, the more time reduction the firm should expect. A high point total would indicate the presence of factors required for maximum time reduction such as client cooperation, adequate pre-audit planning, proper staff assignment, uninterrupted work time, etc. If many points were assigned to an audit, and the expected time reduction did not occur, the audit firm time reduction specialist could then seek out other factors related to time reduction which may have been omitted as causes of such reduction.

Finally, the points might be correlated with expected time reduction as follows:

1. Variables deemed conducive to time reduction (or time increase)-10 variables. These would be established by combined staff judgment.

2. Maximum points assigned to all variables, 100 points, or 10 points for each variable.

3. Percentage of time reduction in particular year of an audit 20%.

4. Value of points as effecting time reduction:

$$\frac{\text{20\% expected reduction}}{\text{100 points assigned to factors causing reduction}} = \text{.2\% time reduction potential for each point present}$$

5. If then, a total of only 30 points were present on an audit, the expected 6% time reduction would be determined as:

30 points of reduction factors present x .2% = 6%

Summation

Consistent with time reduction curve theory, time reduction in public accounting appears to depend on the B factor and on the slope of the curve. The organizational factors selected for examination are more associated with development of the B factor while the individual factors examined appear to relate to slope of the curve. The two factors most closely correlated with and predictive of time reduction, stability and repetition, appear to be, respectively, B factor and slope components. One factor, hours by new men, was examined as a secondary calculation to account for total hours spent on audits. This factor rated third among all factors examined in its time reduction correlation and predictive qualities and would seem to be properly related and included in the B factor. It represented, especially for national firms, an attempt to improve the C.P.A. firm competence to deal with unusual audit problems

by rotating men through a series of progressively more responsible positions. Thus, the three most important factors bear out the significance of B factor and slope in reducing audit time.

Several other aspects of time reduction curve theory may prove applicable to public accountants. Time reduction curve formulas may be useful for such purposes as estimating: the cost of the trade-off of balanced experience for B factor development vs repetition for slope improvement; the first year audit time; the years needed to reduce audit time; the years needed to reduce audit time; and the cost of audit scope changes. These may all be useful for particular needs but they are dependent on the maintenance of audit time records in proper detail.

The eight basic factors examined, as well as the factor of hours by new men, appear to account for 52% of the time reduction in the second years audits and 61% in the third year audits on a total time basis. Obviously all time reduction has not been explained. Furthermore, on an inter-firm comparison in year three of local firms, the three most significant variables do not reliably predict time reduction. While this may be due in part to the small sample size (42 audits for local firms, year three). it is felt that there are other variables affecting time reduction which are not measured in this study. These factors were not evaluated due to limitations of data availability and due to difficulties of objective measurement as discussed in Chapter VI. These factors, as listed in the sample time control sheet and analysis form, could be incorporated into in-house studies where many of the limitations faced in this study would not be encountered. Finally, those difficulties of obtaining data, experienced in this study due to its ex post facto

nature, could be solved by the public accountant by advance planning prior to conducting such a study over successive years.

In conclusion, it is hoped that this study may provide a "stepping stone" to future "in-house" studies of time reduction in public accounting. It was through such studies that modern industrial and clerical time control systems evolved.

FOOTNOTES

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[3]Ronald Brenneck, "The Learning Curve for Labor Hours for Pricing," N.A.A. Bulletin, June, 1958, p. 77.

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[10]Gordon W. Link and Don A. Ellis, op. cit., p. 2.

[11]Frank J. Andress, op. cit., p. 88.

[12]Carl Blair, "The Learning Curve Gets an Assist From the Computer," Management Review, August, 1968, p. 34.

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[15]Leonard W. Hein, The Quantitative Approach to Managerial Decisions, Englewood Cliffs, New Jersey: Prentice-Hall, 1967, p. 98.

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[17]Ibid., p. 2-2.

[18]Ibid., p. 2-1.

