AN ABSTRACT OF THE THESIS OF

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Interfirm comparisons are used internationally to provide productivity measurement systems. These systems indicate changes in productivity. The development of interfirm comparisons in Britain, Australia, and Canada is discussed. Interfirm comparisons have also been conducted in the United States under the auspices of various trade associations. However, in the United States these comparisons are the exception and not the rule.

Any nation needs to improve productivity if it is to become or remain competitive in the market place. Accurate measurement is a pre-condition for productivity improvement. This study establishes a measure that can be employed by small businesses to determine their own productivity standing. The Weighted Ratio Productivity Index (WRPI) is that measure.

Research was conducted at Electro Scientific Industries (ESI), an electronics firm located in Portland, Oregon. A five year period of financial and production data (1976-1980) were collected and analyzed.

The versatility of the Weighted Ratio Productivity Index is a

tremendous benefit of its development. The WRPI can be modified to suit many types of industry. A benefit for ESI is the creation of the WRPI. Prior to this study a comprehensive method of productivity measurement did not exist in this company. The firm will use the method in this thesis for future productivity measurement.

From this research a Total Productivity Index could be developed with the use of an aggregate weighted ratio productivity index similar to the WRPI. This index would be very useful for both intra- and interfirm comparisons.

Intrafirm and Interfirm Productivity Comparisons

by

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INTRAFIRM AND INTERFIRM PRODUCTIVITY COMPARISONS

INTRODUCTION

This is a study of productivity. It was conducted by using interfirm comparisons to develop a format for intrafirm comparisons. Interfirm comparisons are defined as a comparison of industry-level data with individual company data in order to appraise the performance of the individual firm. The intrafirm productivity comparison is a comparison of a firm's financial and production data on a period to period (year to year) basis to appraise the internal performance of the company. By comparing the data on a period to period basis, favorable and unfavorable trends can be detected and appropriate management decisions can be initiated.

Productivity performance is perhaps the best single indicator of an economy's health. Gains in standards of living come from a rising productivity. Poor productivity growth weakens the ability of a country to compete in world markets and the implications of continued weakness are indeed unpleasant.

Deterioration in American productivity since the mid-1960's has changed the overall trend of positive growth that had been occurring since the early years of this nation's history. Table 1 illustrates the growth rate of productivity, which is defined as "output per worker hour in the private business section," and also indicates the necessity for research into productivity growth.

A comparison of U.S. productivity growth with that of eight other

major industrialized nations is another indicator of diminishing productivity. Table 2 illustrates that the United States, compared to Japan, Italy, Germany, France, the United Kingdom and Canada, was in last place in the period of 1950 to 1973 and is still in last place in productivity growth in the period of 1973 to 1978.

It has been indicated in the literature that an improvement in overall national productivity is dependent upon improvements at the individual level of business.[1] To improve productivity it is necessary to have a measure of corporate productivity before any improvement action can be taken.

The traditional method of productivity measurement relies upon a partial productivity index: OUTPUT/DIRECT LABOR HOURS or PRODUCTS PRODUCED/QUANTITY OF MATERIAL USED. However, a partial index can lead to improper conclusions about productivity. The following is an illustration. Assume a company measures productivity on the basis of OUTPUT/LABOR HOURS and that the company buys a different, higher quality raw material. This new material reduces the man-hours needed to process the product. This, in turn, yields an improved productivity index. However, if the increased cost of materials equals or exceeds the labor-cost savings, there has been no real gain for the company.

A total productivity index is another measurement method. Reviewed literature indicates that a total productivity index (TPI) can be used when TPI = OUTPUT/SUMMATION OF INPUT FACTORS. Input factors are labor, material, capital, energy, and services. However, here again there are problems with the TPI. First, it is difficult to clearly separate and define input categories. For example, "capital" and "materials" are nearly impossible to separate because

Table 1

Productivity growth in the United States 1900-1981

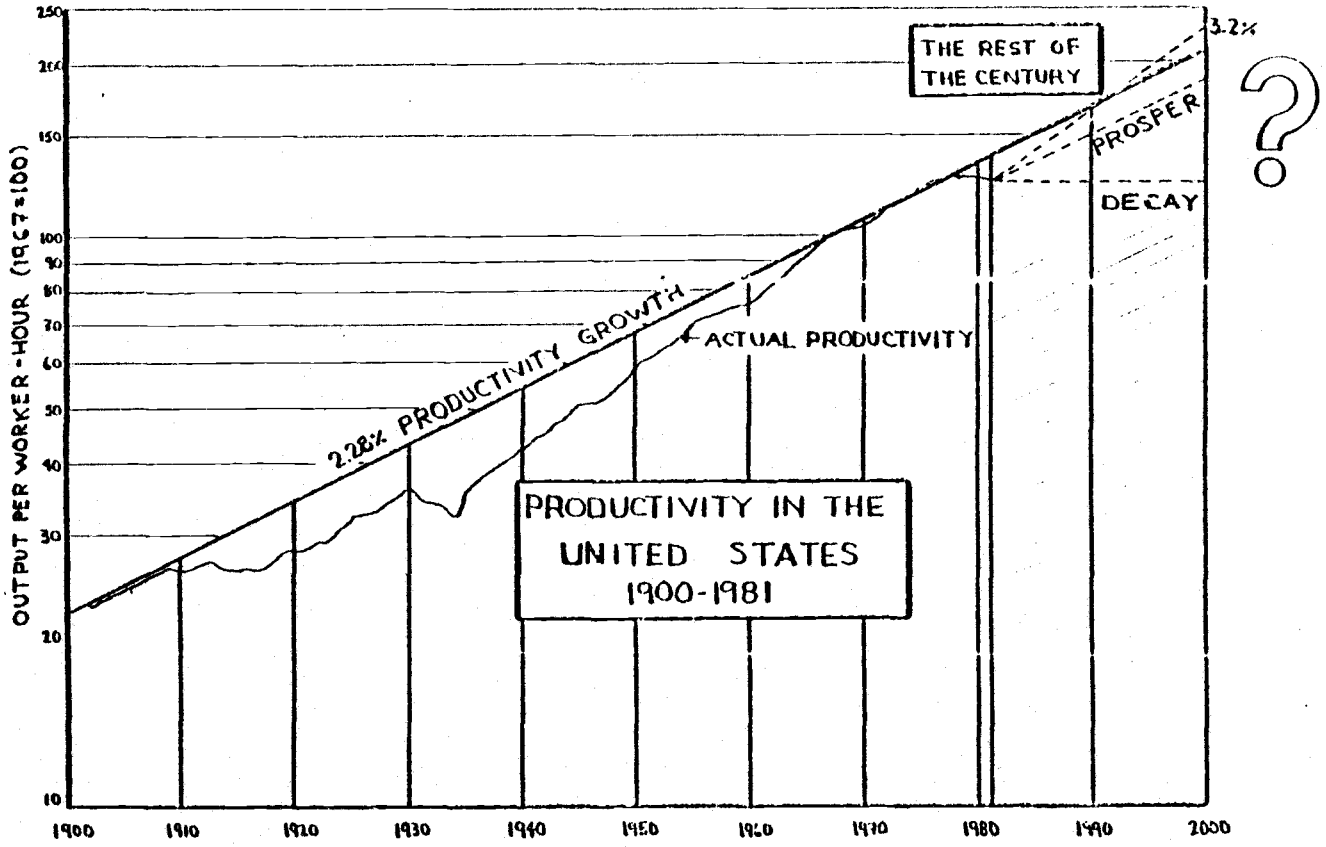
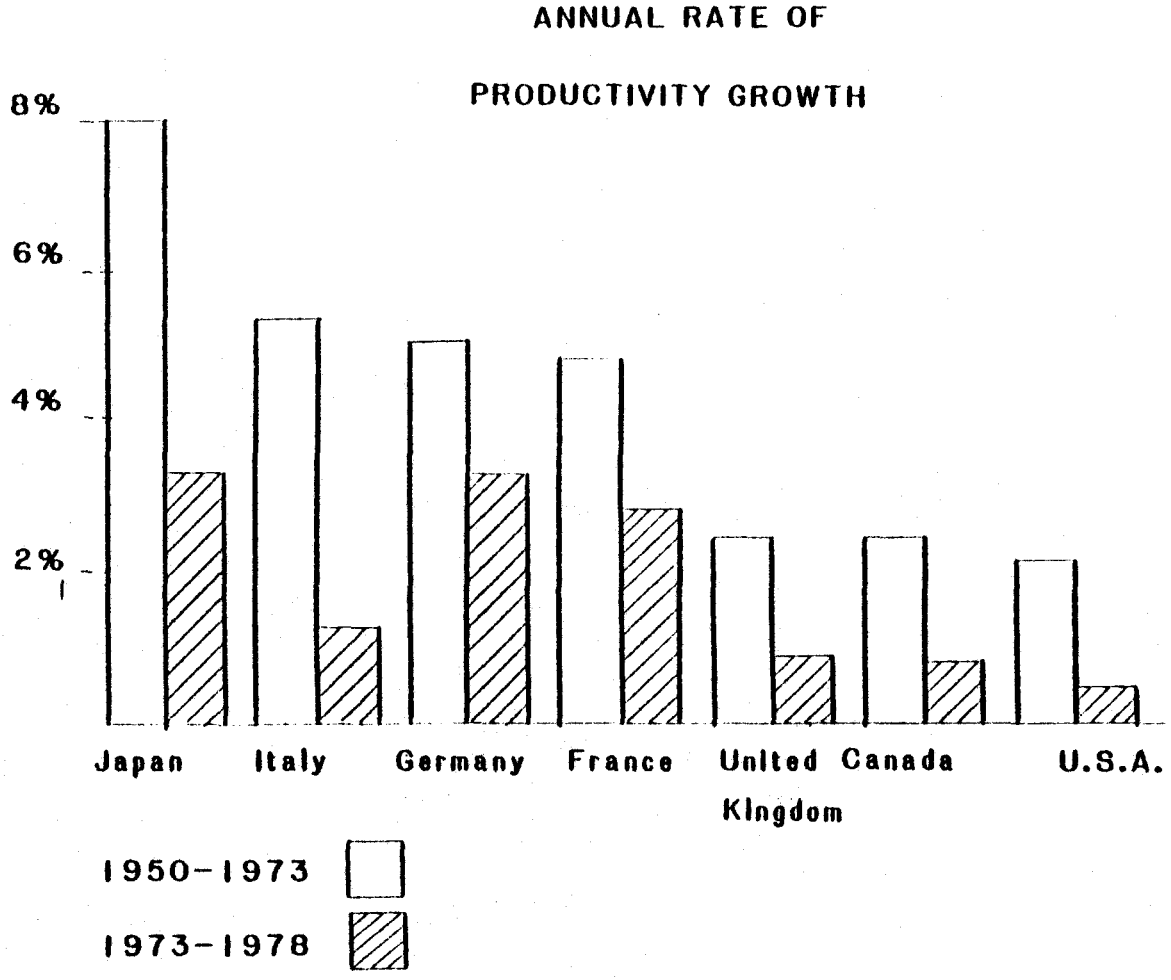


Table 2


ANNUAL RATE OF
PRODUCTIVITY GROWTH
8%
6%
4%
2%
Japan
Italy
Germany
France
United Kingdom
Canada
U.S.A.
1950-1973
1973-1978

some materials may be included in the working capital of a firm. Second, traditional accounting systems available in many small businesses do not provide the immense amount of data needed to establish a TPI.

Therefore, a weighting ratio method of productivity measurement is presented in this study. The ratio method has the ensuing benefits and unique characteristics:

1. The ratios are developed for a particular area of company operations (i.e. machine utilization rates are specific to the production area).
2. By measuring the ratios on a year to year basis, trends can be noted and plotted. If they indicate a needed change, appropriate management activities can be initiated.
3. From a general group of ratios certain key indicators can be selected. Weighting factors are then applied to those indicators and a specific productivity index is the end result.
4. The ratios link any difference in productivity with the source of change. From this, corrective action can be directed to the proper area of company operations.
5. The ratio method is easier to use because it employs readily available production and financial data.

The purpose of this study is to develop a measure which can be used by small businesses to determine their productivity standing, and then take the appropriate action to improve their productivity. This measure is an intrafirm productivity comparison which was conducted at Electro Scientific Industries (ESI) in Beaverton, Oregon. The

study was conducted during the period of December 1980 to May of 1981. Data were collected for financial and production ratios from the subject firm that included a five year period, for fiscal years 1976 to fiscal year 1980. After the data were collected, ratios were formed which indicated financial performance and also served as non-financial performance indicators. As a result of this study, future data collection formats were developed. These will be used in ESI's future operations and include surrogate measures which infer productivity performance, that is, quality control ratios, machine-hour utilization, and lost time.

Interfirm and intrafirm comparisons can help solve a key management dilemma in productivity by answering the following questions: Is the company efficient? Does the company make the best use of resources such as assets, labor, and capital? Does the company make the profits it should? Additionally, the intrafirm comparison has provided a yardstick that ESI can use for future performance measurement. If the data collected in the intrafirm comparison is used in comparison with other firms in the same industry, performance measurements can be inferred. Some examples will help clarify the above statement. Example 1: If budgeted expenditures are six percent for a performance category, but actual expenditures are only five percent for that category, this indicates a favorable performance for the company. However, when the competition spends only four percent in that category, management could question the actual performance in that category. By comparing the data with competitors in the same industry, both the strengths of a company and its weaknesses can be highlighted. By knowing this, the efforts of

management can be concentrated in those areas where it is necessary to improve the performance. Also, the company will be able to keep abreast of changes and trends in the industry.

CHAPTER II

BACKGROUND AND HISTORICAL DEVELOPMENT OF INTERFIRM PRODUCTIVITY COMPARISONS

Although interfirm productivity comparison has not been conducted in the United States on a national scale, some associations engage in comparisons. The National Screw Manufacturer Products Association and the National American Wholesale Grocers Association have done so. Interfirm productivity comparisons are, however, widely used in other countries. In this chapter, there is a discussion of interfirm comparisons in Britain, Australia and Canada.

Interfirm Comparisons in Britain

In 1959 interfirm comparisons were established in Britain. Interfirm comparisons were started under the auspices of the organization called Center for Interfirm Comparisons, Limited. This was established as a non-profit organization which was a sub-group of the British Institute of Management and was in association with the British Productivity Council. In the period of 1959 to 1974 interfirm comparisons were done in 80 industries in Britain and included several thousand individual firms. The types of ratios studied are shown in Table 3. The ratios studied included: OPERATING PROFIT/ OPERATING ASSETS; OPERATING PROFIT/SALES; CURRENT ASSETS/SALES; and FIXED ASSETS/SALES.

The above ratios are formed using the company's data. Then an intrafirm comparison can be made, as shown in Table 4. The intrafirm comparison allows a comparison of data from a base year to a current

Table 3

Types of ratios used in British interfirm comparison studies

(Courtesy of the Centre for Interfirm Comparison Ltd. 1970)

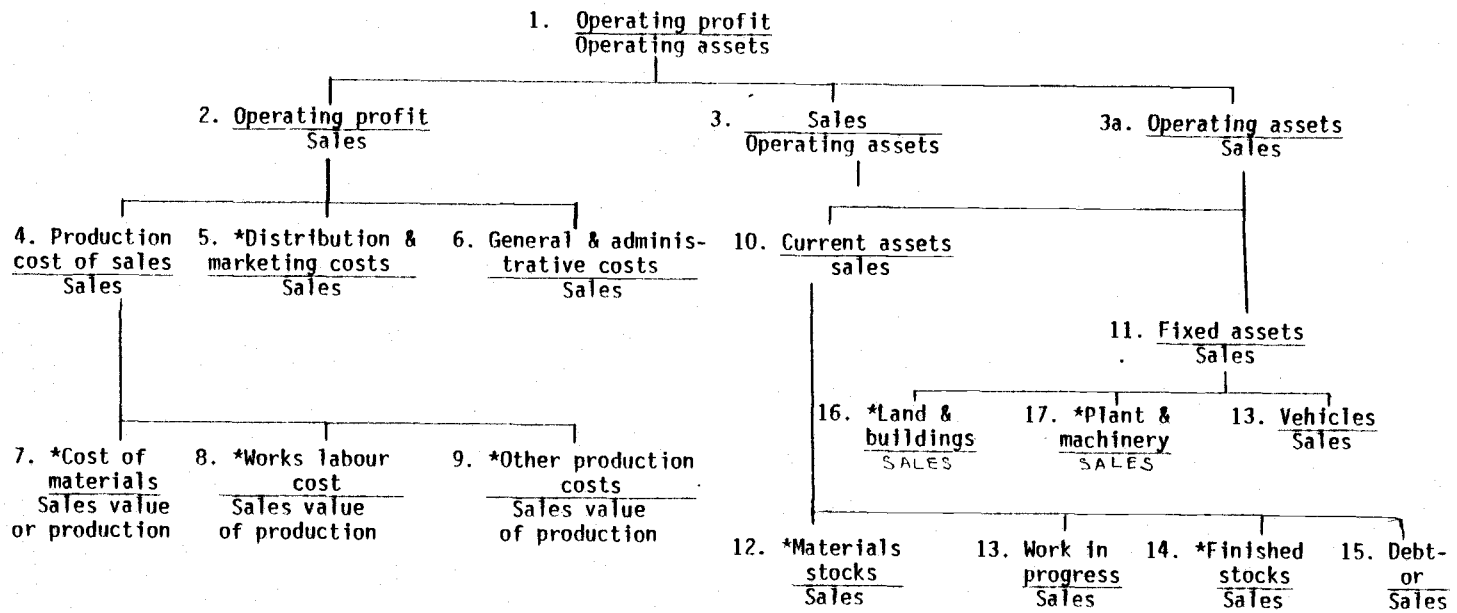


Table 4

Intrafirm Comparison

(Courtesy of the Centre for Interfirm Comparison Ltd. 1970)

	Year 1	Year 2
Return on assets		
1. Operating profits/Operating Assets (%)	8.2	9.8
Profit margin on sales and turnover of assets		
2. Operating profits/sales (%)	7.9	9.0
3. Sales/Operating assets (times per year)	1.04	1.09
Departmental costs (as % of sales)		
4. Production cost of sales	78.3	77.1
5. Distribution and marketing costs	6.4	6.5
6. General and administrative costs	7.4	7.4
Production costs (as a % of sales value of production)		
7. Materials cost	33.8	33.7
8. Works labour cost	28.8	27.9
9. Other production costs	15.7	15.5
General asset utilization (£'s per £1000/sales)		
3a. Operating assets	961	913
10. Current assets	524	479
11. Fixed assets	437	434
Current asset utilization (£'s per £1000/sales)		
12. Materials stock	119	100
13. Work in progress	154	130
14. Finished stocks	35	40
15. Debtors	216	209
Fixed asset utilization (£'s per £1000/sales)		
16. Land and buildings	201	200
17. Plant, machinery and works equipment	232	230
18. Vehicles	4	4

Table 5

Industry-wide interfirm comparison

Return on assets							
1. Operating profit/Operating assets (%)	22.9	20.7	16.6	13.1	10.3	9.8	4.2
Profit margin on sales and turnover of assets							
2. Operating profit/sales (%)	18.9	18.0	14.4	12.4	9.9	9.0	4.7
3. Sales/Operating assets (times per year)	1.21	1.15	1.15	1.06	1.04	1.09	0.89
Departmental costs (as a percentage of sales)							
4. Production cost of sales	66.0	67.5	71.0	74.0	76.2	77.1	81.7
5. Distribution and marketing costs	8.2	7.9	7.4	5.9	6.0	6.5	5.6
6. General and administrative costs	6.9	6.6	7.2	7.7	7.9	7.4	8.0
Production costs (as a percentage of sales of production							
7. Materials cost	33.1	32.7	32.9	33.7	33.9	33.7	35.8
8. Works labour cost	18.8	21.1	24.2	25.1	26.8	27.9	29.4
9. Other production costs	14.1	13.7	13.9	15.2	15.5	15.5	16.5
General asset utilization (£'s per£1000/sales)							
3a. Operating assets	827	872	866	042	958	913	1127
10. Current assets	448	469	477	529	524	479	654
11. Fixed assets	379	403	389	413	413	434	473
Current asset utilization (£'s per£1000/sales)							
12. Materials stock	80	95	105	97	107	100	110
13. Work in progress	71	76	87	105	147	130	205
14. Finished goods stock	87	85	77	108	58	40	115
15. Debtors	210	213	108	219	222	209	224
Fixed asset utilization (£'s per£1000/sales)							
16. Land and buildings	188	207	190	197	200	200	214
17. Plant and machinery	185	191	194	213	221	230	256
18. Vehicles	6	5	5	3	3	4	3

year, or in the case of the data presented in Table 4, year one versus year two. Some of the ratios compared are return on assets, profit margin on sales, and asset turnover.

The next part of the interfirm study involves comparing the firm's current operating ratios with other firms' ratios in the same industry. (See Table 5). The ratios compared are similar to those previously discussed. The most important part of the interfirm comparison is the Interpretation and Guidance Towards Improvements section. In reference to the Table 4 for Firm F, the report states:

> You have stated that while in your Year One sales of stock produced standard products represented 15 percent of your total sales, you had estimated that with more intensive marketing of these lines their sales might represent 20 percent of total sales in Year Two. You expected that this would make it necessary to spend more on selling, but that the additional selling expenditure would be offset by production economies achieved through longer production runs. These longer runs would reduce idle hours (due to changes in machine setup) and thereby result in lower works labor cost, less work in process and better machine utilization. Furthermore, greater concentration on certain stock items would enable you to purchase some materials in larger quantities, and therefore at lower prices. In fact, you found at the end of the year that sales of these stock lines had not represented 20 percent, but only 18 percent of your total sales. These developments would seem to explain the rises in your finished stock ratio #14, and your distribution and marketing cost ratio #5, as well as the falls in your production cost ratios (ratios 4, 8 and 9), your stock of materials ratio 12, your work in process ratio 13, and your plant investment, ratio 17. Furthermore, you seem to have taken action to improve your debtors ratio, #15, and so on and so forth ... (H. Ingram and L. Harrington).