[19]Ibid., p. 2-4.

[20]Ibid., p. 2-8.

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[22]Frank J. Andress, op. cit., p. 88.

[23]Wayne J. Morse, The Allocation of Production Costs with the Use of Learning Curves, Unpublished Doctoral Dissertation, Michigan State University, 1971, p. 15.

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[25]James A. Broadston, "Learning Curve Wage Incentives," Management Accounting, N.A.A., August, 1968, p. 16.

[26]Ibid., p. 17.

[27]Raymond S. Jordan, op. cit., p. 1-7.

[28]William F. Brown, Roy W. Smith, William C. Lansing, and Henry G. Horton, Improvement Curve, The Boeing Company, Seattle, Washington, 1963, p. 17.

[29]Ronald Brenneck, op. cit., p. 71.

[30]Gordon W. Link and Don A. Ellis, op. cit., p. 3.

[31]Raymond S. Jordan, op. cit., p. 2-10.

[32]Ibid., p. 2-10.

[33]Frank J. Andress, op. cit., p. 89.

[34]Leonard W. Hein, op. cit., p. 107.

[35]Frank J. Andress, op. cit., p. 89.

[36]J. M. Blackburd, "The Acquisition of Skill, an Analysis of Learning Curves," Report No's. 67-73, Medical Research Council, Industrial Health Research Board, London, 1936, p. 20-21.

[37]S. Alexander Billon, op. cit., p. 23.

[38]Winfred B. Hirschman, op. cit., p. 128.

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[40]Wayne J. Morse, op. cit., p. 9-10.

[41]Brown, Smith, Lansing, and Horton, op. cit., p. 60.

[42]Gordon W. Link and Don A. Ellis, op. cit.

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[47]Ibid., p. 193.

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[55]Ibid., p. 91.

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[66]S. Alexander Billon, op. cit., p. 30.

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[69]Winfred B. Hirschman, op. cit., p. 134.

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[74]Maurice L. Taylor, op. cit., p. 22.

[75]Frank Powers, op. cit., p. 91.

[76]Nicholas Baloff, op. cit., p. 281.

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APPENDICES

APPENDIX A

Selected Comments on Time Reduction Study

by Certified Public Accountants

From National Firms:

"No appreciable time reduction (on nine audits surveyed) but there is a shifting of work load to more junior members of the firm. The same economic advantage accrues to the firm as though a total time reduction took place."

"There are too many variables affecting examinations from one year to the next to make regression analyses provide meaningful results."

"It is unusual for an individual to repeat on such phases as bank reconciliations.
In firms specializing by industry-as with hotels-there may be found the degree of repetition needed for the study.
There may be some repetition by supervisors in charge of field work."

"I know there is a definite improvement pattern but apparently no one has tried to measure it or to quantify it in any way."

"The principal benefit accrues from the reduction of supervision time rather than the time devoted to the task itself. The reduction in detail checking and rapid advancement of staff accountants would significantly reduce the situations from which to draw conclusions."

"Study would be useful to practicing accountants but records may not be kept in sufficient detail to give data needed."

"Hopefully, experienced men returning to the job will cause time reduction even though he may not serve in the same capacity."

From Local Firms:

"There is too wide a range of competency of client personnel. Constant attempts are made for client preparation of detailed analysis and work schedules. There is a constant input of new members to audit engagements as men mature into supervisory positions."