There are target levels for the ratios suggested for each industry type. Improved productivity can be achieved from the above information.

Table 6

Extract of ratios used in the equipment hire industry

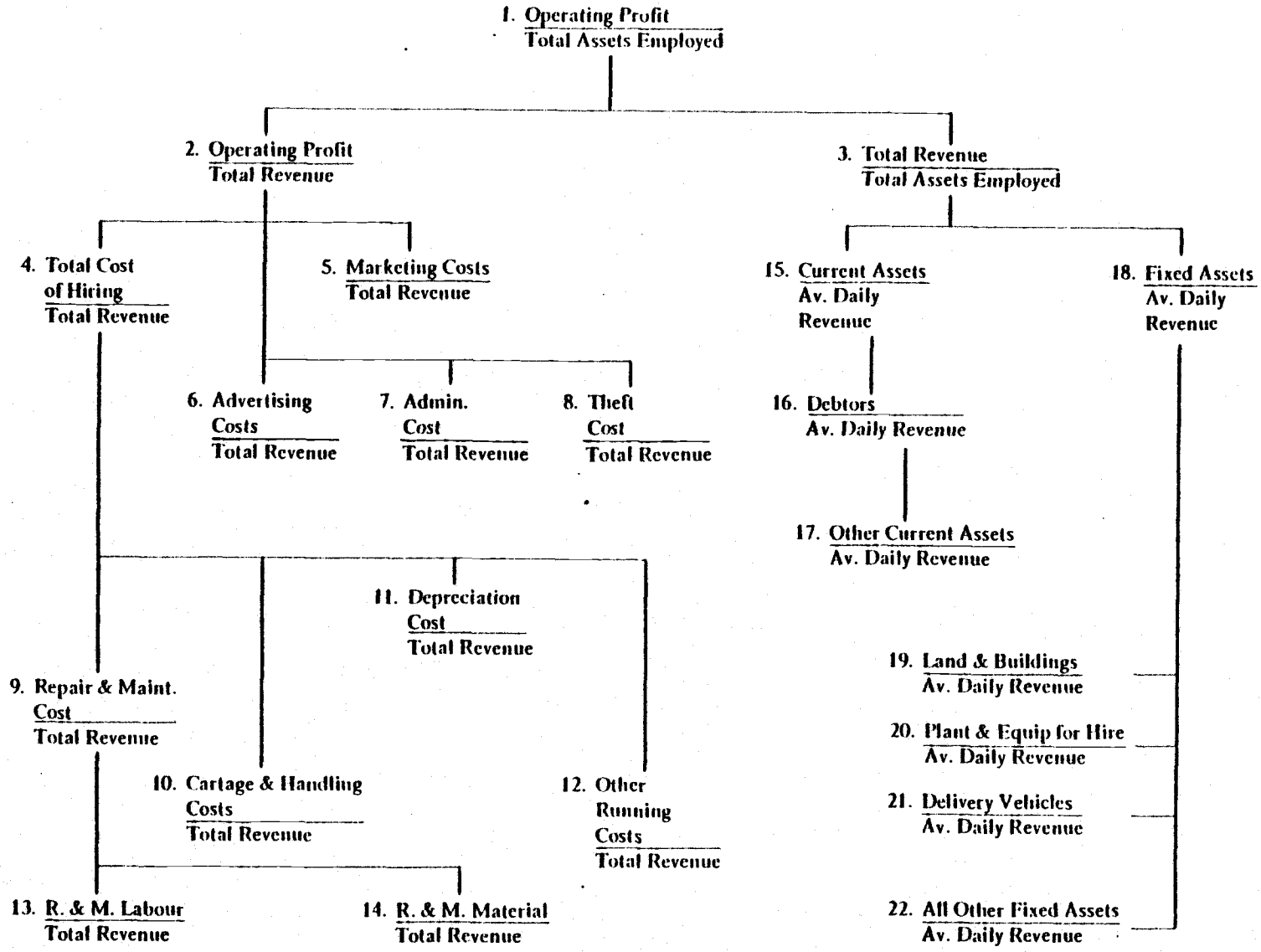


Table 7

Extract of ratios used in the foundry industry

$$\frac{\text{Net Weight of all Casting (including rejects)}}{\text{Weight of Metal Charged}}$$

$$\frac{\text{Net Weight of all Good Castings}}{\text{Weight of Metal Charged}}$$

$$\frac{\text{Net Weight of Internally Rejected Castings}}{\text{Net Weight of all Castings (including rejects)}}$$

$$\frac{\text{Net Weight Customer Returns}}{\text{Net Weight of all Castings (including rejects)}}$$

$$\frac{\text{Cost of Fuel}}{\text{Weight of Metal Charged (Cupola only)}}$$

$$\frac{\text{Total Factory Labour Cost}}{\text{Net Weight of all Castings (including rejects)}}$$

$$\frac{\text{Manhours for Moulding and Coremaking}}{\text{Net Weight of all Castings (including rejects)}}$$

$$\frac{\text{Total Manhours in Factory}}{\text{Net Weight of all Castings (including rejects)}}$$

$$\frac{\text{Furnace Maintenance Costs (Cupola)}}{\text{Weight of Metal Charged}}$$

$$\frac{\text{Furnace Maintenance Costs (Electrical Furnace)}}{\text{Weight of Metal Charged}}$$

$$\frac{\text{Melting Loss}}{\text{Weight of Metal Charged}}$$

$$\frac{\text{Factory Man Days Lost Due to Industrial Strife}}{\text{Total Factory Man Days}}$$

$$\frac{\text{Sales Value of Manufacture}}{\text{Net Weight of all Good Castings}}$$

Sales Value of Manufacture per factory Employee

Interfirm Comparisons in Australia

In Australia there are two basic groups of ratios compared in the interfirm comparison (IFC) studies. These ratios are financial ratios which are extracted from balance sheets and profit loss statements, and technical ratios based upon operating data, such as output per man hour. The ratios compared for the participant industries are those which are considered key ratios for their industry. The administrators of the Interfirm Comparison in Australia found that the participants demanded more ratios as time went on to match their own internal needs. The types of ratios compared are illustrated on Tables 6 and 7. Table 6 is an extract of ratios used in the equipment hire industry. In this particular area 22 different ratios are shown. Table 7 is an extract of ratios as used in the foundry industry. Fourteen specific ratios are used in the foundry industry. The ratios used are specifically designed for that particular industry.

Perhaps the most unique portion of the Australian Interfirm Comparison reports is the way the results are presented. Table 8 is a sample of an interfirm comparison report. For each ratio compared, the middle, best, and worst quarters are provided. This allows management to see exactly where its firm stands. In the report, the firms' results are shown and the variance of each firm is indicated. Additionally, the dollar value of that variation is calculated. If a ratio is adverse, the impact is shown as a dollar variation or potential profit loss. When a ratio is adverse, its potential impact is highlighted. With these data, the management of the organization can take appropriate actions to bring the firm in line

Table 8

Sample of an Interfirm Comparison Report

		Ex-pressed as	Your Firm's result was	Best 25% of firms	Middle firm	Worst 25% of firms	Your result varied from the middle firm by	Dollar Value of Var-iation	If Adverse ratio No.
GENERAL									
1.	Operating Profit / Assets Employed	%	12.2	21.8	16.1	12.5	3.9	* 21081	2
2.	Operating Profit / Sales	%	6.6	11.8	9.9	8.2	3.3	* 33000	4
3.	Sales / Assets Employed	Times	1.85	1.85	1.62	1.49	0.23	12432	
COSTS									
4.	Production Costs / Sales	%	85.5	76.5	81.1	85.3	4.4	* 44000	8,9
5.	Marketing Costs / Sales	%	31.	3.5	5.7	8.2	2.6	26000	
6.	Administration Costs / Sales	%	3.8	3.6	4.6	6.0	0.8	8000	
PRODUCTION COSTS									
7.	Direct Materials / Sales	%	48.1	45.8	48.3	50.4	0.2	2000	
8.	Direct Labour / Sales	%	26.3	20.2	22.9	25.7	3.4	* 34000	
9.	Production Overheads / Sales	%	11.1	9.8	10.7	13.1	0.4	* 4000	
DIRECT LABOUR COSTS									
14.	Skilled Direct / Sales	%	13.5	9.1	10.1	11.9	3.4	* 34000	
15.	Unskilled Direct / Sales	%	12.8	11.8	13.0	13.9	0.2	2000	

* Variations which may be unfavourable

with competing companies and improve profitability and productivity.

There are additional advantages to firms participating in these interfirm comparison studies. For instance, as a part of the interfirm comparison, wage rates are made available to the participants. Also, capital investment levels and employee turnover levels are known throughout the industry. One of the concerns to participating industrial members is that confidential data might be made known to competitors and their position would be compromised. To eliminate problems in confidentiality, two different types of actions were taken by the Australian IFC group. First, the data is shown in a ratio format so that no actual operating data is disclosed. Second, assignment of code numbers to each of the participants enabled confidentiality to be maintained. One benefit cited in this study is the ability for participating companies to relate their future budgets to the interfirm comparison yardstick. Also, by using the results of the interfirm comparison, companies are able to set budgets in certain areas according to the inefficiencies discovered. The IFC serves as a practical yardstick of industry performance and provides goals by which an individual enterprise can measure its own performance. IFC data also provides management with valuable guides for capital investment decisions. The data shows how the firm utilizes its assets and then compares the results to other industries.

Interfirm Comparisons in Canada

In Canada, as well as in Australia, interfirm comparisons are done under the auspices of the federal government. In Canada, interfirm comparisons are a service of the Federal Department of Industry and

are directed by Imre Bernolak, director of the Productivity Improvement Service Programs Branch, a subgroup of the Department of Industry, Trade and Commerce, in Ottawa, Canada. Literature obtained from Mr. Bernolak outlined what is involved in interfirm comparisons in Canada and the objectives of IFC in Canada. These objectives are: (1) To improve firm productivity, profitability, and competitiveness in domestic and international markets, (2) to promote productivity measurement techniques, (3) to provide knowledge to the government regarding policy decisions for business sectors.

The types of ratios produced are the primary ratios, such as return on assets invested and operating profit over operating assets. These ratios show how effectively the resources at the disposal of an enterprise are used. Productivity is usually measured in terms of sales per employee, and value added per hour worked of production labor. Also, physical output is used to measure productivity when the production of all the participants in a group is homogeneous. Interfirm comparisons were started in Canada in 1969 and are continuing. To date, 45 different industry sectors have been studied and a total of 1200 firms have participated in the interfirm comparison system.

In contrast with the Australian case study method, where questionnaires or surveys are mailed out to participants, a caseworker method is used in Canada. Each caseworker goes to the firm and studies the firm's financial and production records in order to form ratios for the industry segment being studied. The caseworker then standardizes the data so that all the data are treated uniformly. For example, it may be necessary for the caseworker to reorganize certain accounting data so that it matches other firms being studied in that particular

industrial sector. The Canadian Interfirm Comparison literature also points to the importance of using measured cost rather than standard cost, which is recorded in some accounting systems.

Of significant interest are the results of a survey conducted by the Canadian Interfirm Comparison group. This survey asked participants in the Canadian IFC to determine the value received by the companies participating in these studies. The results were: 95.6 percent found the interfirm comparison studies provided a very favorable benefit to them; 3.7 percent of the participants found mixed benefits; and only .71 percent of the participants found no new knowledge to be gained by the interfirm comparison studies.[5]

Interfirm Comparison at the National American Wholesale Grocers Association

The National American Wholesale Grocers Association consists of distribution centers in the wholesale grocery industry which have established productivity standards for its warehousing organizations. NAWGA is an organization which is providing interfirm comparisons for their member industries. The wholesale grocers measure labor hours, facilities (i.e. square feet of facilities used), and equipment capitalization ratios. The ratios formed are broken into three groups; productivity ratios, utilization ratios, and performance ratios. An example of some typical measures of a receiving operations efficiency are shown in the attached Table #9. This table describes labor in terms of categories mentioned above. Some examples of labor productivity ratios are DOLLAR VALUE RECEIVED/LABOR HOURS, VEHICLES UNLOADED/LABOR HOURS, EQUIVALENT VEHICLES UNLOADED/LABOR HOURS, TONAGE/LABOR HOURS, CARTONS RECEIVED/LABOR HOURS. A utilization ratio for labor is:

Table 9

Typical measures of receiving-operations efficiency

What is Measured	Productivity ratios	Utilization ratios	Performance ratios
Labor	Dollar value received/ labor hours Vehicles unloaded/ labor hours Equivalent vehicles unloaded/labor hours Tonnage/labor hours Cartons received/ labor hours Pallets received/ labor hours Lines received/labor hours	Labor hours receiving/ labor hrs.	Actual equivalent vehicles unloaded per labor hour/standard equivalent vehicles unloaded per labor hour Actual weight received per labor hour/ standard weight received per labor hour Actual lines received per labor hour/standard lines received per labor hour Standard hours of work accomplished/ actual labor hours
Facilities	Vehicles unloaded per dock door/day Weight unloaded per dock door/day	Dock doors used per day/dock doors available	Actual vehicles unloaded per dock door per day/standard vehicles unloaded per dock door per day
Equipment	Dollar value received/ equipment hours Weight received/equipment hours Units received/equipment hours	Equipment hours used in rec'v./ equipment hrs. available Actual wt. per movement/maximum wt. capacity	Actual equipment down-time/standard equip-down-time Actual equipment cost/ budgeted equipment cost

Based on data from National Council of Physical Distribution Management.

Table 10

A basis for comparison - warehouse productivity figures from the wholesale grocers

Where they Measured	1976			1977			1978			1979		
	Small[1] Warehouses	Medium[2]	Large[3]	Small[1] Warehouses	Medium[2]	Large[3]	Small Warehouses	Medium	Large	Small Warehouses	Medium	Large
Tons per hour (total labor)	0.98	1.08	1.09	1.02	1.00	1.19	0.94	1.01	1.26	0.86	0.78	1.06
Pieces selected per hour	119	132	128	138	120	127	120	134	137	118	126	126
Stockturn rate (turns per year)	15.07	15.33	17.98	14.83	14.99	18.09	14.61	16.04	16.42	14.32	15.22	16.66
Payroll cost per case shipped	0.21	0.18	0.19	0.17	0.19	0.25	0.25	0.20	0.21	0.27	0.23	0.26
Payroll as percent of sales	1.6	1.6	1.7	1.4	1.6	2.1	1.6	1.6	1.8	1.8	1.8	2.0
Payroll cost per ton (in and out)	7.05	5.88	6.49	5.66	6.45	8.34	8.72	6.88	7.45	10.80	8.20	8.93

[1]Small - less than 100,000 sq ft

[2]Medium - 100,000 to 200,000 sq ft

[3]Large = over 200,000 sq ft

LABOR HOURS RECEIVING/LABOR HOURS WORKED. Performance ratios for labor are as follows: ACTUAL EQUIVALENT VEHICLES UNLOADED PER LABOR HOUR/STANDARD EQUIVALENT VEHICLES UNLOADED PER LABOR HOUR, ACTUAL WEIGHT RECEIVED PER LABOR HOUR/STANDARD WEIGHT RECEIVED PER LABOR HOUR, and ACTUAL LINES RECEIVED PER LABOR HOUR/STANDARD LINES RECEIVED PER LABOR HOUR.

Performance ratios are as follows: VEHICLES UNLOADED PER DOCK DOOR/DAY, and WEIGHT UNLOADED PER DOCK DOOR/DAY. Examples of facility utilization ratios are; DOCK DOORS USED PER DAY/DOCK DOORS AVAILABLE and HOURS DOCK DOORS USED/AVAILABLE HOURS. NAWGA collects the data for their members annually during a four-week period sometime between July and September of each year. A total of 23 different productivity indices covering many different warehouse functions are compiled and reported to their members. Table 10 shows the reports' formats, what items are measured, and their breakdown between a small, medium, and large warehouse operations. Gerald E. Peck, NAWGA President stated in Modern Materials Handling:

> Tons and pieces are two of the most valid and revealing indicies for our industry, however even they must be monitored carefully as output factors. The output varies over time. For example, as the number of pieces per ton has increased over the years, so has the number of individual handlings required. Also, delivering merchandise on a cart or pallet that moves directly to the display shelf in a store, gives it a greater value than the same merchandise delivered dead-piled. Similarly, cases with labels carrying computer printed warehouse and retail store information have a greater value than the same cases without the labels.

Interfirm Comparisons in the National Screw Machine Products Association

The National Screw Machine Products Association started an inter-

firm comparison program in 1956 and continuing this on a monthly basis today. All members of the National Screw Machine Products Association receive the annual report, but some 200 companies report to the association monthly and receive monthly reports. SALES DOLLAR/SCREW MACHINE HOURS, SALES DOLLAR/ALL MACHINE HOURS, SALES DOLLAR/MAN HOURS WORKED, CAPACITY USAGE/MACHINE HOURS, QUOTATIONS MADE/SCREW MACHINE, ORDERS RECEIVED/SCREW MACHINE, AVERAGE BACKLOG/COMPANY, and AVERAGE CANCELLATION/COMPANY are ratios used to indicate productivity growth. Similar to the National Wholesale Grocers Association, the ratios are arranged according to size of company: small, medium, and large. A small company is one whose sales is less than one million dollars for the year. The annual report is classified into turnover ratios and other ratios. Turnover ratios are NET SALES/TOTAL EMPLOYEES, NET SALES/TOTAL MACHINE HOURS, NET SALES/MAN HOURS WORKED, NET SALES/COST OF FIXED ASSETS, NET SALES/TOTAL ASSETS, and NET SALES/ NET WORKING CAPITAL. Other ratios are defined as: RAW MATERIALS IN OUTSIDE WORK COST/NET SALES, DIRECT LABOR/VALUE ADDED, (value added is defined as net sales, minus the sum of raw materials plus outside work costs), TOTAL FACTORY COST/VALUE ADDED, SALES & ADMINISTRATIVE/VALUE ADDED, CURRENT ASSETS/CURRENT LIABILITIES, NET FIXED ASSETS/NET WORTH, LONG-TERM DEBT/NET WORKING CAPITAL, GROSS PROFIT/NET SALES, NET PROFIT/NET SALES, and NET PROFIT/NET WORTH. There are a total of 30 ratios available through the National Screw Machine Products Association in the annual report. The value to the industry is illustrated by an incident related by Mr. Seth Young of Enoch Manufacturing of Oregon City, Oregon. Mr. Young relates the following:

> When we read one of our reports and found that our indirect labor costs were out of line for the industry, we went out into the shop and by re-organizing and combining some operations were able to save one man in indirect labor.[1]

Because Enoch is a small manufacturing firm with a total of 80 employees, a saving of one man per year means a substantial improvement in Enoch's operation. Additionally, the National Screw Machine Products Association provides target levels for their ratios that participants should achieve. For an example, in the case of CURRENT ASSETS/ CURRENT LIABILITIES, the target level would be 2+ for a company with sales less than one million dollars per year. The screw machine products industry is also concerned about the confidentiality of data. This is accomplished by using ratios to report the data. However, Mr. Young has pointed out that there is a cooperative climate in the Screw Machine Products Association. Mr. Young demonstrated a great deal of enthusiasm about the reports and the cooperative attitude of the industry.

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[1]Interview with Mr. Seth Young, General Manager Enoch Manufacturing on 2-13-81. Dr. James Riggs, Glenn Felix, and D.R.B.

CHAPTER III

DEVELOPMENT OF APPROACH

It is important to show how financial ratios are related to productivity. Financial ratios are the ratios that are most readily available from company records. Financial flows are made up of operational relationships which relate profit to total investment. Dr. James L. Riggs of Oregon State University and Bella Gold have developed the following sets of equations.

a. $$\frac{\text{Profit}}{\text{Total Investment}} = \frac{\text{Profit}}{\text{Output}} \times \frac{\text{Output}}{\text{Total Investment}}$$

b. $$\frac{\text{Profit}}{\text{Output}} = \frac{\text{Product Value}}{\text{Output}} - \frac{\text{Total Costs}}{\text{Output}}$$

c. $$\frac{\text{Total Costs}}{\text{Output}} = \frac{\text{Wages}}{\text{Output}} + \frac{\text{Material Cost}}{\text{Output}} + \frac{\text{Other Cost}}{\text{Output}}$$

d. $$\frac{\text{Output}}{\text{Total}} = \frac{\text{Output}}{\text{Capacity}} \times \frac{\text{Capacity}}{\text{Fixed Investment}} \times \frac{\text{Fixed Investment}}{\text{Total Investment}}$$

e. $$\frac{\text{Profit}}{\text{Total}} = \left[\frac{\text{Product Value}}{\text{Output}} - \frac{\text{Wages}}{\text{Output}} - \frac{\text{Materials}}{\text{Output}} - \frac{\text{Other Cost}}{\text{Output}}\right] \times \frac{\text{Output}}{\text{Capacity}} \times \frac{\text{Capacity}}{\text{Fixed Investment}} \times \frac{\text{Fixed Investment}}{\text{Total Investment}}$$

Each component of the sets of relationships can be a partial productivity index by linking an individual ratio from sequential periods. A partial productivity index is a ratio of output to one or more of the input factors, such as OUTPUT/LABOR INPUT or OUTPUT/LABOR plus MATERIALS. The total productivity index is the relationship of output to all the factors of input, such as labor, materials, capital energy

and services.

The most difficult input factor to measure is capital. There are several different treatments discussed in the literature. Bernolak[9] has suggested using the square footage of land and buildings as a measure of the fixed asset portion of the capital input. That is, to determine how many square feet are in the land and buildings and determine a market value for those items. By knowing the market value for those items and the service life, a rental equivalent can be charged to the year's production. Bernolak has also suggested that lease charges for assets not owned are a capital input.

Perhaps the best way to treat the calculation of capital input is to consider depreciation as the capital input factor. The use of depreciation as a basis for the contribution of capital investment of plant and equipment to the productive process has some disadvantages. First, the basis of the depreciation charge must be determined. If the basis is a service life, then the use of depreciation is adequate. However, if the depreciation is based on some tax law, which has no bearing to the actual service life of the equipment being depreciated, it is more difficult to determine what the capital input factor is. In spite of these difficulties, treating depreciation as the capital input factor has the major advantage of being recorded in company records and, therefore, is easily recoverable for calculations.

There must also be a method by which the current assets, or in particular, working capital can be credited for input to the productive process. The best way to treat working capital is to consider it as an equivalent to an annuity, discounted by the weighted average cost of capital for the subject firm. Working capital can be treated as a

constant, or a perpetual annuity because it is a part of the cost of doing business. By multiplying the percentage figure for weighted average cost of capital by the average amount of working capital a firm has for a year, the contribution of working capital to the productive process can be determined. For example, if a company finances itself 50 percent from equity and 50 percent from debt and the tax rate for the company is 40 percent, the weighted average cost of capital[10] can be calculated as follows:

Weighted average cost of capital = cost of equity*50%
+ cost of debt*(1-tax rate)*50%.

where the cost of equity is equal to the expected growth rate in market value per share per year plus the dividend rate percentage and the cost of debt is equal to the weighted cost of all long term (more than one year) debt instruments. Then, the cost of working capital for the year equals the weighted average cost of capital times the average working capital held during the year.

Another way to treat the capital input is to consider it as equivalent to an annuity discounted at the weighted average cost of capital for a firm.[11] This is for plant and equipment only. An example serves best to illustrate this concept. If a firm has a cost of capital of ten percent, then a 100,000 dollar piece of equipment with a five year service life annualized would have a capital contribution of $26,379.75 for the year of interest. For a small firm, with not many pieces of equipment, or a limited number of buildings for which adequate service life estimates exist, this would be the best way to determine the capital input for that firm. However, for a much larger firm with many pieces of equipment and buildings at various ages and locations, this

is a very difficult method. For these reasons, depreciation is the method used to calculate capital input for this study.

Labor input is often measured in terms of numbers of hours worked. Where information on the number of hours is unavailable, it may be necessary to use the number of employees, or even the total labor costs. If different skill levels are involved in labor input, it could be desirable to measure each category separately and combine them with a weighting system based on compensation rates. If labor standards exist, it may be necessary to add the variances to the standard allowances for the output produced. The factors used to calculate labor input are necessarily dependent upon what records the company has available.

Materials are another input factor which is considered. For instance, in a single product industry, such as steel, the materials input is a volume measurement (i.e. tons of ore consumed). However, in a multi-product industry the materials input is in many different forms. In the auto industry where materials purchased range from raw steel to finished products, the measurement of materials volume becomes difficult. In more complex cases it is necessary to measure materials volume based upon dollars spent in purchasing materials that are used in production.

The contribution of energy is becoming more important to the productive process as costs of energy have escalated sharply in the years since 1973 (see Table 12). Similar to materials, the contribution of energy is industry-dependent. The use of energy in a basic metal industry is a far more important factor than the contribution of energy to a high-technology industry such as electronics. The ideal compari-

son for energy is a measurement of the number of British Thermal Units (BTU) or kilowatt hour equivalents used to produce the output. If this data is not available it is necessary to use the dollars spent for energy during the time periods studied.

The final input factor to consider is that of services. Services include such items as: patents; royalties; license fees; outside engineering services; computer services; outside auditor's fees; management consultant services. Because of the somewhat nebulous nature of services, it is necessary to measure the contribution of services based on the dollar cost for those items purchased from the outside.

Output factors range from very simple to very difficult items to measure. Conceptually, the most appropriate measure of output is that of a quantity measure. A quantity measure is easy to use if the items being produced are of a homogeneous nature. But there is a practicality that must be considered when using quantity as an output measure. For instance, in the instruments department at ESI 150 to 200 different types of instruments are produced, some customized. The use of quantity is an inappropriate measure of output because of the multiplicity of the products manufactured.

Bella Gold suggests a method of multi-product output measurement. When measuring output, it is necessary to know if an increase in output revenues is due to an increase in prices or an increase in volume of output. Gold's measure for physical output for a multi-product operation involves weighting the output of each product in the base and comparison period by its average price during the two periods. Using the average price for the two periods allows determination of the differences in

physical output. When several hundred products are involved in output the measurement of output becomes somewhat cumbersome.

Weighing Product Output by Average Cost (Edgeworth Index)

$$\Delta \text{Physical Output}_{2,1} = \frac{\sum Q_{A2}\left[\frac{P_{A1}+P_{A2}}{2}\right] + Q_{B2}\left[\frac{P_{B1}+P_{B2}}{2}\right] + \ldots}{\sum Q_{A1}\left[\frac{P_{A1}+P_{A2}}{2}\right] + Q_{B1}\left[\frac{P_{B1}+P_{B2}}{2}\right] + \ldots}$$

A,B = Products P = Price
Q = Quantities 1,2 = Periods

The development of a productivity measurement system must satisfy the following factors if it is to be useful: (1) The ratio system must be relevant and useful to a company; (2) it must be understandable; (3) the cost benefit ratio should be favorable; (4) firms using the system should be involved in the development.

For the ratios to be effective tools the following questions must be answered: What does each ratio mean? What impact does a ratio or a family of ratios have on the company? Is a particular ratio a predictor of future condition, a measure of current condition, or both? How do the company ratios compare to other companies in the same industry? Is a ratio detailed enough to evaluate the smallest segment of company operations? For example, ADMINISTRATIVE EXPENSES/ DIRECT LABOR HOURS, tells how much administrative load each direct labor hour must carry before a profit can be earned. The ratio of INVENTORY/CURRENT LIABILITIES tells the extent to which product mix effects the capital structure.

In this study, it is proposed to measure productivity and performance for a single firm, ESI, and use the ratio model developed as a basis for future interfirm comparison studies. By using data which is readily available from financial, production, quality control, payroll, and other records, a set of ratios is developed that measures performance and predict future conditions.

The ratios include the following: financial, production, quality control, payroll, and miscellaneous ratios. Financial ratios include items such as profit versus assets, sales, employees, and net worth. Other financial ratios comprise inventory relationships, work in process, finished goods inventory, raw materials inventory compared to output, sales and production components. Receivable and payable turnover ratios are also calculated. In addition, capital investment, fixed asset and working capital investment asset ratios are related to output and sales. Production ratios consider manufactured items compared to labor and material quantities, set up time is compared to run time for machines, and lost time for the system. (Lost time for the system is defined as delays in production caused by failure of control systems or other delays which are not directly related to labor stoppages or machinery breakdowns.) Quality control ratios consider items such as rejects compared to production quantities, scrap rates, costs of customer service due to poor workmanship, and the reject rate compared to the rework rate. Payroll ratios include terminations as a percent of total payroll and lost time and sick time. Other ratios include purchasing-expediting costs, comparison of direct labor to indirect labor, and customer service.

The first step in developing a set of ratios is to audit the present productivity standing of the company. The audit has the following purposes: (1) It determines if any existing productivity measures are being used firm-wide or at departmental, group or unit, or individual level. (2) It develops an initial productivity index that can be compared with later ones. The audit is done in the form of a "walk through" of company operations and is done with the assistance of an accountant or some other person knowledgeable with company records and operations. The audit does not go into the detail of a departmental operation but is primarily concerned with overall company operations at the firm-wide level.

The second step in the development of the system is a more detailed collection of company data that involves selecting data on company operations from a three to five year period. These data are gathered from the financial production and personnel records that are available in the company. From these data, 35 to 40 or more ratios are formed and a table is constructed. Some of the ratios are: OPERATING PROFIT/SALES; WORK IN PROCESS INVENTORY/AVERAGE DAILY SALES; OPERATING PROFIT/EMPLOYEES; NUMBER OF DIRECT LABOR EMPLOYEES/NUMBER OF INDIRECT LABOR EMPLOYEES; NET SALES/INVENTORY. Table 11 shows the initial set of ratios evaluated during the collection of data. There may be modification of those ratios required if the data desired has not been recorded in company records.

Each ratio is plotted against each year's data and the ratios that are related or have the same patterns are plotted together. The plotted patterns are analyzed and relationships are determined.

TABLE 11

Some Possible Key Ratios to be Formed/Developed

(1) $\frac{\text{Operating Profit}}{\text{Assets Employed}}$

(2) $\frac{\text{Operating Profit}}{\text{Sales}}$

(3) $\frac{\text{Sales}}{\text{Assets Employed}}$

(4) $\frac{\text{Factory Cost}}{\text{Sales Value of Goods Produced (S.V.G.P.)}}$

(5) $\frac{\text{Selling \& Distributing Cost}}{\text{Sales}}$

(6) $\frac{\text{Administrative Costs}}{\text{Sales}}$

(7) $\frac{\text{Engineering Costs}}{\text{Sales}}$

(8) $\frac{\text{Direct Labor}}{\text{S.V.G.P.}}$

(9) $\frac{\text{Direct Material}}{\text{S.V.G.P.}}$

(10) $\frac{\text{Factory Overhead}}{\text{S.V.G.P.}}$

(11) $\frac{\text{Indirect Labor}}{\text{S.V.G.P.}}$

(12) $\frac{\text{Indirect Material}}{\text{S.V.G.P.}}$

(13) $\frac{\text{Other Factory Overhead}}{\text{S.V.G.P.}}$

(14) $\frac{\text{Fixed Assets}}{\text{Average Daily Sales}}$

(15) $\frac{\text{Current Assets}}{\text{Average Daily Sales}}$

(16) $\frac{\text{Land and Buildings}}{\text{Average Daily Sales}}$

(17) $\frac{\text{Plant and Equipment}}{\text{Average Daily Sales}}$

(18) $\frac{\text{Raw Materials}}{\text{Average Daily Sales}}$

(19) $\frac{\text{Accounts Payable}}{\text{Average Daily Sales}}$

(20) $\frac{\text{Work in Process}}{\text{Average Daily Sales}}$

(21) $\frac{\text{Finished Goods Inventory}}{\text{Average Daily Sales}}$

(22) Growth of Sales

(23) Operating Profit/Employee

(24) Direct Employee/Indirect Emp.

(25) Sales/Direct Labor Employee

(26) Overtime/Direct Hours Total

(27) Avg. Wage/Direct Worker/40 hr.

(Table 11 continued)

(28) Factory Man Days Lost Internal-External Causes vs. Total Factory Man Days

(29) $\frac{\text{Cost of Debt}}{\text{Sales}}$

(30) Net Profit/Net Worth

DEPARTMENTAL MEASURES

CUSTOMER SERVICE DEPT.

1. $\frac{\text{Orders Processed}}{\text{Number of Hours}}$

2. $\frac{\text{Pieces of Correspondence}}{\text{Number of Days}}$

3. $\frac{\text{Phone Calls Handled}}{\text{Number of Days}}$

4. $\frac{\text{Number of Orders/Month}}{\text{Number of People}}$ et. al.

QUALITY ASSURANCE DEPT.

1. $\frac{\text{\# of Inspectors}}{\text{Total Prod. Personnel}}$

2. $\frac{\text{Number of Failures}}{\text{Months}}$

3. $\frac{\text{Sales}}{\text{Total Cost of Quality}}$

4. $\frac{\text{Days Inspection Backlog}}{\text{Total Days}}$

5. $\frac{\text{Lots Rec'd/Hr.}}{\text{\# Receiving Inspectors}}$

PURCHASING DEPT.

1. $\frac{\text{Purchasing \$}}{\text{Salary \$}}$

2. $\frac{\text{Delivery Rec'd Within Lead Time}}{\text{Number of P.O.'s Rec'd.}}$

3. $\frac{\text{Number of Expedite Actions}}{\text{Number of hours spent expediting}}$

PRODUCTION CONTROL & ENGINEER. DEPT.

1. $\frac{\text{Excess Inventory \$}}{\text{Total Inventory \$}}$

2. $\frac{\text{Production Control Costs}}{\text{Total \$ Shipped}}$

3. $\frac{\text{Product Cost}}{\text{Sales}}$

4. $\frac{\text{Actual Costs}}{\text{Planned Costs}}$

5. $\frac{\text{Number of Rejects}}{\text{Number of Units}}$

6. $\frac{\text{Reject Rework Etc. (Time)}}{\text{Total Earned Hours}}$

7. $\frac{\text{Lost Machine Time}}{\text{Total Available Machine Hours}}$

8. $\frac{\text{Set-Up Time}}{\text{Parts}}$

PERSONNEL DEPARTMENT

1. $\frac{\text{Total Employees}}{\text{Personnel Dept. Employees}}$

2. $\frac{\text{Total Pay}}{\text{Personnel Dept. Pay}}$

The important relationships are those that serve as leading or lagging indicators of company condition, as well as those that indicate the present condition. (Condition is defined as productivity and profitability status of the organization.)

The third step is to survey key managers about indicators which are the most relevant to their operations. A consensus of opinion is required when selecting key indicators. Then the managers are asked to assign a weighting factor to each selected key ratio. The weighting factors are combined with each key indicator to provide a weighted productivity index for the company. The following is an example of how a weighted productivity index is derived from productivity indicators.

Weighted Productivity Index

BASE YEAR

Weighting Assigned	Selected key indicator Ratio	Value of Ratio	Weighting*Value of Ratio
1	Administrative Costs / Sales	0.0280	0.0280
1	Indirect Employees / Direct Employees	0.5000	0.5000
3	Operating Profit / Assets Employed	0.1100	0.3300
5	Operating Profit / Sales	0.1500	0.7500
Totals 10	Weighted Productivity Index	=	1.608

In the example, only four ratios are utilized to form the WPI, but in actual practice many more ratios may be selected. However,

having one productivity index is not adequate. In order to be a measure of performance or a comparative measure of performance, base year data must be compared to the current year. The following is an example of how to calculate a weighted productivity index for the subject company by comparing the current weighted factor to the base factor.

Weighted Productivity Index

CURRENT YEAR

Weighting Assigned	Selected key indicator Ratio	Value of Ratio	Weighting*Value of Ratio
1	Administrative Costs / Sales	0.0300	0.0300
1	Indirect Employees / Direct Employees	0.4700	0.4700
3	Operating Profit / Assets Employed	0.1000	0.3000
5	Operating Profit / Sales	0.1400	0.7000
Totals 10	Weighted Productivity Index	=	1.5000

The weighted productivity indicator calculated for the current year is 1.5000. By comparing the current indicator to the base indicator, the current productivity index of the company can be determined:

$$\text{Productivity index for current year} = \frac{\text{Current weighted indicator}}{\text{Base weighted indicator}}$$

or

$$P.I. = \frac{C.F.\ CWI}{B.F.\ BWI}$$

or

$$P.I. = \frac{1.500}{1.608} = \underline{\underline{.9328}}$$

Productivity declined by 1.000-0.9328 = 0.0672, or 6.72%. By itself, the WPI in the above calculations is limited in its usefulness to the company. However, combined with the various ratios and their plots, plus the knowledge of the company's overall productivity trend, the management has a valuable tool. With this knowledge, the managers are able to determine the reasons for productivity decline or improvement in a given time period.

There are some practical limitations which affect the approach used in productivity study. The preliminary format of data to be collected must be modified for each individual firm. The type of product being manufactured or produced has a relationship that affects the type of data collected by the firm. For example, a steel mill has a great deal of information on the input of ores, how much energy is used, and how much water is being used. A food processor has information on tonage of raw materials purchased and how much water is used in the production process. Thus, it becomes necessary to adapt the format to the individual firm or type of operation being studied.

Another limitation which must be considered is that all the necessary data may not be available. The records needed for the data collection may not have been retained or the records may be

incomplete. There is also the problem of confidentiality. A company may not wish to disclose some of the data to an outside investigator. However, this is not a problem when a comparison is conducted internally.

In any growing company there are systems changes in the accounting records. As new operations open up, new accounting systems may have been merged together or separated. Thus, there may be some inconsistencies in the data collected. Another consideration related to the growth of a company is that major capital expenditures may have been made which then change the nature of the productive process. For example, a purchase of a robotic or a numerically controlled machine causes a decrease in labor expenditure.

Technological innovations can also distort the data and can change the complete character of the company. The recent advent of the integrated circuits into industry and the advances that have been made in computer technology are examples of this. However, major technological changes are not common occurrences and effects from them can generally be discounted in time periods of three to five years.

There is also the influence of seasonal or periodic variations in the production process. An example of this is the production of food processors which takes place in a three month period during the year. During the seasonal peak there is a drastic change in the work in process inventory and other inventory carryovers. This may also have a secondary effect if the company is dependent upon, or a supplier to, a seasonal company. An example of this is an agricultural supply company dependent upon the growing season.

Definitions of the terms used in collection of data are important. For example, the term of direct labor may have different interpretations within the same company or between different companies. In some firms direct labor includes material-handling people, supervisors, and other personnel not normally considered as real direct labor. The definition to be used for this study is as follows: Direct labor is made up of those people who are physically involved in the production process. Supervisors, materials handlers and other secondary types are excluded from direct labor. The same type of dilemma can exist in considering direct materials and indirect materials.

Because this study compares data from different time periods the effects of inflation must be considered. Each component of the productive process (labor, capital, materials, services and energy) has a different inflation rate and each must be accounted for separately. Table 12 below illustrates the various price indices and their differences for materials, capital equipment, finished consumer goods, labor and energy. However, because of the use of ratios in this study, inflation is assumed to have an equal effect upon the numerator and the denominator of each ratio. Thus, any change in a ratio is traceable to a change in real dollar terms, not inflation.

TABLE 12

Table of Price Indices

Wholesale Price Index/
Purchasing Price Index

Basis 1976 = 100

	1976	1977	1978	1979	1980
Intermediate Materials	100	106.1	114.4	128.7	146.8
Capital Equipment	100	104.5	117.1	137.6	148.4
Finished Consumer	100	106.5	115.0	125.1	138.3
Labor	100	105.9	114.0	127.6	147.3
Electricity Gas Utilities	100	106.4	114.9	124.2	135.4
	100	108.7	116.3	147.2	206.9

CHAPTER IV

DATA COLLECTION AND ANALYSIS

The method of data collection at ESI consisted of personal surveys by the researcher. Data from profit and loss statements, budget versus actual accounting files, and other miscellaneous accounting reports, and certain desk and private records kept on direct labor composition were collected.

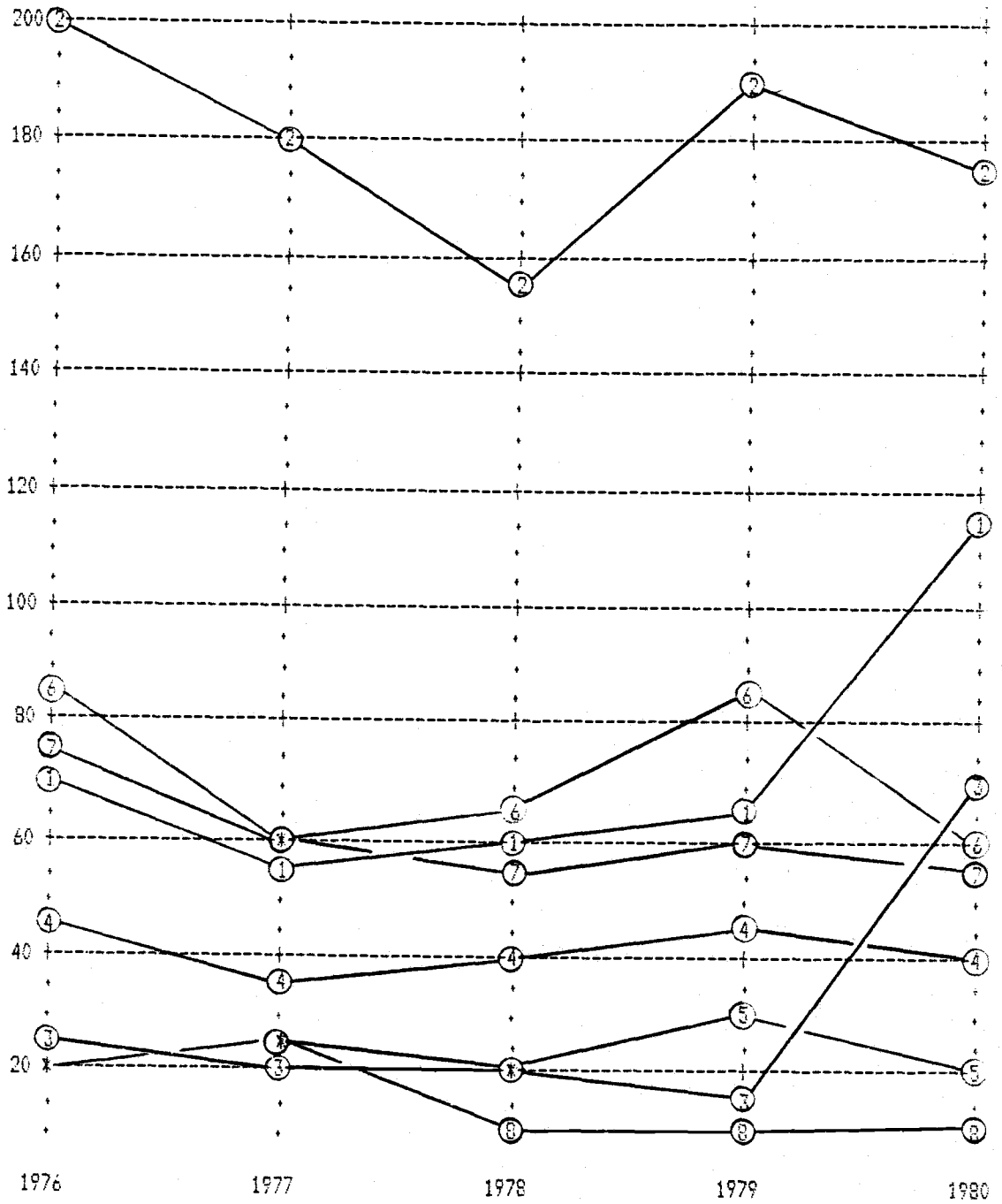
There were some areas in which the data desired for analysis were not available (see Tables 13 and 14). Table 13 illustrates the initial data needed for the analyses. The actual ratios formed from available data is shown in Table 14. The ratios in Table 14 were plotted and the plots of the data can be seen in Figures 1 through 15. Table 15 describes each ratio, shows the direction of a good ratio, and explains what each ratio means. For example, in the ratio of SALES/ASSETS EMPLOYED, the direction is up. It shows how effectively assets have been used. The ratio of SALES/ASSETS EMPLOYED shows a more intense use of assets. It also indicates the number of times during the year that the investment in assets has been turned over. A total of 40 ratios are described in Table 15.