(Regarding differences in tax time required) "Complications arise in:
Differences in personnel
If the same person repeats (on the tax) his time should be improved.
Varying information on the taxpayer from one year to the next
Differences in methods, manual vs computer
Differences in interview time required

APPENDIX B

Detailed Listing of Comments by CPA Firms Regarding Proposed Time Reduction Analysis for CPA Firms

	Factors which will cause difficulty in the study	Firms citing this factor
1.	Variability of clients by size	1
2.	Variability of clients by type	1
3.	Changes in the type of client's business	1
4.	Changes in client's geographic area	1
5.	Changes in client's corporate structure	1
6.	Personnel turnover in client's office	2
7.	Changes in client's accounting procedures	1
8.	Changes in composition of the audit staff	1
9.	Varying degrees of experience of audit staff	1
10.	Lack of detailed records at CPA firms	2
11.	Confidential nature of the records	1
12.	Records will vary from client to client	2
13.	There is rapid avancement of staff accountants	1
14.	There is a reduction in detailed checking	1
15.	Manpower vs computer processing changes	1
16.	Lack of repetition of men on same tasks	1

	Factors which are favorable to the study	
1.	It is known that there is a reduction in supervisory time	1
2.	Should be time reduction in specialized CPA firms	1
3.	There is certainly a pattern of reduction	1
4.	Indirect time reduction through shifting more work in second and third years to less experienced personnel	2
5.	Men do repeat on audits but not on same phases, should be time reduction through familiarity	1

APPENDIX C

Determination of Slope for an 80% Time Reduction Curve

In the formula $y = ax^m$, y is time required per unit after time reduction occurs, a is the initial time required per unit, x is the number of years, and m is the slope or degree of learning or time reduction.

The slope, m, for an 80% time reduction curve may be calculated as:

When $x = 1$, $y = 100$

$x = 2$, $y = 80$

$x = 4$, $y = 64$

$$\log y = \log a + \log x^m$$

$$\log y = \log a + m \log x$$

(1) $\log 100 = \log a + m \log 1$

(2) $\log 80 = \log a + m \log 2$

Then, (1) $\log a = \log 100 - m \log 1$

(2) $\log 80 = \log 100 - m \log 1 + m \log 2$

$$\log 80 - \log 100 = m \log 2 - m \log 1$$

$$m \log 2 - m \log 1 = \log 80 - \log 100$$

$$m (0.30103 - 0.00) = 1.9031 - 2.0000$$

$$.30103\ m = .0969$$

$$m = \frac{-0969}{.30103}$$

$$m = -.322$$

The slope of -.322 may now be used in the formula $y = ax^m$ to compute unit time requirements.

APPENDIX D

Calculation of Yearly Time Requirements

Assume year 1 requires 1,200 hours = a

Assume slope or degree of learning is 80% = m
(Appendix C shows m value of -.322 for an 80% slope)

Assume year of the audit = x

Then, $y = ax^m$ and $y = ax^{-.322}$

For year 1 = 1,200 hours given

For year 2 = $y = ax^m$ or $y = ax^{-m}$

$y = 1200\ (2^{-.322})$
$\log y = \log 1200 + \log (2^{-.322})$
$= \log 1200 + (-.322) \log 2$
$\log y = \log 1200 + (-.322 \log 2)$
$= 3.0792 + (-.322 \times .3010)$
$\log y = 3.0792 - .0969$
$y =$ antilog of 2.9823
$y = 960$ hours

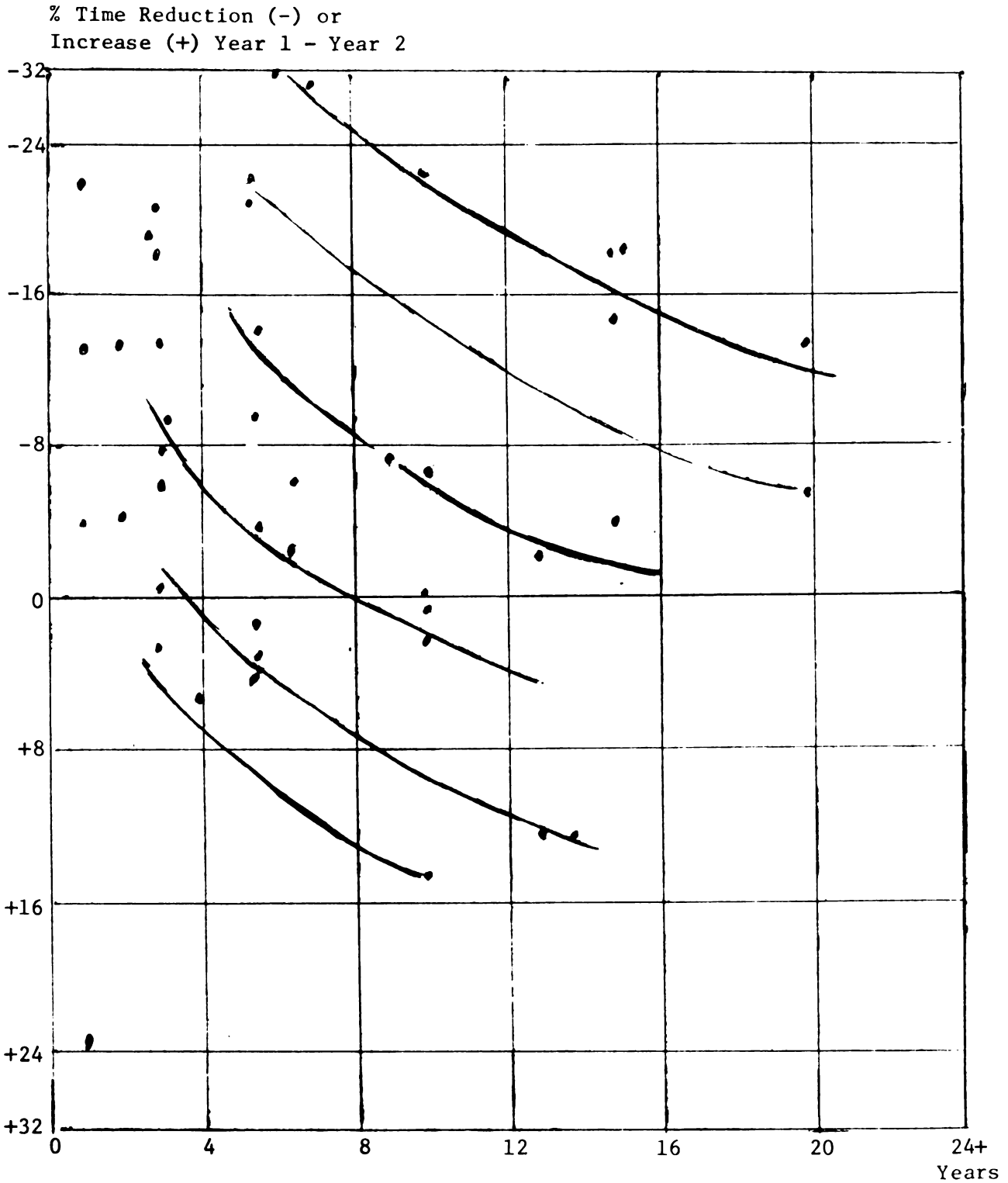
For year 3 = $y = 1200\ (3^{-.322})$
$\log y = \log 1200 + \log (3^{-.322})$
$= \log 1200 + (-.322) \log 3$
$\log y = \log 1200 + (-.322 \log 3)$
$= 3.0792 + (-.322 \times .4771)$
$\log y = 3.0792 - .1536$
$y =$ antilog of 2.9256
$y = 842.5$ hours