Inverviews were conducted with two key ESI managers. These gentlemen are Mr. Wally Masters, Manager of Manufacturing, and Mr. Dean Finley, Vice-President of Finance. With the collected data on hand and the information in Table 15, the ratios that were most relevant to ESI's operations were selected. The ratios were then presented, by the researcher, to the Advisory Committee. The committee was

especially interested in ratios which track asset utilization and labor utilization in the productive process. These are the relationships of direct labor to sales and indirect labor to sales (Figure 2) and current assets and fixed assets as they are related to average daily sales (Figure 1). The work in process related to average daily sales and finished goods inventory related to average daily sales ratios were also selected (Figure 3). In the future, ESI will plot the described ratios on a quarterly, monthly, and sometimes a weekly basis. This will then emphasize with more detail how those items relate to sales (Figure 3).

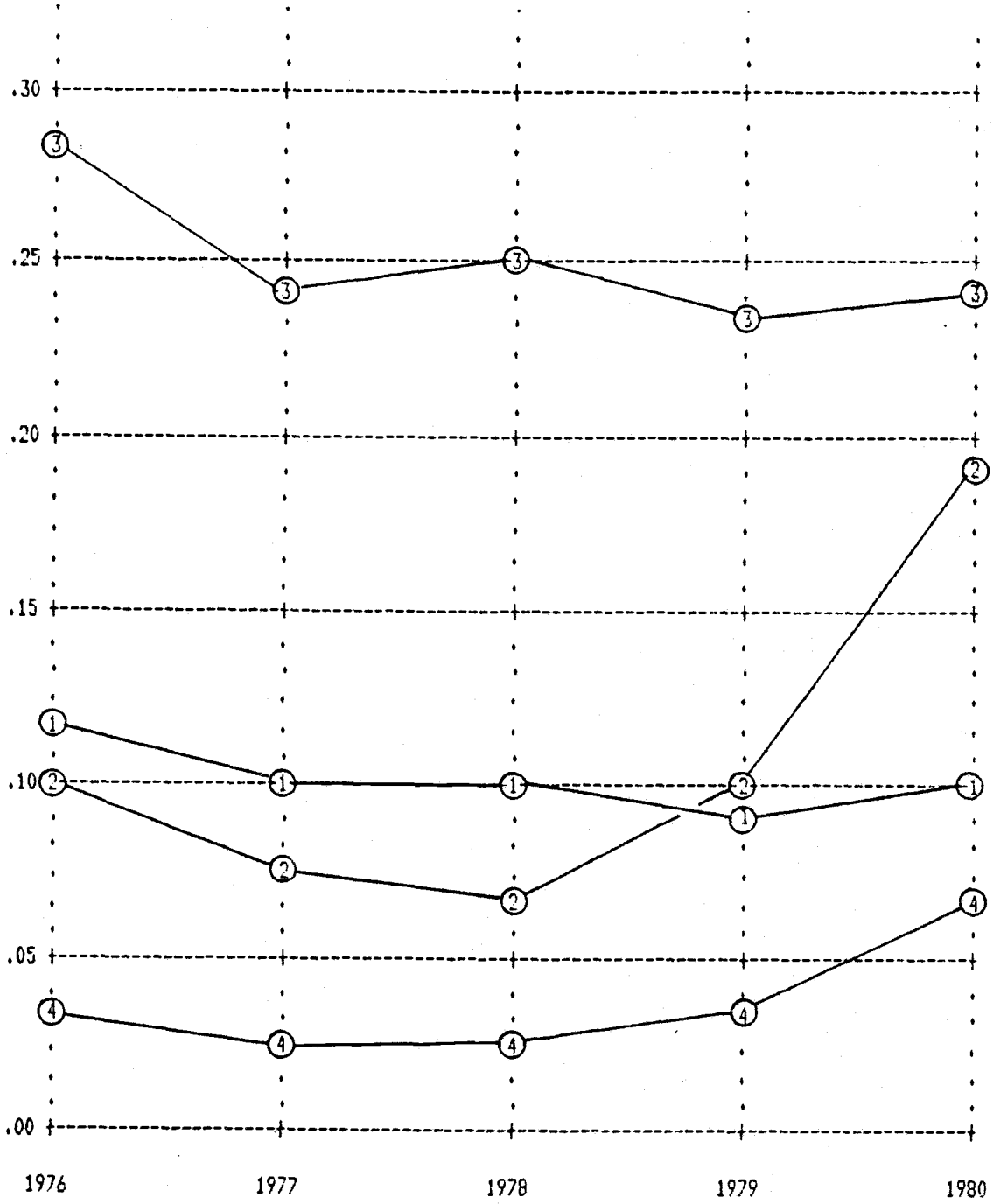
The analysis of the plots and combination of plots, as shown in Figures 1 through 15, highlights some interesting relationships. Figure 4 is an illustration. The plot of TOTAL MATERIAL USAGE/SALES compared to return on assets for the same time periods shows that as material usage decreased, the return on assets increased. As material usage increased, the return on assets decreased. Other plots, such as DIRECT LABOR/SALES, DIRECT MATERIALS/SALES, INDIRECT LABOR/SALES, and INDIRECT MATERIALS/SALES are combined on one chart (Figure 2) and indicate that ESI has decreased the proportion of labor in relation to sales, but materials usage has increased sharply since 1978. This implies that the company is becoming more materials intensive and less labor intensive. This is an unexpected result because in 1976 the average number of employees was 284, and in 1980 the average number of employees was over 600.

Figure 5 illustrates net profit percent, return on equity percent, and return on assets percent. The decline in return on assets is explained by a large capital investment, the purchase of a



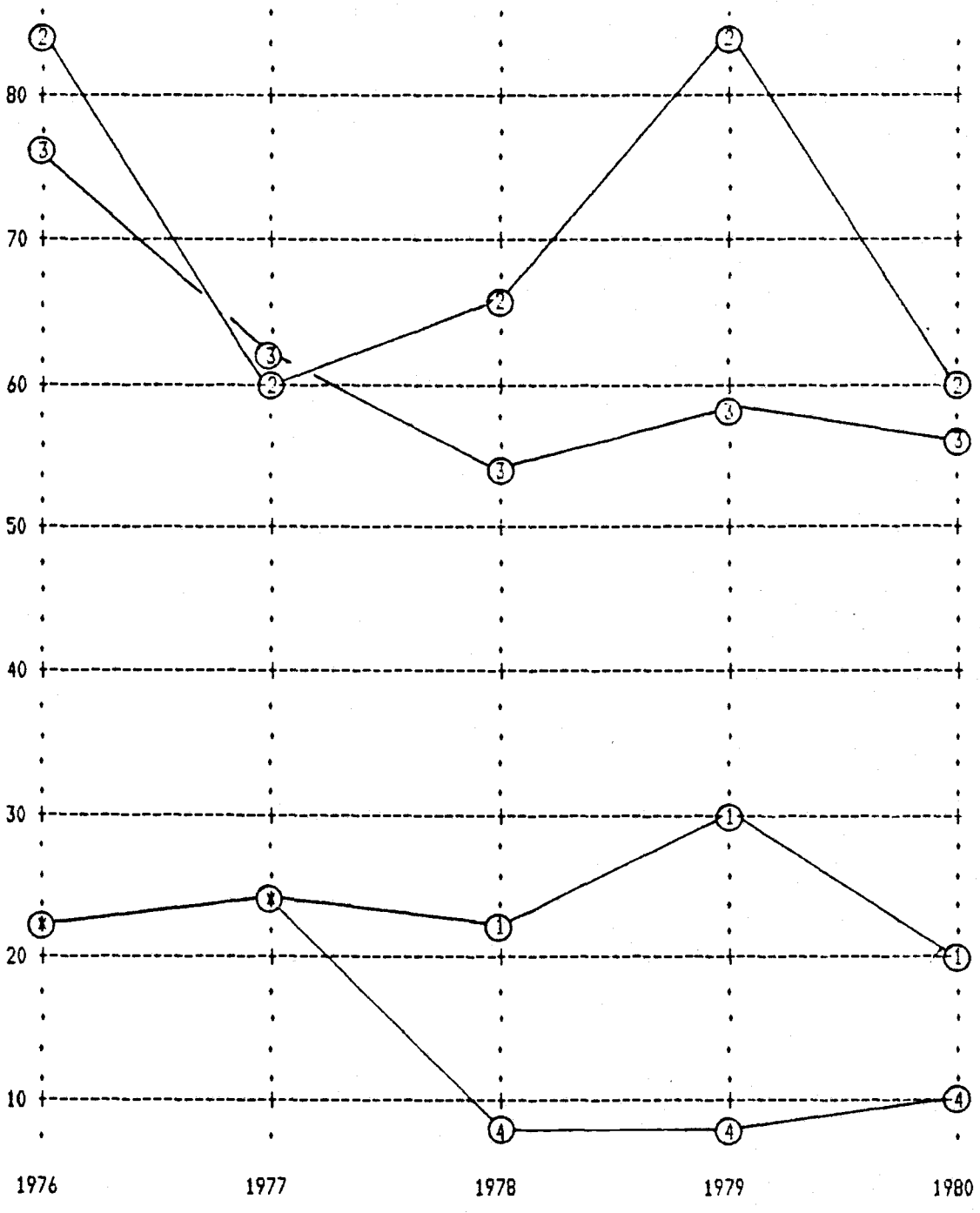
1 - FIXED ASSETS/AVG DAILY SALES
2 - CURRENT ASSETS/AVE DAILY SALES
3 - LAND&BUILDINGS/AVG DAILY SALES
4 - PLANT&EQUIPMENT/AVG DAILY SALES
5 - RAW MATERIALS/AVG DAILY SALES
6 - ACCOUNTS REC /AVG DAILY SALES
7 - WORK IN PROCESS/AVG DAILY SALES
8 - FINISHED GOODS INV /AVG DAILY SALES

Figure 1



1 - DIRECT LABOR/SALES
2 - DIRECT MATERIAL/SALES
3 - INDIRECT LABOR/SALES
4 - INDIRECT MATERIAL/SALES

Figure 2



1 - RAW MATERIALS/AVG DAILY SALES
2 - ACCOUNTS REC /AVG DAILY SALES
3 - WORK IN PROCESS/AVG DAILY SALES
4 - FINISHED GOODS INV /AVG DAILY SALES

Figure 3

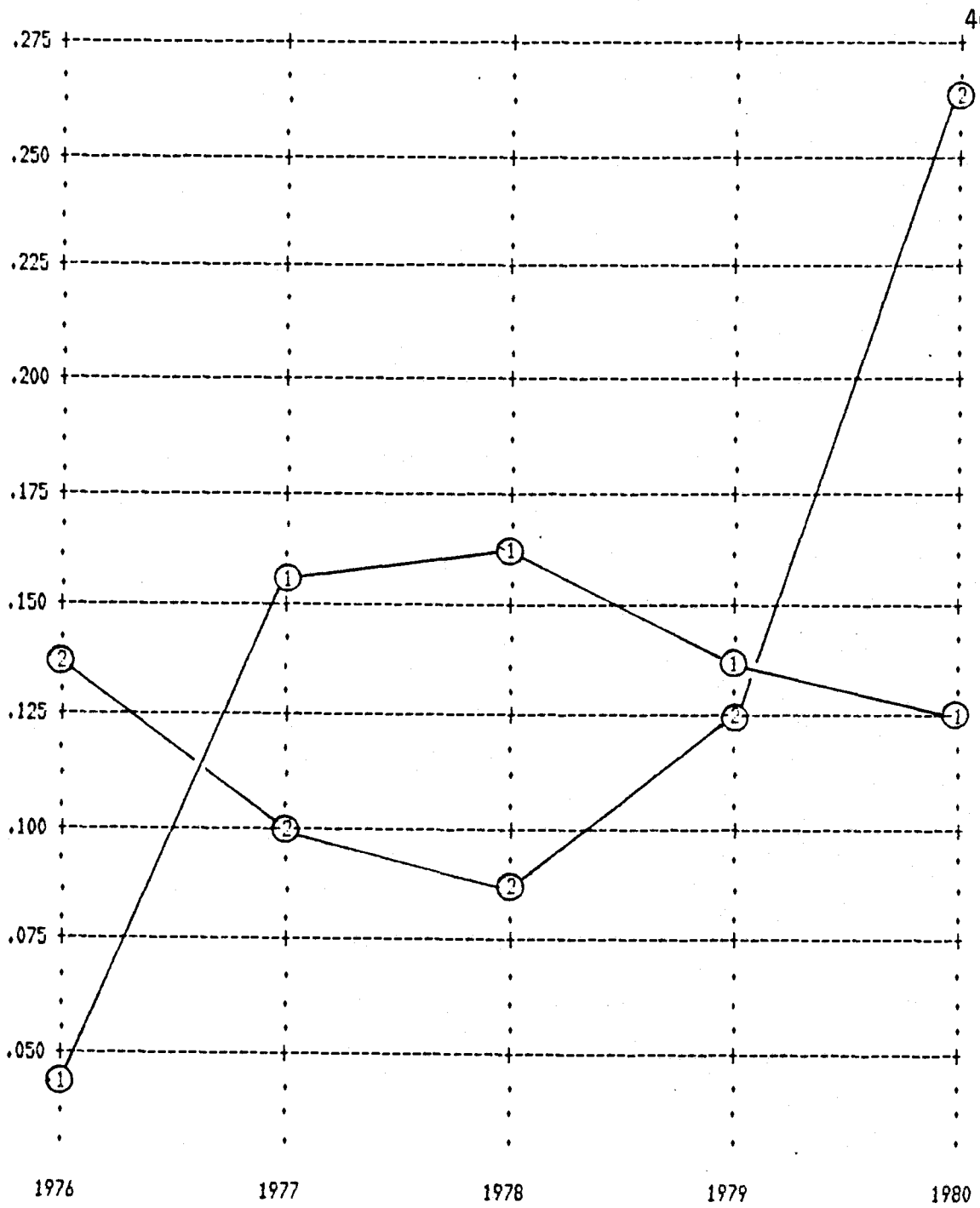

.275
.250
.225
.200
.175
.150
.125
.100
.075
.050
1976
1977
1978
1979
1980
1 - ROA
2 - TOTAL MATERIAL /SALES

Figure 4

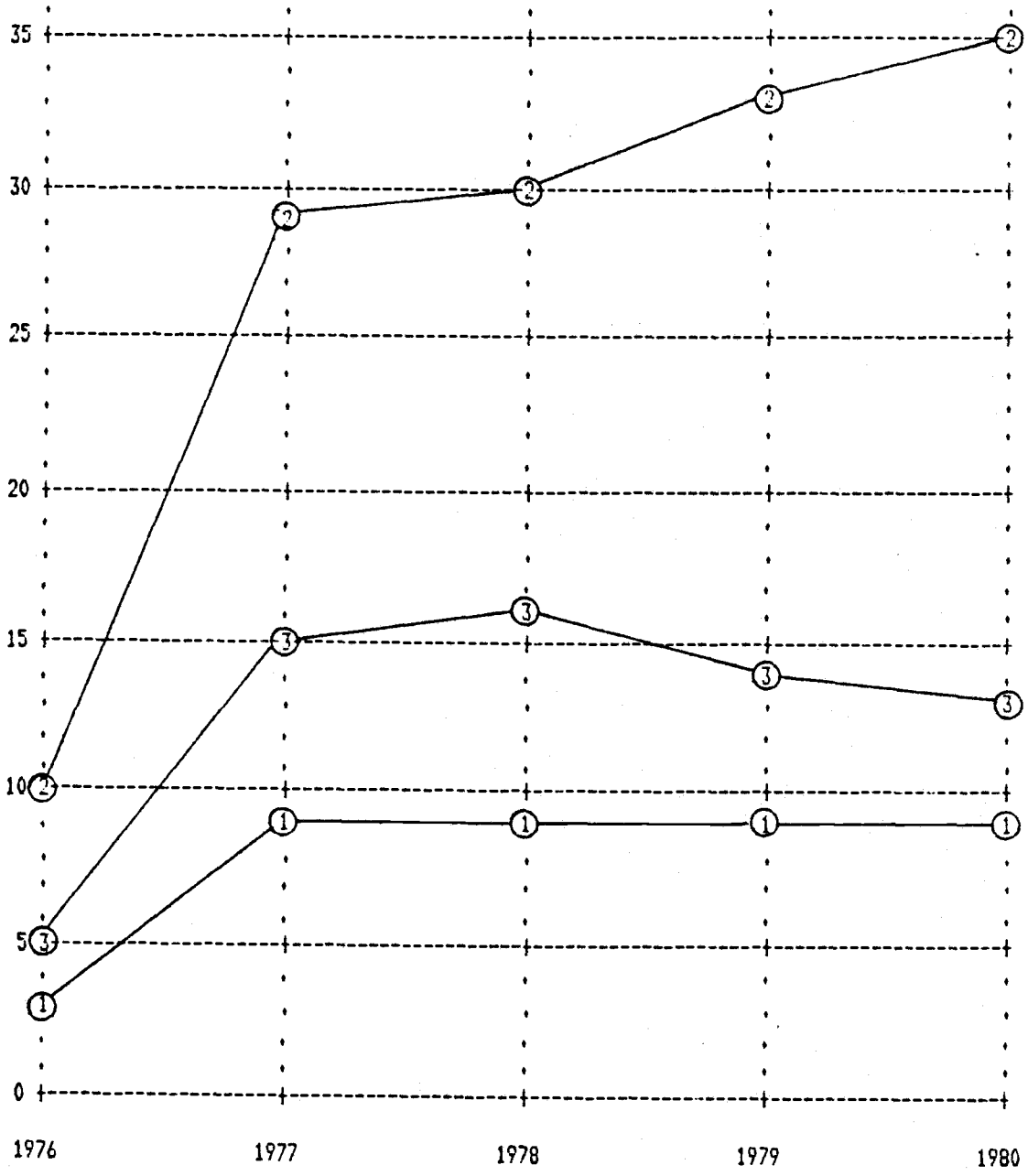
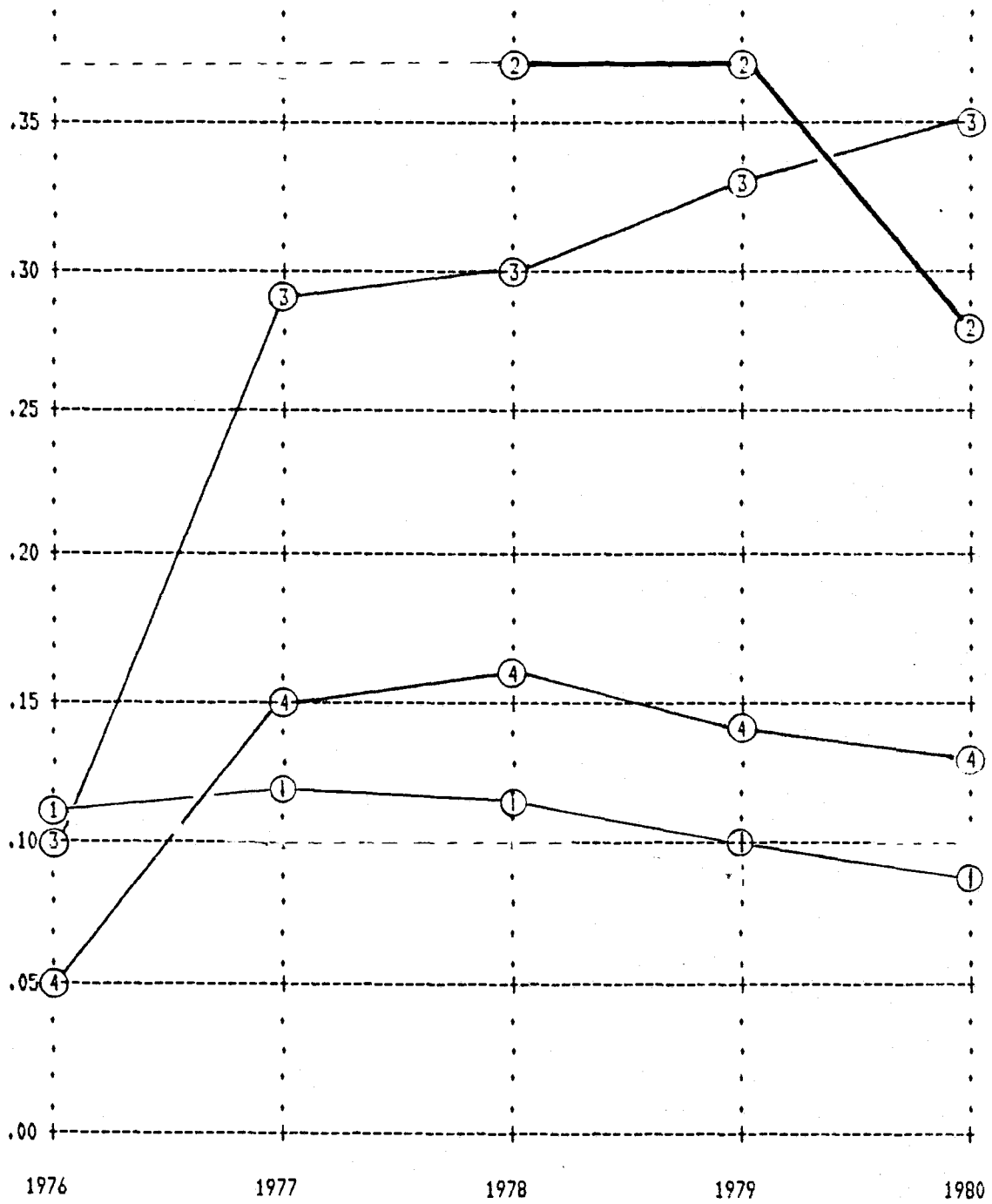

35
30
25
20
15
10
5
0
1976
1977
1978
1979
1980
1 - NET PROFIT PERCENT
2 - RETURN ON EQUITY PERCENT
3 - RETURN ON ASSETS PERCENT

Figure 5

schoolhouse which is being converted into ESI office space. Figure 6 shows the relationship of direct labor to sales and the number of direct employees compared to the number of indirect employees. The plot of Figure 6 also shows the Return on Equity (ROE) and Return on Assets (ROA) as a fraction of sales. Two things can be noted here: (1) The ratio of direct labor employees has declined in relationship to indirect employees. (2) The total direct labor relationship to sales has declined since 1978. This is in spite of an actual increase in numbers of direct labor employees (84 to 185) and increased labor costs. Figure 7 shows growth of sales, net profit, return on equity, and return on assets percentages. There is a substantial growth of sales from the period 1976 to 1977. A healthy trend is noted here because growth of sales has been accompanied by increasing return on equity.

Figure 8 illustrates the relationships of labor, materials, and energy to sales. The affiliation of direct materials to sales shows an alarming increase in the period of 1978 to 1980. This increase was caused by the following factors: (1) The type of product made became more complicated and required more expensive subassemblies for its production. (This was a result of a change in emphasis from instrument sales into laser trimming sales.) (2) The price of subassemblies purchased increased more quickly than the sales price of the products. The relationship of energy to sales also shows a substantial increase. At the present time, energy usage is not a primary concern to ESI. However, if the present growth holds, this may become a more pressing problem.

Figure 9 illustrates the ADMINISTRATIVE COST/SALES, DIRECT LABOR/



1 - DIRECT LABOR/SALES
2 - DIRECT EMPLOYEE/INDIRECT EMPLOYEE
3 - ROE
4 - ROA

Figure 6

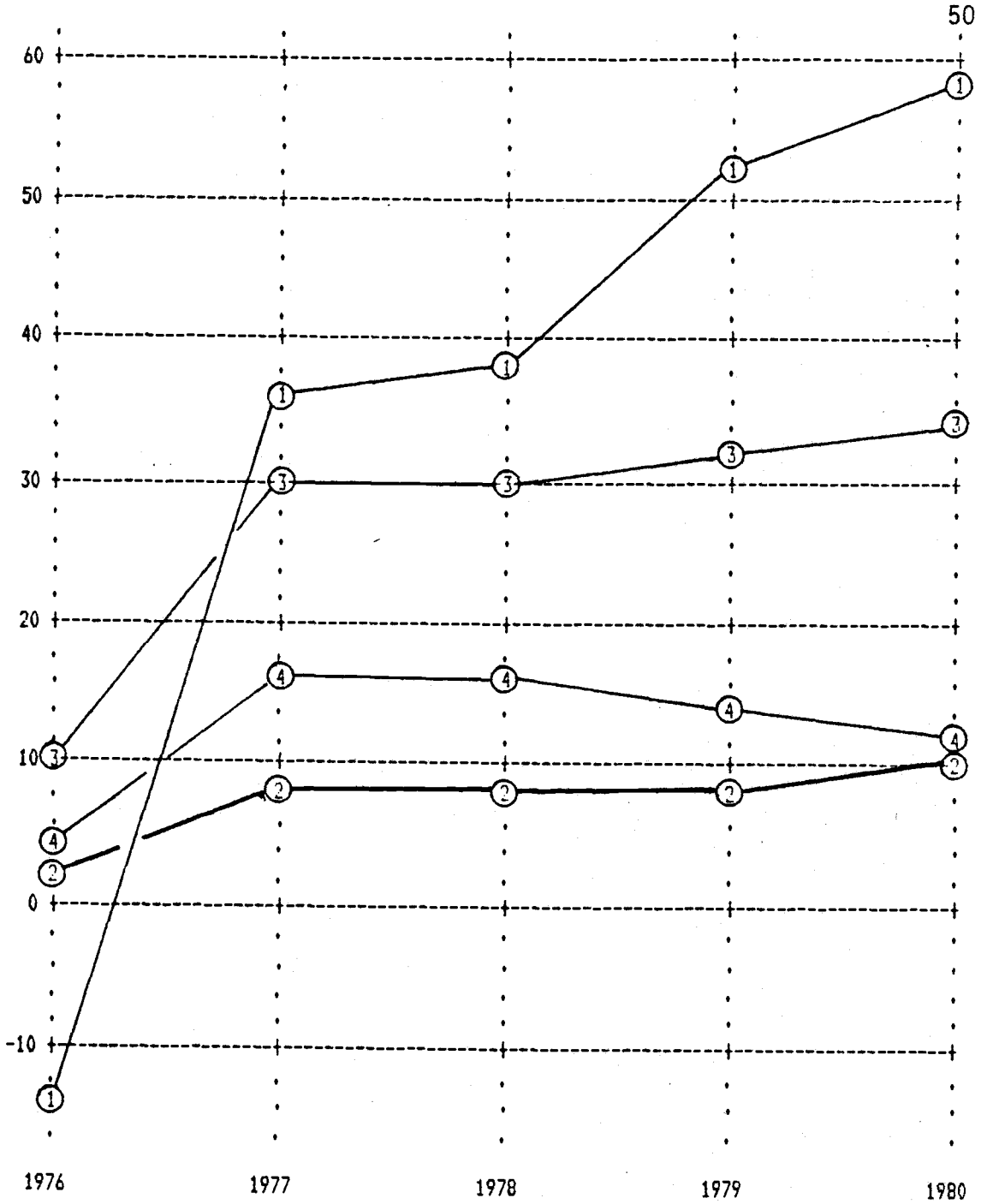

50
60
50
40
30
20
10
0
-10
1976
1977
1978
1979
1980
1 - GROWTH OF SALES
2 - NET PROFIT PERCENT
3 - RETURN ON EQUITY PERCENT
4 - RETURN ON ASSETS PERCENT

Figure 7

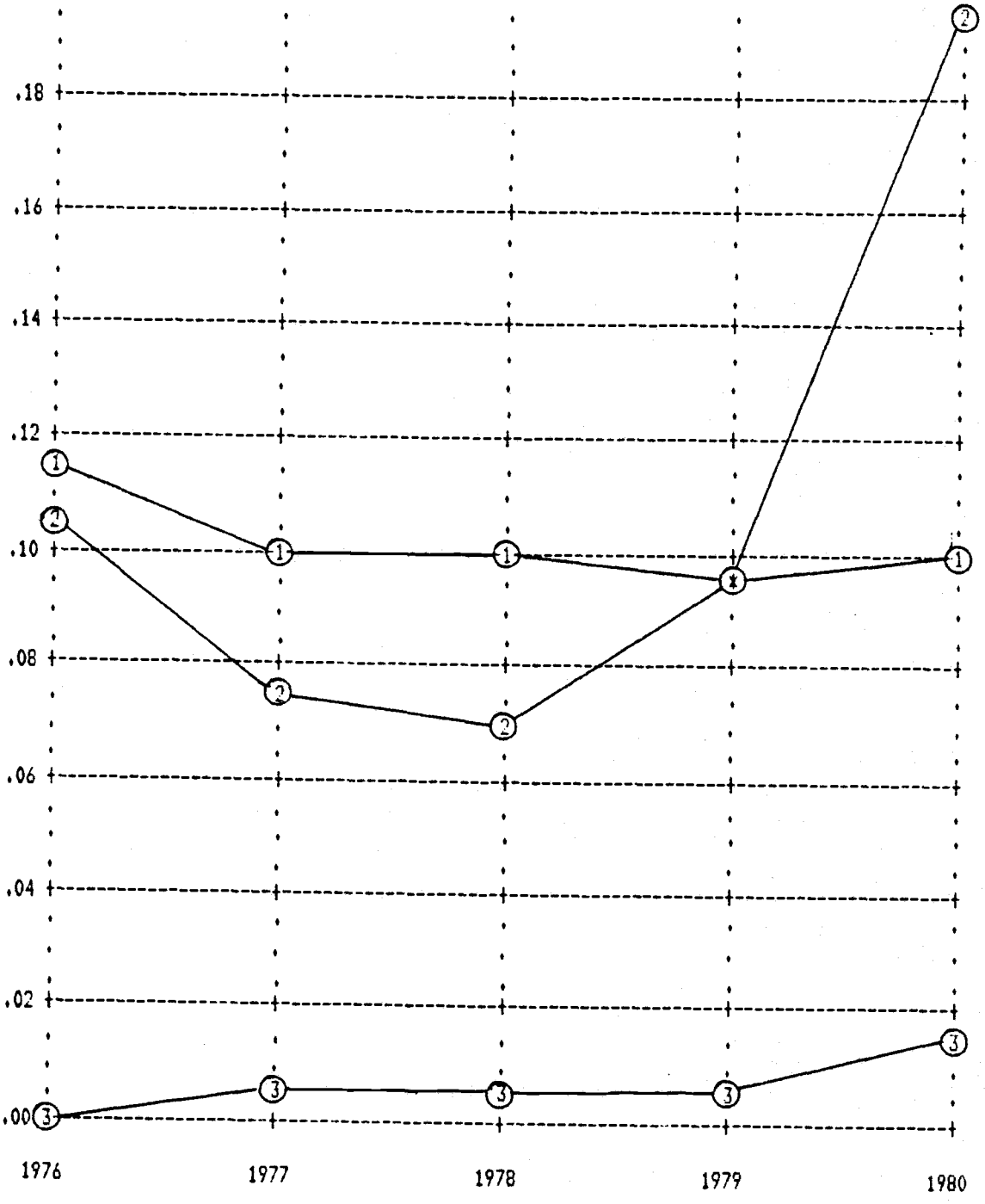
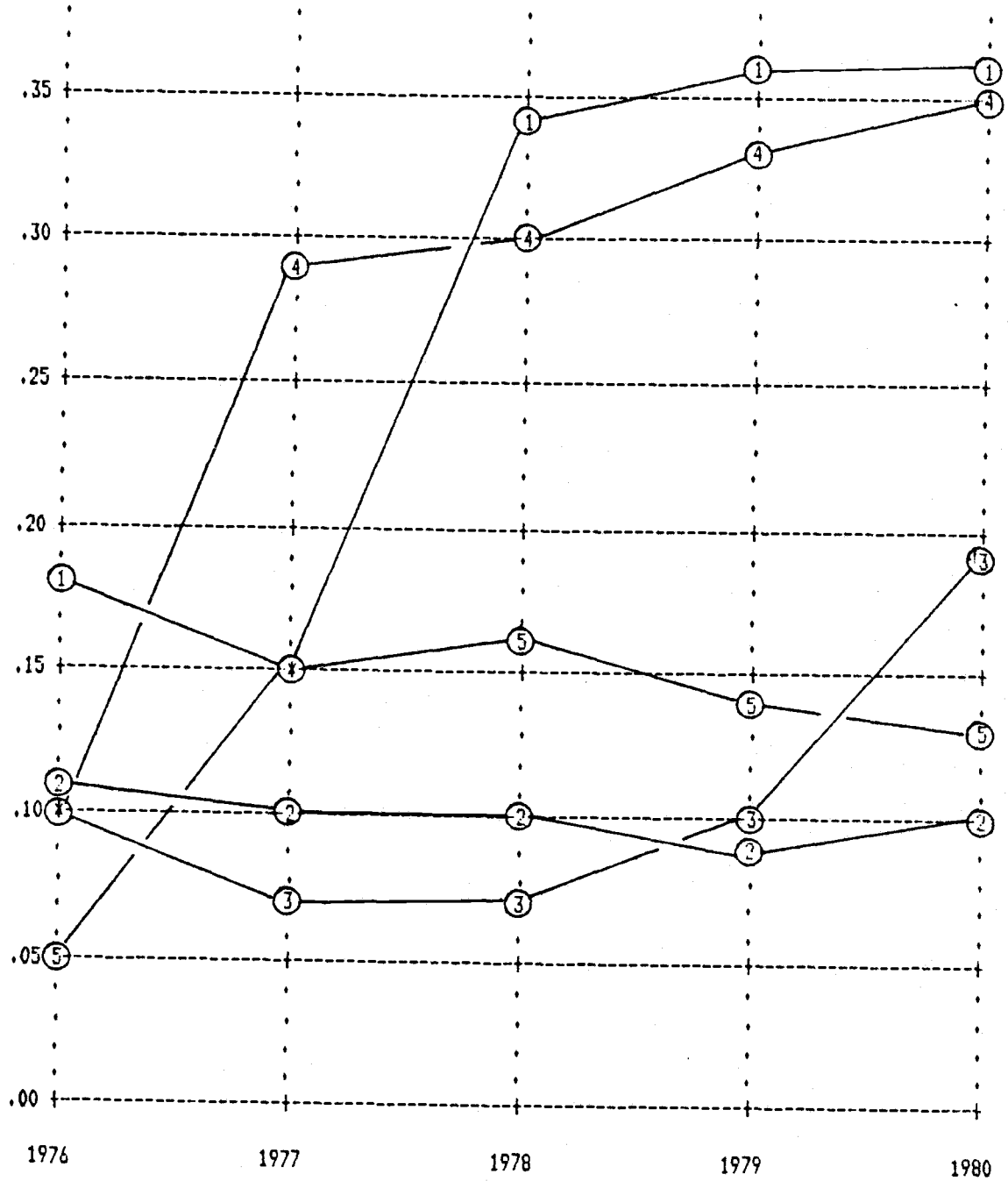

.18
.16
.14
.12
.10
.08
.06
.04
.02
.00
1976
1977
1978
1979
1980
1 - DIRECT LABOR/SALES
2 - DIRECT MATERIAL/SALES
3 - ENERGY /SALES

Figure 8



1 - ADMIN COST/SALES
2 - DIRECT LABOR/SALES
3 - DIRECT MATERIAL/SALES
4 - ROE
5 - ROA

Figure 9

SALES, DIRECT MATERIAL/SALES, and return on equity on assets. There was a substantial growth in ADMINISTRATIVE COST/SALES in the period of 1976 to 1978, but this was caused by a change in the accounting methods. However, since 1978 that ratio has continued to grow, which indicates that controls need to be instituted.

Figure 10 shows ADMINISTRATIVE COST/SALES, DIRECT LABOR/SALES, DIRECT MATERIAL/SALES, INDIRECT LABOR/SALES, and INDIRECT MATERIAL/SALES. The indirect labor line is much higher than the direct labor line, which is expected since the number of indirect labor employees and the average cost of an indirect labor employee is much higher than a direct labor employee. (Indirect labor includes engineers, accountants, secretaries, and highly skilled technicians.) The increase seen in indirect materials is due to remodeling supplies used in the new school-office complex. This ratio is expected to drop or hold constant after 1980.

Figure 11 shows the relationships of OPERATING PROFIT/DIRECT LABOR, OPERATING PROFIT/DIRECT MATERIAL, and OPERATING PROFIT/INDIRECT LABOR. (Operating profit is earnings before income taxes and profit sharing.) The ratio of OPERATING PROFIT/DIRECT MATERIAL has shown a precipitous, unfavorable decline since 1978 due to increased materials cost. Operating profit compared to both labor components has increased since 1979, which is a favorable trend.

Figure 12 shows the ratios of DIRECT LABOR/ASSETS EMPLOYED and DIRECT MATERIAL/ASSETS EMPLOYED. Both ratios show the increase in capital intensity of the company since 1978. Because Assets Employed has increased dramatically from 1978, both ratios have declined substantially.

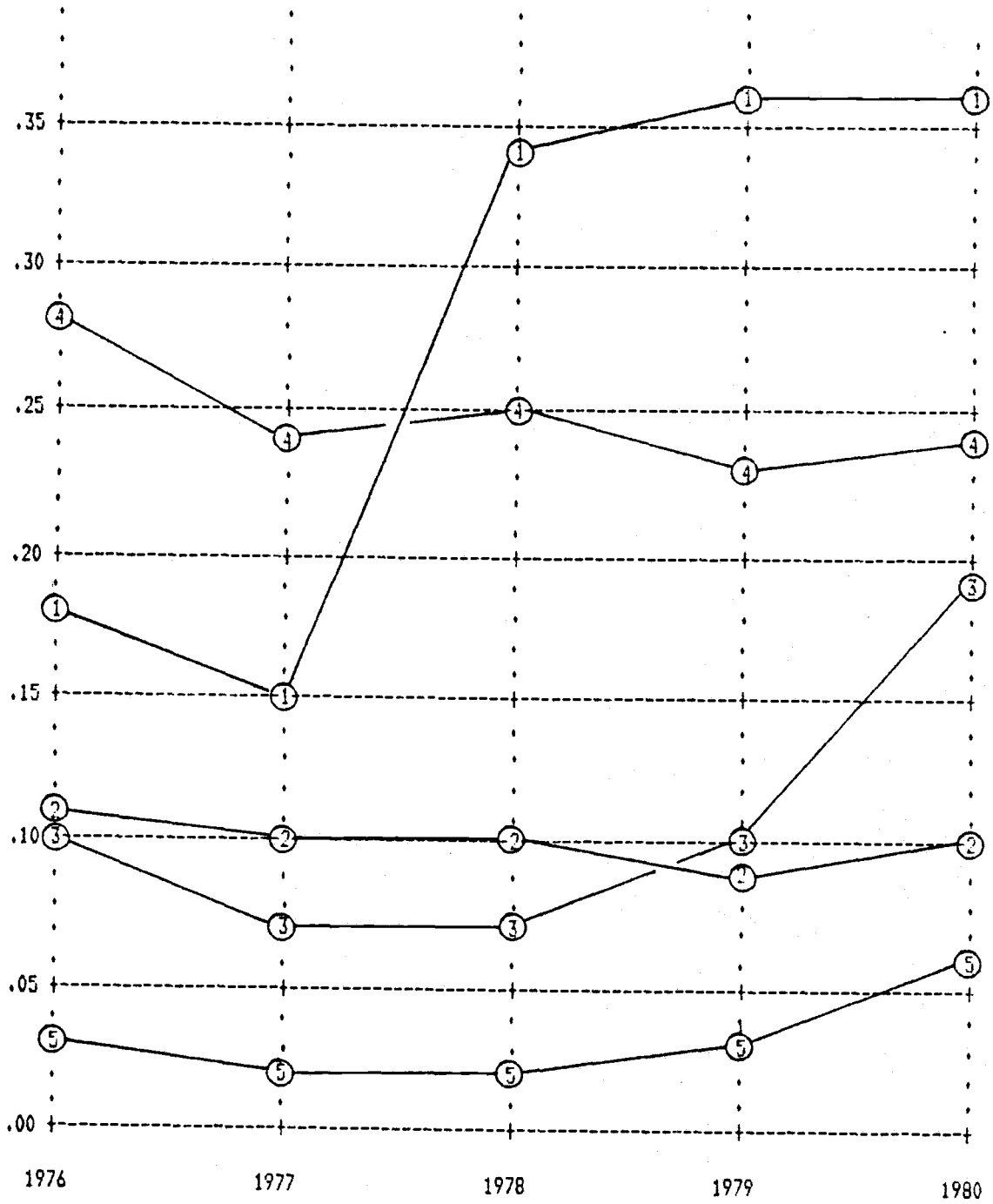

.35
.30
.25
.20
.15
.10
.05
.00
1976
1977
1978
1979
1980
1 - ADMIN COST/SALES
2 - DIRECT LABOR/SALES
3 - DIRECT MATERIAL/SALES
4 - INDIRECT LABOR/SALES
5 - INDIRECT MATERIAL/SALES