For year 4: $y = 768$ hours by the same method as above

APPENDIX E-1

FIGURE 38

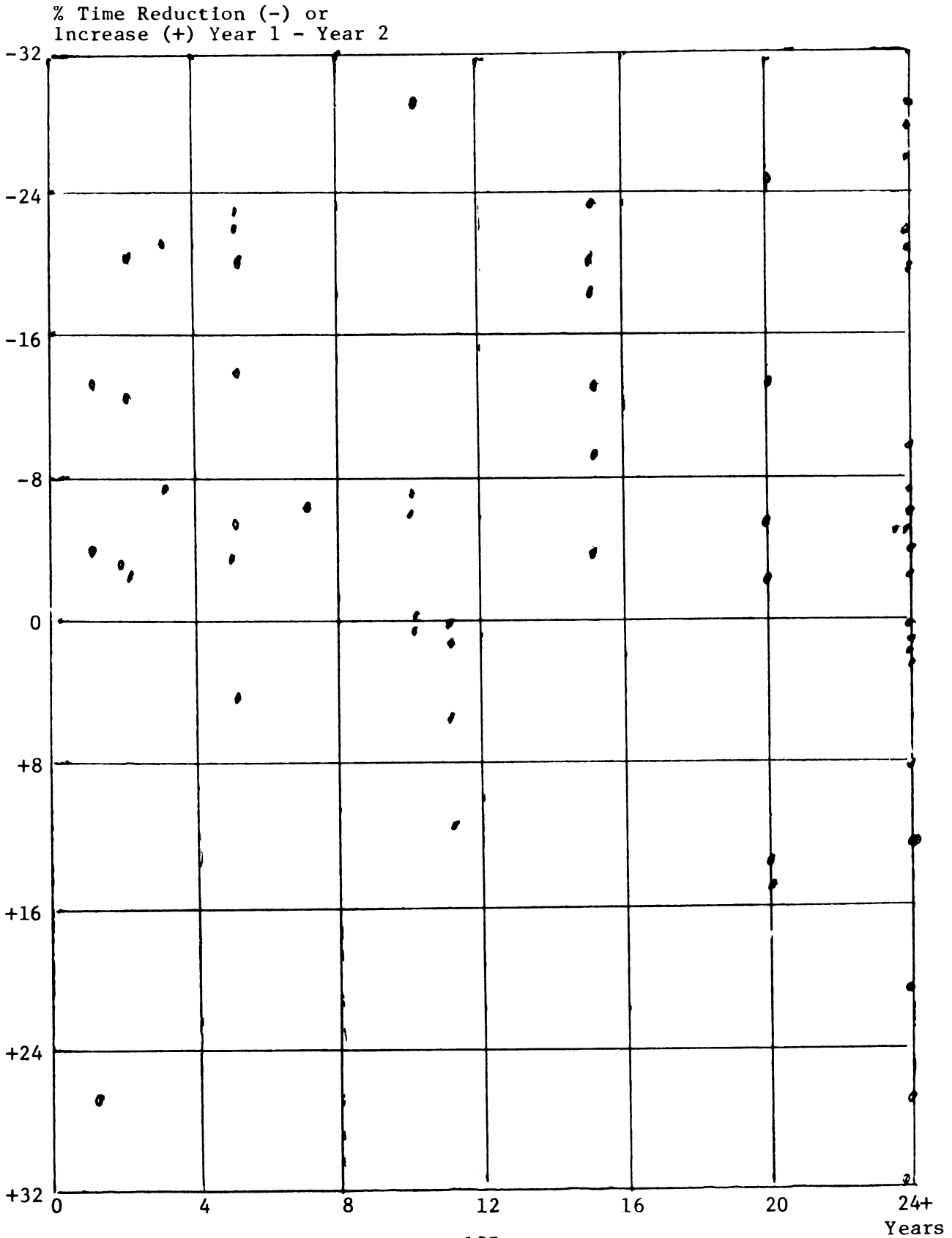
RELATION OF FIRM EXPERIENCE AND TIME REDUCTION
(Curved Lines Represent Decreases in Time Reduction)
Trend Over the Years



APPENDIX E-2

FIGURE 39

RELATION OF CLIENT INDUSTRY EXPERIENCE AND TIME REDUCTION



APPENDIX E-3

FIGURE 40

RELATION OF AUDIT SIZE AND TIME REDUCTION

(All Audits Grouped as those Requiring 90 to 150, 150 to 210, etc.)