Figure 10

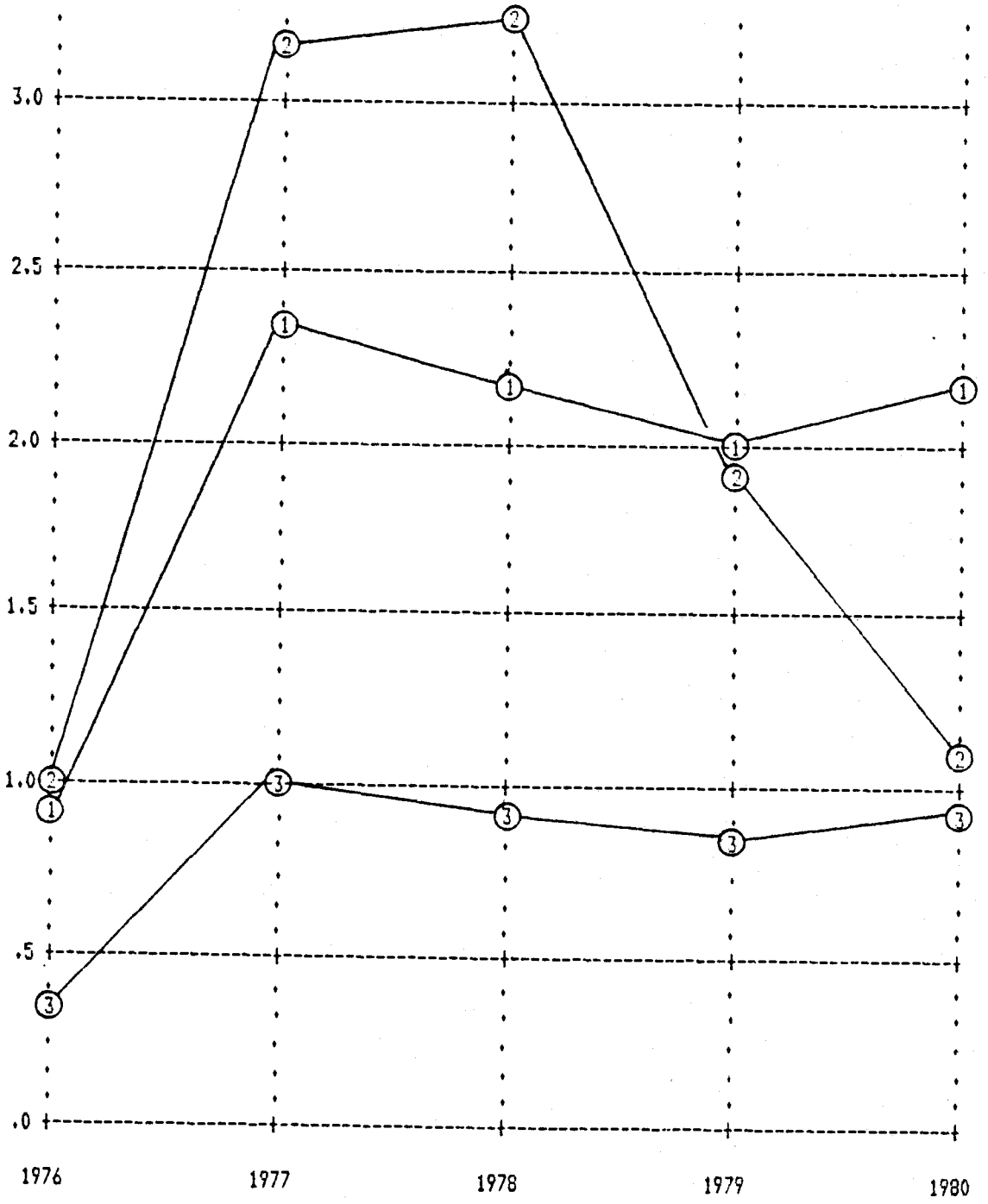

3.0
2.5
2.0
1.5
1.0
.5
.0
1976
1977
1978
1979
1980
1 - OPERATING PROFIT/DIRECT LABOR
2 - OPERATING PROFIT/DIRECT MATERIAL
3 - OPERATING PROFIT/INDIRECT LABOR

Figure 11

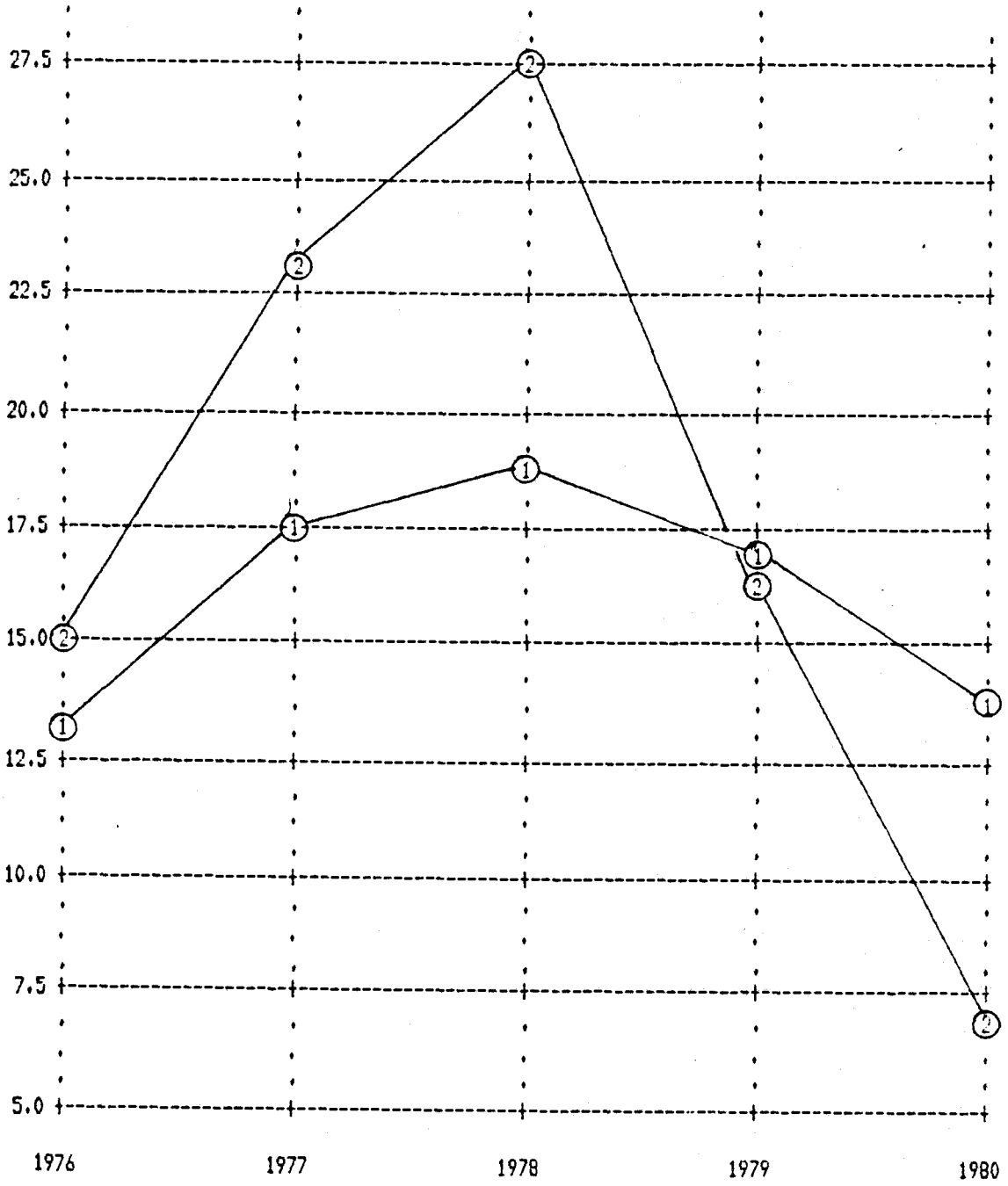

27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
1976
1977
1978
1979
1980
1 - DIRECT LABOR/ASSETS EMPLOYED
2 - DIRECT MATERIAL/ASSETS EMPLOYED

Figure 12

Figure 13 shows DEPRECIATION/PREVIOUS YEARS SALES, DEPRECIATION/FIXED ASSETS, DEPRECIATION/PLANT AND EQUIPMENT and DEPRECIATION/LAND AND BUILDINGS. DEPRECIATION/PREVIOUS YEARS SALES indicates the extent that earnings are returned to investment. Since the depreciation is taken on the prior year's investment, this ratio gives a better indication of how earnings were reinvested in the firm. This ratio shows a favorable trend. The ratio of DEPRECIATION/FIXED ASSETS is declining because of the increased investment made in buildings and plant and equipment. The major drop in DEPRECIATION/LAND AND BUILDINGS was due to the purchase of the schoolhouse at the end of fiscal year 1980. Very little depreciation was taken during the 1980 fiscal year which skewed this ratio. It should return to a more stable pattern after 1980.

Figure 14 shows FIXED ASSETS/AVERAGE DAILY SALES, CURRENT ASSETS/AVERAGE DAILY SALES, and PLANT AND EQUIPMENT/AVERAGE DAILY SALES. Average daily sales has been calculated on a 365 days per year basis. The favorable downward trend since 1979 of CURRENT ASSETS/AVERAGE DAILY SALES is offset by an unfavorable upward trend in FIXED ASSETS/AVERAGE DAILY SALES. The Fixed Assets increase is due to the purchase of the school building. Future trends in fixed assets should return to a more favorable pattern.

Figure 15 shows OPERATING PROFIT/EMPLOYEE and SALES/DIRECT LABOR EMPLOYEE. The increase in SALES/DIRECT LABOR EMPLOYEE in 1979-1980 is due to a substantial increase in sales.

ESI's Weighted Ratio Productivity Index

Additional interviews at ESI yielded more information about

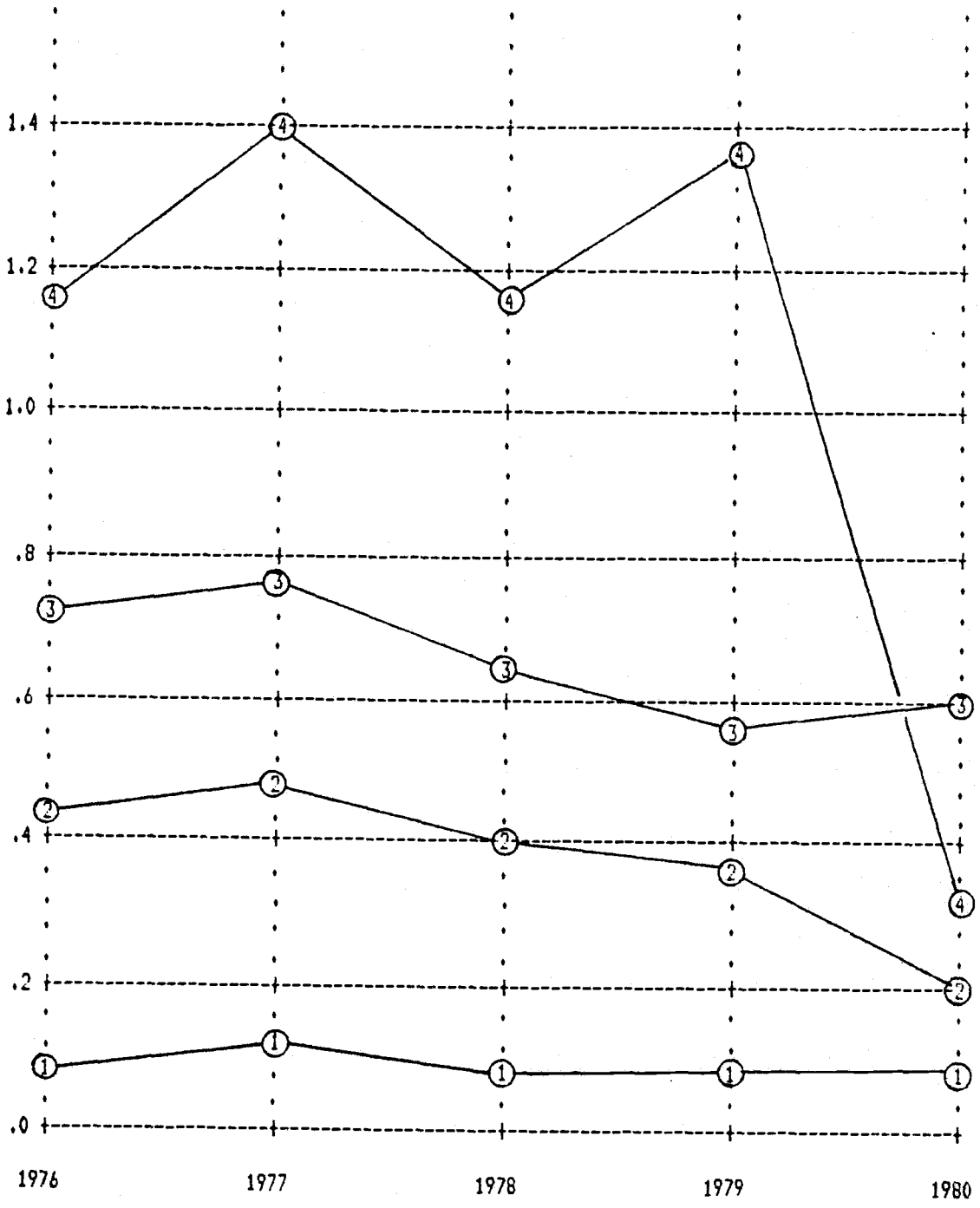

1.4
1.2
1.0
.8
.6
.4
.2
.0
1976
1977
1978
1979
1980
1 - DEPRECIATION/PREVIOUS YEAR SALES
2 - DEPREC /FIXED ASSETS
3 - DEPREC /PLANT&EQUIPMENT
4 - DEPREC /LAND&BUILDINGS

Figure 13

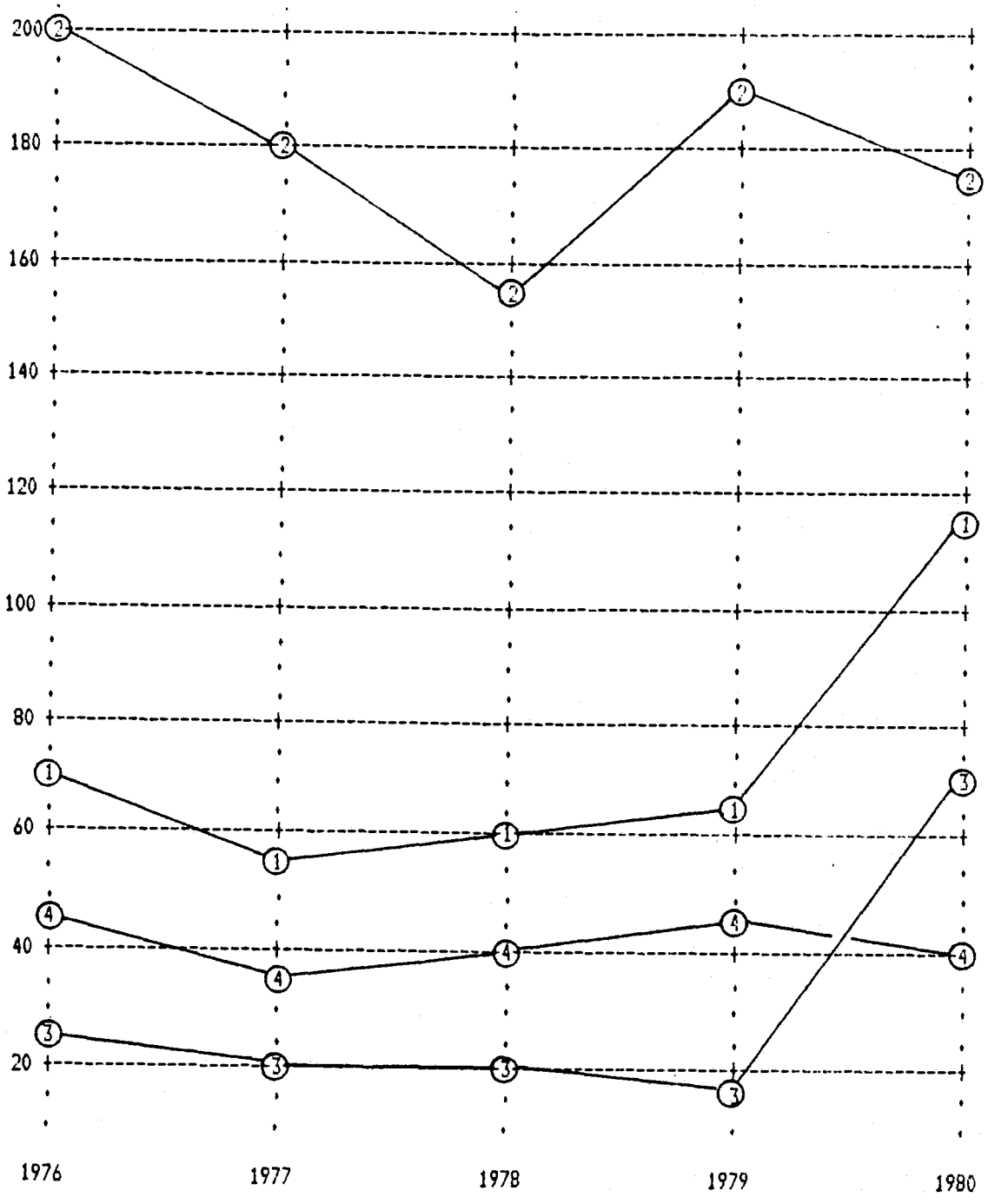

200
180
160
140
120
100
80
60
40
20
1976
1977
1978
1979
1980
1 - FIXED ASSETS/AVG DAILY SALES
2 - CURRENT ASSETS/AVE DAILY SALES
3 - LAND&BUILDINGS/AVG DAILY SALES
4 - PLANT&EQUIPMENT/AVG DAILY SALES

Figure 14

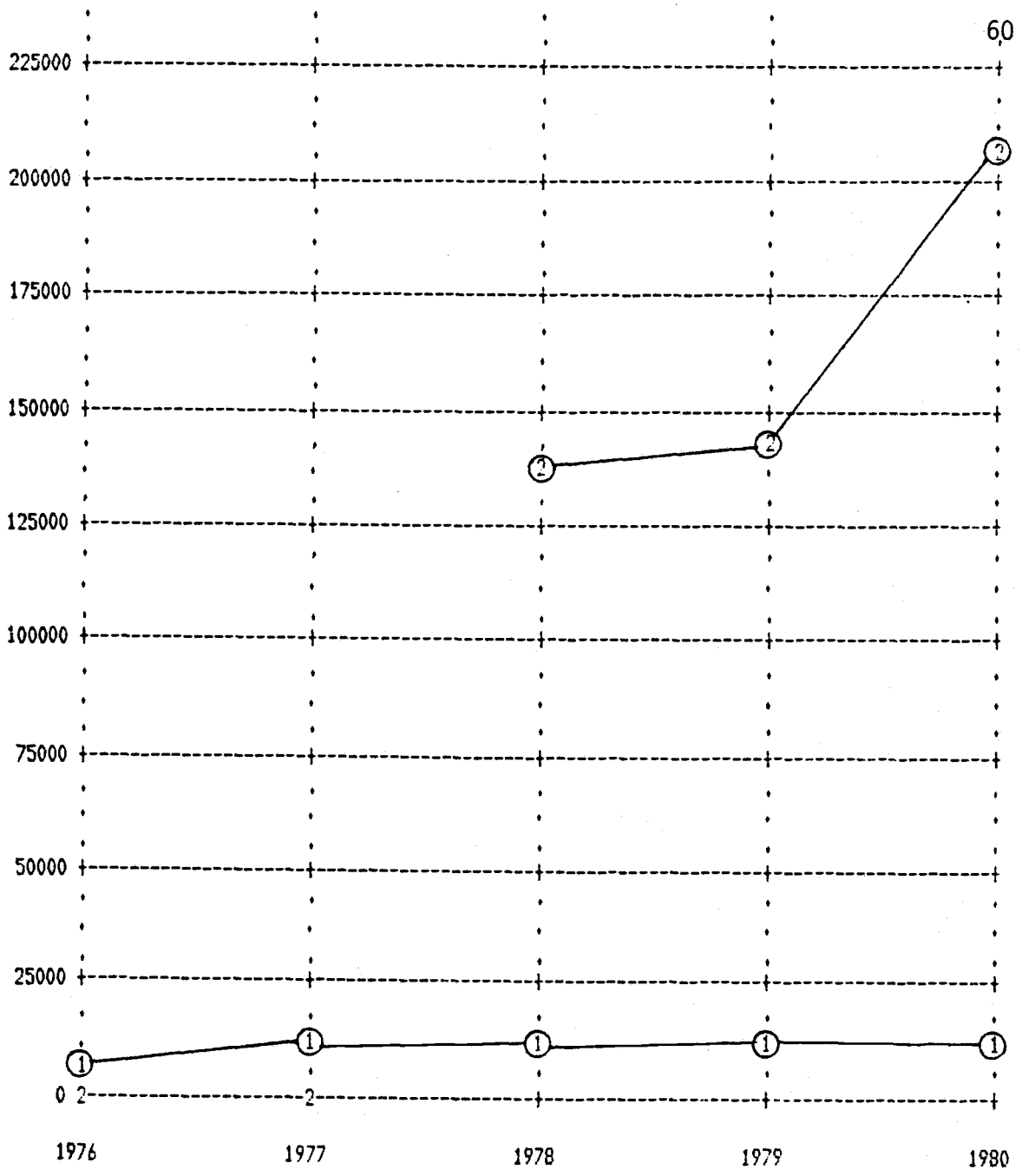

60
225000
200000
175000
150000
125000
100000
75000
50000
25000
0
2
1976
1977
1978
1979
1980
1 - OPERATING PROFIT/EMPLOYEE
2 - SALES/DIRECT LABOR EMPLOYEE

Figure 15

production, quality control, finance, and additional areas. A data model for future productivity measures (Weighted Ratio Productivity Index) was then developed by the researcher. This model is shown in Appendix B and includes instructions for completing the data. Some items, such as TOTAL ASSETS/SALES will be collected on an annual basis. Others will be more frequently gathered, depending upon need and preference. Weighted ratios can then be developed from the collected data. Because of the innovative nature of the electronics industry, ratio categories were suggested in the areas of research and development.

Some unique ratios are also suggested for quality control, production control, capital investment, energy and scarce material usage. For example, the ratios of FAULT PREVENTION HOURS/INSPECTION HOURS, and WARRANTY REPAIR COST/WARRANTY REPAIR ITEMS were developed to monitor quality control in a more precise manner.

Presentation to ESI Advisory Committee

On May 16, 1981, the researcher presented a packet of data concerned with productivity performance to the ESI Advisory Committee. This is summarized in Appendix A. As a result of the presentation the following things were accomplished. (1) Ten key indicators were selected by ESI for a weighted productivity indicator. (2) Weighting was assigned to those indicators and the current year Weighted Ratio Productivity Index (WRPI) was derived, as shown below. (3) A new management position for productivity measurement is to be established at ESI.

Weighted Ratio Productivity Index

RATIO	RATIO VALUE	WEIGHTING ASSIGNED	WEIGHTED VALUE
Total Materials / Sales	.265	15	3.975
Present Growth / Operating Profit	.890	20	17.800
Total Labor $ / Sales	.350	20	7.000
Manufacturing Direct Labor $ / Sales	.0585	10	0.585
Selling, Administrative Engineering Cost / Sales	.3578	5	1.789
Raw Materials / Average Daily Sales	19.916	10	199.160
Work in Process / Average Daily Sales	55.256	5	276.280
Finished Goods Inventory / Average Daily Sales	9.222	5	46.110
Fixed Assets / Average Daily Sales	112.500	5	562.500
Current Assets / Average Daily Sales	117.19	5	885.950
TOTAL		100	2001.149

Table 13

Data desired for the analysis

DATA COLLECTION

SALES AND COSTS:

1. Direct Material____
2. Direct Labor____
3. Indirect Labor____
4. Indirect Material____
5. Other Factory Overhead____
6. Factory Overhead (3+4+5)____
7. Factory Cost (1+2+6)____
8. Cost of Goods Sold (Production)____
9. Sales and Distribution Cost____
10. Administration Cost____
11. Engineering Costs____
12. Operating Cost (8+9+10+11)____
13. Sales____
14. Sales Value of Production____
15. Operating Product (13-12)____

ASSETS:

16. Average Raw Materials____
17. Average Accounts Receivable____
18. Average Work-In-Process____
19. Average Finished Goods Inventory____
20. Total Current Assets (16+17+18+19)____
21. Land and Buildings____
22. Plant and Equipment____
23. Fixed Assets (2+22)____
24. Fixed Assets (2+22)____

OTHER ITEMS:

25. Number of Direct Labor Employees____
26. Number of All Other Employees____
27. Total Employees (25+26)____
28. Total Overtime Hours Worked____
29. Total Direct Labor Hours Worker____
30. Average Wage/Direct Worker Paid 40 hrs. week____
31. Factory Man-Days Lost due to Internal Reasons____
32. Factory Man-Days Lost Due to External Reasons____
33. Financing Costs____
34. Net Profit (Line 15-33)____
35. Sales Last Year____

TABLE 13 (Cont.)

MATERIAL INPUTS

	Period 1	Period 2
Raw Materials Consumed	$_____	_____
Maintenance Materials Consumed	_____	_____
Operating Supplies Consumed	_____	_____
TOTAL MATERIALS	$_____	_____(1)

Input to be consumption only. Inventory build-up would be accounted for as a capital input.

SERVICES INPUTS

Outside Engineering	$_____	_____
Auditor Fees, etc.	_____	_____
Computer Services	_____	_____
Other Services	_____	_____
TOTAL SERVICE INPUTS	$_____	_____(2)

LABOR INPUTS

Direct Labor	$_____	_____
Indirect Labor	_____	_____
TOTAL	$_____	_____(3)

ENERGY INPUTS

Process Energy	$_____	_____
Building Energy	_____	_____
TOTAL	$_____	_____(4)

TABLE 13 (Cont.)

CAPITAL INPUTS

VALUE

	Period 1	Period 2
Physical Assets* (Owned & Leased)		
Land	$_____	_____
Buildings	_____	_____
Machinery and Equipment	_____	_____
TOTAL	_____	_____

*Physical asset consumption based upon service life depreciation or monthly lease charge.

Working Capital:		
Inventories	_____	_____
Accounts Receivable	_____	_____
Cash	_____	_____
TOTAL	_____	_____ (4)

PHYSICAL QUANTITIES

Land (Acres or Sq-ft)	_____	_____
Buildings (Sq-ft or volume)	_____	_____

TABLE 13 (Cont.)

SUMMARY

VALUE

	Period 1**	Period 2**
Output:		
Product* A	$_____	_____
Product* B	_____	_____
Product* C	_____	_____
TOTAL	_____	_____

* Could possibly be department rather than product, if, for instance, a large number of products are produced.

**Period for audit purpose should be current month and previous month.

Input:		
(1) Materials	_____	_____
(2) Labor	_____	_____
(3) Energy	_____	_____
(4) Capital	_____	_____
TOTAL	_____	_____
Capital Return	_____	_____
Reported Profit & Loss	_____	_____

Table 14

Table of ratios and data available from ESI

RATIO RELATIONSHIP	1976	1977	1978	1979	1980
Operating Profit / Assets Employed	.1562	.4033	.4086	.2940	.2874
Operating Profit / Sales	.1033	.2344	.2185	.1860	.2119
Sales / Assets Employed	1.5116	1.7205	1.8702	1.5812	1.3563
Total Admin. Cost / Sales	.177	.154	.338	.355	.358
Direct Labor $ / Sales	.1145	.1204	.1111	.1012	.0904
Direct Material / Sales	.1029	.0748	.0677	.0962	.1941
Indirect Labor / Sales	.2808	.2438	.2465	.2307	.2416
Indirect Material / Sales	.0337	.0245	.0221	.0314	.0635
Fixed Assets / Avg. Daily Sales	71.085	57.336	61.045	64.75	112.5
Current Assets / Avg. Daily Sales	198.32	179.75	155.469	190.374	177.195
Land & Buildings / Avg. Daily Sales	27.429	20.349	21.733	17.366	71.728
Plant & Equipment / Avg. Daily Sales	43.66	36.92	39.31	43.89	38.00
Raw Materials / Avg. Daily Sales	22.403	24.023	22.038	29.343	19.916
Accounts Rec. / Avg. Daily Sales	83.054	60.906	66.243	84.894	59.570

Table 14 (Con't)

RATIO RELATIONSHIP	1976	1977	1978	1979	1980
Work in Process / Avg. Daily Sales	75.873	62.212	53.147	58.837	55.256
Fin. Goods Inv. / Avg. Daily Sales	22.403	24.023	8.000	7.757	9.222
Growth of Sales %	-14.4%	+35.5%	+38.6%	+52.7%	+57.4%
Operating Profit / Employee	$3471	10,909	11,021	9,924	12,023
Depreciation / Previous Year Sales	.0735	.1047	.0968	.0940	.0968
Depreciation / Fixed Assets	.4411	.4923	.4174	.3668	.1996
Depreciation / Plant & Equipment	.7182	.7646	.6481	.5412	.5908
Depreciation / Land and Buildings	1.1430	1.3870	1.1723	1.3679	0.3130
Direct Labor / Assets Employed	13.20	17.30	18.61	16.80	13.76
Direct Material / Assets Employed	14.69	23.00	27.62	16.44	6.99
Operating Profit / Direct Labor	0.902	2.355	2.174	1.977	2.149
Operating Profit / Direct Material	1.004	3.134	3.227	1.933	1.092
Operating Profit / Indirect Labor	.3678	.9614	.8864	.8062	.8771
Current Assets / Fixed Assets	2.789	3.135	2.547	2.939	1.575

Table 14 (Con't)

RATIO RELATIONSHIP	1976	1977	1978	1979	1980
Direct Employee / Indirect Employee	-	-	.373	.373	.275
Sales / Direct Labor Empl.	-	-	$134,895	$142,772	$206,196
Avg. Wage/Hour	6.98	7.95	8.25	8.44	9.80
Net Profit %	2.98	8.9	8.5	8.7	9.3
ROE %	10.26	29.38	30.29	32.54	34.72
ROA %	4.5	15.32	15.94	13.81	12.58
Sales $ / Labor %	2.55	2.71	2.68	2.69	2.94
Sales $ / Payroll Hour	17.69	23.03	23.49	24.40	27.70
Energy $ / Sales $	-	.004	.004	.005	.016
Labor $ / Sales $	.395	.343	.346	.324	.350
Total Material $ / Sales $	.1365	.0993	.0898	.127	.265
Avg. Monthly Empl. Turnover %	-	-	-	1.85	2.0

Table 14 (Cont'd)

RATIO RELATIONSHIP	1976	1977	1978	1979	1980
$\frac{\text{Direct Labor}}{\text{Direct Material}}$	1.1127	1.3302	1.4845	.9782	.5080
$\frac{\text{Direct Labor \$}}{\text{Indirect Labor \$}}$	.408	.494	.451	.439	.374
$\frac{\text{Mfg. Direct Labor \$}}{\text{Sales}}$	Unknown	0.0627	0.0652	0.0637	0.0585
$\frac{\text{Selling Admin. \& Engr. Costs}}{\text{Sales}}$	.3687	.3076	.3379	.3552	.3578

Table 15

Description of ratios and what they mean

RATIO	DIRECTION FOR A GOOD RATIO	WHAT IT MEANS
Operating Profit / Assets Employed	High	Summarizes overall profitability of business - indicates rates of return on investment in assets.
Operating Profit / Sales	High	Shows profit making on sales.
Sales / Assets Employed	High	Shows how effectively assets have been used. Higher ratios show more intense use of assets. Shows number of times during year investment in assets turned over.
Total Admin. Cost / Sales	Low	Should fall as sales increase since many administrative expenses are relatively fixed. Low ratio could mean efficient administrative costs or contrawise administrative resources are stretched. High Admin. costs - because of extensive planning and control could yield lower costs elsewhere.
Direct Labor / Sales	Low	Should be little change as percent of sales - more efficient D.L. should drop in percent of sales.
Direct Material / Sales	Low	Should also be a constant or lower percent of sales. High could mean material too expensive for sales price, high spoilage rate, write-off of obsolete stock, high proportion of non-standard items, lack of quantity or trade discount.
Indirect Labor / Sales	Low-Med	Higher proportions here should yield lower direct labor costs, i.e. quality control, production palnning, material handling, maint.

Table 15 (Con't)

RATIO	DIRECTION FOR A GOOD RATIO	WHAT IT MEANS
$\frac{\text{Fixed Assets}}{\text{Avg. Daily Sales}}$	Low	Indicates number of days taken to turn over investment in fixed assets. Plant and equipment should have close connection between value and capacity, value of land and buildings not so closely connected as property costs are increasing at a dramatic rate.
$\frac{\text{Current Assets}}{\text{Avg. Daily Sales}}$	Low	Reflects days to turn over investment in current assets. High ratios may be due to high raw materials, high A.R., high W.I.P. high F.G.I.
$\frac{\text{Land and Building}}{\text{Avg. Daily Sales}}$	Low	Indicates days to turn over investment in land and buildings. High ratio indicates less efficient use of available area and/or higher property costs.
$\frac{\text{Plant and Equipment}}{\text{Avg. Daily Sales}}$	Low	Indication of efficient use of plant and equipment. Fast turn over (low ratio) spreads fixed expenses, depreciation and maintenance over larger volume of sales, thus reduces unit overhead costs.
$\frac{\text{Raw Materials}}{\text{Avg. Daily Sales}}$	Low	Low ratio indicates stocks being turned over rapidly. Funds are not lying idle. High stock level may indicate wide range stock required for large range of products, accumulation of obsolete stock. Too much stock in relation to needs. Difficulty in obtaining continuous delivery of materials from suppliers, requiring holding of high stocks.
$\frac{\text{Accounts Receivable}}{\text{Avg. Daily Sales}}$	Low	Indicates time taken to collect accounts receivable is dependent upon terms of trade and credit policy.

Table 15 (Con't)

RATIO	DIRECTION FOR A GOOD RATIO	WHAT IT MEANS
Work in Process / Avg. Daily Sales	Low	Determined by job size, type of work, length of production process, and sales demand. A high level of WIP can reduce ROA and cause liquidity problems. If WIP is high and DL is also high, more production planning or machinery is needed.
Finished Goods / Avg. Daily Sales	Low	High level of FGI requires extra storage handling and administrative costs.
Growth of Sales	High	Should be compared with competitors. Should also be compared to effect on profits and return on assets. Growth in sales should be accompanied by profits on sales.
Operating Profit / Employee	High	Indication of average contribution of employees to the profits of firm. Low ratio may be due to: More labor used-less capital equipment, operating inefficiencies; large number employees in relation to profit earned; difference in mix of labor; classifications or senior/junior employees.
Direct Employees / Indirect Employees	High	Generally high ratio favorable. Low unfavorable with some important exceptions: 1. Number direct employees relative to indirect so large that effective control over use of direct labor can't be established. 2. Amount of plant and equipment is large and number of D.L. employees is low. 3. Quality Control standards are required to be at very high level. 4. Work is very complex requiring a great deal of supervision.

Table 15 (Con't)

RATIO	DIRECTION FOR A GOOD RATIO	WHAT IT MEANS
$\frac{\text{Sales}}{\text{Direct Labor Employee}}$	High	Indication of direct labor intensity of operations. Result of: 1. Labor machinery mix. 2. Efficient use of direct labor. 3. Type of product manufactured.
$\frac{\text{Average Wage}}{\text{Hour}}$		High earnings may result in a more stable workforce. More highly skilled workers. High skilled workers. High skill may yield more productivity which may yield lower labor costs.
Net Profit %	High	
ROE %	High	Dependent upon profitability and proportion of debt capital used by company.
ROA %	High	Dependent upon profit margin on sales, and turnover of total assets.
$\frac{\text{Sales \$}}{\text{Labor \$}}$	High	As increase indicates more efficient use of total labor.
$\frac{\text{Sales \$}}{\text{Payroll Hour}}$	High	Should be at least constant or increase if labor more efficient
$\frac{\text{Energy \$}}{\text{Sales \$}}$	Low	Should be constant or decrease as % of sales dependent upon price of energy. Total energy measured in KWHR or MBTU's should be constant proportion of sales or output.
$\frac{\text{Labor \$}}{\text{Sales \$}}$	Low	Inverse of $\frac{\text{Sales \$}}{\text{Labor \$}}$
$\frac{\text{Total Material \$}}{\text{Sales \$}}$	Low	Should be constant proportion relative to sales. Dependent upon product type, materials price, losses, etc.

Table 15 (Con't)

RATIO	DIRECTION FOR A GOOD RATIO	WHAT IT MEANS
Avg. monthly employee Turnover	Low	Should be fairly constant over time. Unusual changes warrant investigation.
Depreciation / Previous Years Sales		Constant or increasing level indicates reinvestment of capital into operations.
Depreciation / Fixed Assets		Shows extent of capital investment in fixed assets. Components are plant and equipment and land and buildings. Land doesn't depreciate.
Depreciation / Plant & Equipment		As it goes down, it indicates more investment in plant and equipment.
Depreciation / Land & Buildings		As it goes down, it indicates more investment in land and buildings.
Operating Profit / Direct Material	High	Shows how direct material contributes to the operating profit. Downward change in this ratio may be caused by increased materials price, changes in materials composition of the product produced.
Operating Profit / Indirect Labor		Shows how indirect labor contributes to the operating profit. Dependent upon profit margin and proportion of labor contribution to profits.
Operating Profit / Direct Profit	High	Shows relationship of direct labor to profit. High ratio might indicate more effective use of direct labor.
Direct Labor / Assets Employed		Indicates relation between direct labor and capital. Lower ratio means more capital intensive.
Direct Material / Assets Employed		Relationship between direct material and capital. Lower ratio means more capital intensive.

Table 15 (Con't)

RATIO	DIRECTION FOR A GOOD RATIO	WHAT IT MEANS
Current Assets / Fixed Assets		Relationship of where capital is concentrated. Must know where capital is more productive to determine if ratio should be high or low. (i.e. Plant & Equipment vs. Inventory tradeoffs.)

CHAPTER V

CONCLUSIONS AND EXTENSIONS

The study at ESI revealed that there was a great need for precise productivity measurement and understanding. The managers at ESI were favorably impressed with the ratio method of measurement and saw need for future application. Mr. Wally Masters, manager of the manufacturing area, has stated that he will record productivity measurements in the future as a function of his job responsibilities. Some others interviewed used the ratio format to develop further extensions and measurements in their own departments.

Method for Conducting an Intra- and Interfirm Comparison Study

The following is a procedure for a researcher desiring to do an intrafirm or interfirm comparison study.

Step 1: Establish the data format to be used in the collection of the data early in the study. Initially, the data format should be based upon financial ratios which can be derived from profit and loss and income statements that are published by the companies. The technical ratios related to production quantities and input factors (such as labor, materials, services and energy) can be developed later as more knowledge is gained about the company.

Step 2: Obtain early top management support. This can be done in different manners. One way is to "sell" the benefits that can be derived from the productivity study. For example, the benefit of an audit of the productivity status of a company done by an outside

unbiased observer can be highlighted. The letter in Appendix C, written by Mr. Imre Bernolak is another example. It can be used to show firms the benefits achieved from a productivity study. An excerpt of that letter follows:

> What firm D learned: 1.) its return was less than half that of its more successful rivals. 2.) The main reason was a low margin of profit on sales and another reason was a slower turnover of assets. 3.) Its production cost of sales was particularly high and this stemmed largely from a high production labor cost and low productivity, suggesting that planning and scheduling needed attention. 4.) A reduction should be obtainable in the cost of materials and components. 5.) Promotional costs were comparatively low, suggesting that more aggressive marketing might be helping other firms to increase sales volume, which in turn would tend to reduce several other cost ratios and improve the utilization of fixed assets.

Step 3: The researcher interviews both accounting and production managers to determine what data are available and obtain sample reports. The researcher then reviews the formats of those reports and returns to the managers interviewed to resolve any questions raised in the review.

Step 4: The next step is to interview key personnel in the accounting and production areas who are responsible for the production or the quality control of the reports that have been obtained. In this manner the reliability of the reports can be ascertained and a determination can be made of what informal records are available to the researcher.

Step 5: Next, the researcher can start collecting and confirming the data needed for the ratio analysis. The researcher needs to cross-check with other reports to determine if the data are accurate.

Step 6: The ratios can now be formed and graphical plots made from them. Then the data, plots, and ratios are presented to top management. Here they are shown any unusual data and causal factors discussed. Corrective action can then be implimented.

Step 7: The results of the study are published and made available to the company.

It is suggested that the researcher conducting the study mention that a productivity council could be established if one is not already in existence. The productivity council conducts on-going productivity measurements, analyzes decisions about the effects of capital on future productivity, keeps management informed about productivity developments of concern to the company. The productivity council could report to the highest level of management in the company to insure direct communication and that reports be made on no less than a quarterly basis.

Extensions

The intrafirm productivity study can be extended to interfirm productivity comparisons. Adjustments must be made, however, for the industry which is being compared. Like industries must be compared with like industries to insure comparability of data. In May of 1981 a pilot interfirm comparison study was conducted for the Northwest Food Processors by the Oregon Productivity Center. In this study 16 different ratios were compared for the Northwest Food Processing Association. One of the difficulties in conducting this study was that a concensus had to be reached on what constituted direct labor. After the concensus was finally reached the study

proceeded very quickly to completion. Confidentiality of data was also one of the concerns of the participants in the study. Special precautions were taken by the Oregon Productivity Center and the Northwest Food Processors to maintain that data confidentiality.

CHAPTER VI

SUGGESTIONS FOR FUTURE APPLICATIONS

The formats developed for the intrafirm comparison can be used in multi-firm studies. The logical vehicle used to obtain the co-operative effort needed in this type of study is the trade associations to which each firm belongs. Trade associations are used by the National Screw Machine Products Association and the National American Wholesale Grocers Association to conduct interfirm comparisons. The advantages are that the data format is standardized and uniform definitions and accounting methods already exist. If these uniformities do not exist, the trade association can inform their members about the definitions and methods to be used in the IFC study.

The format for the IFC study can also be used in government operations and other nonprofit organizations. The major adaptation is changing "output of goods" or "production of goods" to "services performed". By tracking "services performed" compared to the input over a time period the effectiveness or improvement in the operation can be measured.

International comparisons of an interfirm comparison study can be made. An industry group in the United States could be compared to existing interfirm comparisons done in Australia and Canada. By comparing the ratios developed by various trade areas the most efficient industry groups can be highlighted and the least effective industry groups can be pointed out. This comparison could be a predictor of future balance of trade deficits or surpluses.

A potential application area for the ratio method of productivity measurement is for interdepartmental comparisons. For example, various departments could benefit from knowledge of economies or turnover ratios established in other departments in the same company. If one department seems to be more effective in utilization of its labor, the cause can be relayed to the other departments. The fact of this better labor utilization would then be pointed out by the ratios reported to each of the departments. If another department has ratios which are less effective, the department can work with the more effective departments to determine what improvements can be made. The expected benefit is that improvement for the company as a whole could be made by the improvements of each individual department.

A suggested future use for the Weighted Ratio Productivity Index as discussed in Chapter III and IV is to use a weighting system in a company by department. Combine each departmental measure and form a total productivity index for the company. It is realized that this would not be a simple task but it would be a task well worth undertaking. Mr. Wally Masters of ESI has stated that he would allow ESI to be used for the development of a pilot program of this type in cooperation with Dr. James Riggs of O.S.U.

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APPENDICES

APPENDIX A

Ratios Presented to ESI Advisory Committee on May 16, 1981

TABLE OF RATIOS COLLECTED FROM E.S.I. RECORDS

	1976	1977	1978	1979	1980	1981 YTD
Growth of Sales	14.4	35.5	38.6	52.7	57.4	
Net Profit %	2.98%	8.9%	8.5%	8.7%	9.3%	
Return on Equity %	10.26%	29.38%	30.29%	32.54%	34.72%	
ROA%	4.5%	15.32%	15.94%	13.81%	12.58%	
Percent Growth/ Operating Profit	23%	240%	25%	30%	89%	
Selling,Administrative & Engineering/Sales	.3687	.3076	.3379	.3552	.3578	
Gross Profit/Sales	.4682	.5574	.5632	.5477	.5893	
Operating Profit/Sales	.0995	.2498	.2253	.1925	.2314	
Raw Materials/Average Daily Sales	22.403	24.023	22.038	29.343	19.916	
Accounts Receivable/ Average Daily Sales	83.054	60.906	66.243	84.894	59.570	
Work In Process/Average Daily Sales	75.873	62.212	53.147	58.837	55.256	
Finished Goods Inventory/ Average Daily Sales	22.403	24.023	8.000	7.757	9.222	
Fixed Assets/Average Daily Sales	71.085	57.336	61,045	64.760	112.500	
Current Assets/Average Daily Sales	198.32	179.75	155.47	190.37	177.19	
Land and Buildings/ Average Daily Sales	27.429	20.349	21.733	17.366	71.728	
Plant and Equipment/ Average Daily Sales	43.66	36.92	39.31	43.89	38.00	
Operating Profit/Direct Labor	.902	2.355	2.174	1.977	2.149	
Operating Profit/Direct Material	1.004	3.134	3.227	1.933	1.092	
Operating Profit/ Indirect Labor	.3678	.9614	.8864	.8062	.8771	
Direct Labor Dollars/Sales		.1204	.1111	.1012	.0904	.0887
Manufacturing Labor Dollars/ Sales		.0626	.0652	.0637	.0585	.0589
Total Direct Labor/Indirect Labor		.7072	.6420	.5788	.5154	2982
Manufacturing Direct Labor/ Indirect Labor		1.051	1.0008	.9232	.7733	.4597
Energy/Sales	Unknown	.004	.004	.005	.016	
Labor/Sales	.395	.343	.346	.324	.350	
Total Material/Sales	.1365	.0993	.0898	.127	.265	

APPENDIX B

Data Format for Weighted Ratio
Productivity Index

Instruction Sheets and Defninitions,
and Suggested Future Ratios

DATA FORMAT FOR E.S.I. PRODUCTIVITY MEASURES

FINANCIAL DATA

Direct Material $_____

Direct Labor _____

Indirect Labor _____

Indirect Material _____

Factory Overheads:

Energy $_____

Services _____

Other _____

Total Factory Overhead _____

Administrative Cost _____

Engineering Cost _____

Selling and Distribution Cost _____

Incoming orders/Bookings _____

Backlog/Unfilled Orders _____

Sales _____

Operating Profit _____

Average Accounts Payable _____

Average Accounts Receivable _____

Cash & Short Term Securities _____

Return on Assets % _____

Return on Equity/Investment % _____

Cost of Debt:

Time	Principle	%	Annual Cost
			$

$ New Purchase Orders $_____

$ Amount Committed in Purchase Orders _____

Average Raw Material _____

Average Work In Process _____

Average Finished Goods _____

Building $_____

Land _____

Square Feet _____

Plant and Equipment _____

New Capital Equipment
During Year $_____

Building Depreciation
Basis in Years _____ _____

Plant & Equipment Depreciation
Basis in Years _____ _____

ENERGY & SCARCE RESOURCE USAGE

Building Energy KHW _____ or MBTUs _____ $_____

Process Energy KHW _____ or MBTUs _____ $_____

Transport Energy-Gallons Fuel Consumed _____ $_____

Useage of Gold, Silver, Copper, etc., Rare Metals, Chemicals:

Item_____ Pounds or Ounces _____

_____ _____

_____ _____

Dollars Paper Used $_____

OTHER RATIOS

Overtime Hours _____

Sick Time Hours/Days _____

OSHA Ratios Lost Time _____ Freq. Rate _____

Severity Rate _____

Turnover Rates:

Skilled Labor _____

Unskilled Labor_____

Professional _____

Number of Direct Labor Employees (Average)_____

(OTHER RATIOS Cont'd)

Number of other Labor Employees (Average) _____

Engineering Change Costs _____

R & D Budget $_____ Actual: _____

Mantenance Budget $_____ Actual: _____

NEW PRODUCT INNOVATIONS

New Products Developed _____

New Products Introduced _____

New Products Into Production _____

DEPARTMENTAL TYPE MEASURES

PRODUCTION DATA

Total Direct Labor Hours Available _____

Lost Production Time/Hours:

- System Down Time _____ hours
- Wait for Materials _____ hours
- Wait for Instructions _____ hours
- Set Up Time _____ hours

Standard Time Allowed for Production Achieved during Period _____ hours

Actual Time _____ hours

Machine Utilization Rate _____ %

Planned Cost $_____

Actual Cost $_____

Scrap Rate Data:

- $ Scrap During Period _____
- Lbs. of Material or quantity scrapped _____

Work Orders Completed on Time _____

Work Orders Completed _____

Total Kits Dispatched No Shortages _____

Total Kits Dispatched _____

Work Orders Received with Adequate Lead Time _____

Work Orders Received _____

Products Produced - Quantities

Systems	Handlers	Lasers
44_____	S&R(44)_____	80_____
44A_____	S&R(80)_____	44/25_____
80_____	S&R(25)_____	
25_____	Slide_____	
88_____	4-Position_____	

Instruments

Standard_____

Custom_____

QUALITY DATA

Number of Q.A. Personnel _____

Prevention Hours _____

Inspection Hours _____

Total Cost of Quality $_____

Number of Customer Complaints _____

Warranty Repair Cost $_____

Warranty Repair Items _____

Warranty Maintenance Hours _____

Dead On Arrival Rate _____

Field Service Hours _____

Field Service Cost $_____

Scrap and Repair Cost $_____

Total Material Issues $_____

Reject Line Items:

Incoming _____

Shipments of Instruments _____ Failures _____

Systems _____ Failures _____

INSTRUCTIONS/DEFINITIONS

1. Direct Material -- Material used in product for sale, does not include any consumable items, maintenance items or office supplies. Can be determined by material issued to work orders during time period.

2. Direct Labor -- Include benefits, vacation, sick leave, taxes, insurance for production workers. A production worker is defined as a worker who is a "hands on" worker.

3. Indirect Labor -- All other labor costs, factory.

4. Indirect Material- All materials not used in salable product, consumables, tools, etc. Include maintenance materials, product development materials, etc.

5. Factory Overheads- Energy: include building, process and transport fuel (Unless transport included in distribution costs),
   Services: Management information services, auditors fees, outside engineering services, etc.
   Other: Maintenance repairs, transport, fire insurance, lease/rental of equipment, all other factory overheads.

6. Administrative Costs -- Telephone, data processing, service charges, employment fees, management consultant fees.

7. Engineering Costs -- Cost attributable to engineering design R & D, lab and materials testing, license fees, patent fees, etc.

8. Selling and Distribution Costs -- Outside sales office costs; sales promotional activities; travel; entertainment, agent fees, other marketing costs, distribution costs. All costs incurred after product leaves production.

9. Incoming orders/ Bookings -- A measure of future activity - marketing effectiveness - predictor of manufacturing activity.

10. Backlog/Unfilled Orders -- Measure of present activity.

Instructions/Definitions (Cont'd)

11. Sales -- Sum of Systems Sales $_____
Instrument " _____
Other Sales _____

$_____

12. Operating Profit--Earnings before Income Taxes and Profit Sharing.

13. Average Accounts Payable -- Use best available average.

14. Average Accounts Receivable -- Use best available average, subtract out allowance for bad debts.

15. Cash and Short Term Securities -- Use existing definition.

16. Return on Assets % -- Use existing definition.

17. Return of Equity/ Investment % -- Use existing definition.

18. Cost of Debt -- Separate long term debt from short term debt (accounts payable, etc.)
Use line for each debt instrument
A weighted average cost of debt can be calculated at this time where cost of debt = annual cost x (1 - tax rate)

19. $ New Purchase Orders -- Provides a tracking of purchasing department activity. Should be compared to new bookings.

20. $ Amount Committed in Purchase Orders -- Provides a measure of expected $ outflow for purchases compared to new bookings and backlog.

21. Average Raw Materials -- Value at Cost or Market, whichever is lower.

22. Average Work in Process -- Value at labor + material + appropriate share of variable production overhead. Use best available average.

23. Average Finished Goods Inventory-- Value at full cost or market, whichever is lower, use best available average.

Instructions/Definitions (Cont'd)

24. Building $/Land$--Use assessed value for tax purposes or cost, whichever is higher.

25. Plant and Equipment --Use existing definition.

26. New Capital Equipment During Year $ --A measure of reinvestment of capital into business.

27. Building Depreciation --Use existing definition.**

28. Plant & Equipment Depreciation --Use existing definition.**

ENERGY AND SCARCE RESOURCE USAGE:

As energy costs have escalated sharply since 1973, it is suggested that it would be appropriate to track this item.

29. Building Energy KWH, MBTU's $ -- Heat, air conditioning, etc.

30. Process Energy KWH, MBTU's $ -- Machine Costs, etc.

31. Transport Energy/ Gallons Fuel Used-A tracking here might reveal a potential for cost $ savings, pooling, etc.

32. Useage of Rare metals, chemicals, etc.-- Unusual increases warrant further investigation.

33. Dollars Paper Used --

OTHER RATIOS

34. Overtime Hours -- Indicates possible need for additional manpower if it becomes excessive.

35. Sick Time Hours/ Day -- Indicates a level of employee job satisfaction; monitor it closely as increasing trends (percent of total hours/days).

** = These are a measure of a part of the capital input into the production process.

Instructions/Definitions (Cont'd)

36. OSHA Ratios -- Lost time, frequency rate, severity rate -- can be compared to like industries; measures are effectiveness of safety instruction, etc.

37. Turnover Ratios-- Skilled labor, unskilled labor, professional. Should be monitored separately. Can indicate employee satisfaction with working conditions, wages, supervision. Unusual events in any category indicates investigation appropriate.

38. Number of Direct Labor Employees (Average) -- Factory workers engaged in production.

39. Number of Indirect Labor Employees -- Supervisors, managers, engineers, secretaries, clerks, etc. Materials - non-production workers.

40. Engineering Change Costs $ -- An indicator of the cost incurred to production caused by engineering improvements, changes, modifications.

41. R & D Budget $ Actual -- Indicates planned actual R & D expenditures.

42. Maintenance Budget $ -- Actual $ can indicate difference between planned vs. unplanned maintenance.

43. New Product Innovations -- Indicates effectiveness of R & D expenditures. Great impact on future company health, competitiveness, etc.

PRODUCTION DATA

44. Total Direct Labor Hrs. Available -- Number of direct labor employees x 40 hours/week.

45. Lost Production Time -- An estimate on a weekly basis might be adequate if actual times not recorded. System Down Time: hours lost by inavailability of machines, controllers, etc. Wait for Materials: A measure of time lost due to materials not available, might indicate lead times inadequate; or not enough materials personnel, not enough safety stock, etc. Wait for Industructions: A measure of supervision effectiveness control, etc. Set up Time: Non-production work required.

Instructions/Definitions (Cont'd)

46. Standard Time Allowed for Production Achieved -- Quantities x Standard Hours

47. Actual Time -- Standards compared to actuals may indicate tight standards.

48. Machine utilization rate -- $\frac{\text{Machine Run Hours}}{\text{Machine Available Hours}}$

49. Planned Cost -- The cost planned for a period.

50. Actual Cost

51. Scrap Rate Data-- $ scrap during period - indicates material, quality workmanship, material price change.

52. Work Orders Completed on Time -- the ratio of these items indicates that material shortages exist, lead times are inadequate, etc.

53. Work Orders Completed

54. Total Kits Dispatched, No Shortages

55. Total Kits Dispatched

56. Work Orders Received With Adequate Lead Time -- These items can indicate planning problems. Staffing requirement changes.

57. Work Order Received

58. Products Produced Quantities -- Period of collection for systems quarterly. For instruments perhaps more frequently. A more viable measure of output than sales.

QUALITY DATA

59. Number of QA Personnel -- Prevention Hours -- i.e. Design review, procedures in place to allow product to be built faultlessly; Print and documentation review to eliminate tolerance stack build-up; vendor qualification, survey to select best vendors thus reduce incoming rejections.

Instructions/Definitions (Cont'd)

60. Inspection Hours--Hours on standard inspection operations.

61. Number of Customer Complaints --Reflection of effective quality control.

62. Warranty Repair Cost --Indicates if warranty periods too long, short, etc.

63. Total Cost of Quality --$ budget/actual for QA Dept.

64. Warranty Repair Items --May point out a high failure rate item.

65. Warranty Maintenance Hours

66. Dead on Arrival Rate --Indicator of QC

67. Field Service Hours --Preventive maintenance setup, etc.

68. Field Service Cost --Cost of field service.

69. Scrap & Repair Cost --Could indicate vendor problems.

70. Total Material Issue --Compare to scrap & repair cost--should be constant ratio.

71. Reject Line Items --As per existing procedure.

72. Shipments vs. Failures --Indicator of effective QC workmanship, etc.

ENERGY AND SCARCE RESOURCE USAGE

1. $\frac{\text{Building Heat-AC Energy KWH or MBTU}}{\text{Sales}}$
2. $\frac{\text{Process Energy KWH or MBTU}}{\text{Sales}}$
3. $\frac{\text{Vehicle Fleet Mileage}}{\text{Gallons Fuel Used}}$
4. $\frac{\$ \text{ Worth Paper Used}}{\text{Sales}}$
5. $\frac{\text{Building \$ Energy}}{\text{Sales}}$
6. $\frac{\text{Process \$ Energy}}{\text{Sales}}$
7. $\frac{\text{Vehicle Fuel Cost}}{\text{Sales}}$
8. $\frac{\$ \text{ Rare Metals or Chemicals}}{\text{Sales}}$

OTHER RATIOS

1. $\frac{\text{Overtime Hours}}{\text{Direct Labor Hours}}$
2. $\frac{\text{Sick Time Hours}}{\text{Direct Labor Hours}}$
3. $\frac{\text{Overtime Hours}}{\text{Total Labor Hours}}$
4. $\frac{\text{Sick Time Hours}}{\text{Total Labor Hours}}$
5. OSHA Ratios:

   Lost Time

   Frequency Rate

   Severity Rate
6. Skilled Labor Turnover Rate Per Month
7. Unskilled Labor Turnover Rate Per Month
8. Professional Labor Turnover Rate Per Month
9. $\frac{\text{Direct Labor Employees (Avg.)}}{\text{Total Employees (Avg.)}}$
10. $\frac{\text{Engineering Change Costs}}{\text{Sales}}$
11. $\frac{\text{R \& D Actual \$}}{\text{R \& D Budget \$}}$
12. $\frac{\text{R \& D Actual \$}}{\text{Sales}}$
13. $\frac{\text{New Products Developed}}{\text{New Products Into Production}}$
14. $\frac{\text{Maint. Actual \$}}{\text{Maint. Budget \$}}$
15. $\frac{\text{Maint. Actual \$}}{\text{Sales}}$
16. $\frac{\text{New Products Introduced}}{\text{New Products Into Production}}$

DEPARTMENTAL TYPE RATIOS

1. Lost Production Time / Total Direct Hours Available
2. Actual Direct Labor Hours / Standard D.L. Hours
3. Machine Utilization Rate %
4. Actual Cost of Production / Planned Cost of Production
5. $ Scrap / $ Production
6. Work Orders Completed on Time / Work Orders Completed
7. Work Orders Received with Adequate Lead Time / Work Orders Received
8. Number of Q.A. Personnel / Total Cost of Quality
9. Prevention Hours / Inspection Hours
10. Warranty Repair Cost / Sales
11. Field Service Cost / Field Service Hours
12. Instrument Failures
13. Instrument Shipments
14. Total Kits Dispatched No Shortages / Total Kits Dispatched
15. Number of Customer Complaints / Sales
16. Dead on Arrival Rate
17. Warranty Repair Items / Warranty Repair Hours
18. Scrap & Repair Cost / Total Material Issues
19. Systems Failures / Systems Shipments

SUGGESTED FUTURE RATIOS FOR E.S.I.

FINANCIAL RATIOS

1. $\frac{\text{Direct Material}}{\text{Sales}}$
2. $\frac{\text{Direct Labor}}{\text{Sales}}$
3. $\frac{\text{Total Factory Overhead}}{\text{Sales}}$
4. $\frac{\text{Services}}{\text{Sales}}$
5. $\frac{\text{Engineering Cost}}{\text{Sales}}$
6. $\frac{\text{Incoming Orders}}{\text{Bookings}}$
7. $\frac{\text{Operating Profit}}{\text{Total Assets Employed}}$
8. $\frac{\text{Operating Profit}}{\text{Sales}}$
9. $\frac{\text{Avg. Accounts Payable}}{\text{Avg. Accounts Receivable}}$
10. Weighted Average Cost of Debt %
11. Average Cost of Equity %
12. Return on Assets %
13. Return on Investment %
14. $\frac{\text{\$ New Purchase Orders}}{\text{\$ Amount Committed in Purchase Orders}}$
15. $\frac{\text{New Capital Equipment Investment During Year}}{\text{Sales}}$
16. $\frac{\text{Building Cost}}{\text{Square Foot}}$
17. $\frac{\text{Landcost}}{\text{Square Foot}}$
18. $\frac{\text{Indirect Material}}{\text{Sales}}$
19. $\frac{\text{Indirect Labor}}{\text{Sales}}$
20. $\frac{\text{Energy}}{\text{Sales}}$
21. $\frac{\text{Administrative Cost}}{\text{Sales}}$
22. $\frac{\text{Selling and Distribution Cost}}{\text{Sales}}$
23. $\frac{\text{Backlog}}{\text{Unfilled Orders}}$
24. $\frac{\text{Operating Profit}}{\text{Average Current Assets}}$
25. $\frac{\text{Operating Profit}}{\text{Average Fixed Assets}}$
26. $\frac{\text{Gross Profit}}{\text{Sales}}$
27. $\frac{\text{Average Working Capital}}{\text{Sales}}$
28. $\frac{\text{Average Raw Material}}{\text{Average Daily Sales}}$
29. $\frac{\text{Average Work in Process}}{\text{Average Daily Sales}}$
30. $\frac{\text{Average Finished Goods}}{\text{Average Daily Sales}}$

APPENDIX C

A Letter Written by Irme Bernolak

Used to Influence Firms Into

Cooperating in an Interfirm Comparison Study

GREATER PRODUCTIVITY AND HIGHER RETURNS

THROUGH INTERFIRM COMPARISONS

WOULD IT HELP YOU TO KNOW

- how your company's return on investment and its productivity compare with your competitors'?
- what causes the difference?
- how your position can be improved?

HOW INTERFIRM COMPARISONS HELP

They are based on a set of interrelated ratios as shown in the accompanying diagram. The results are compared in tabular form, as illustrated, and each firm is given an interpretive analysis. No confidential information is revealed. Only the participants see the results and all of them benefit from the comparison. Participation is entirely voluntary.

WHAT FIRM D LEARNED

- its return was less than half that of its more successful rivals (Ratio 1).
- the main reason was a low margin of profit on sales (Ratio 2) and another reason was a slower turnover of assets (Ratio 3).
- its production cost of sales was particularly high (Ratio 4) and this stemmed largely from high production labour costs (Ratio 9) and low productivity (Ratios 11, 12, 15, 16), suggesting that planning and scheduling needed attention.
- a reduction should be attainable in the costs of materials and components (Ratio 8).
- promotional costs were comparatively low (Ratio 6), suggesting that more aggressive marketing might be helping other firms to increase sales volume which, in turn, would tend to reduce several other cost ratios and improve the utilization of fixed assets (Ratio 18).