AN ABSTRACT OF THE THESIS OF

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Title: Supplier Opportunity Cost of Lost Sales in the

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Abstract approved: _____
                             Dr. James L. Riggs

A market survey of aluminum users' purchasing
policies and the concept of opportunity costs are com-
bined in a quantitative decision model designed to
assist aluminum suppliers' efforts in directing products
and services improvements.

The opportunity cost, as the percentage of business
forgone, is determined for seven criteria representing
the products and services interface linking users to
their suppliers. These percentages can then be converted
to actual sales dollars lost. An example application is
included to explicate this conversion.

The mutual advantages of such a decision model are
then presented for both users and suppliers in terms of
strategic profit optimization rather than tactical cost
reduction.

SUPPLIER OPPORTUNITY COST OF LOST SALES

IN THE ALUMINUM INDUSTRY

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SUPPLIER OPPORTUNITY COST OF LOST SALES
IN THE ALUMINUM INDUSTRY

INTRODUCTION

The Business Enterprise

The success of any business enterprise depends on the
ability of its managers and engineers to decide what needs
to be done and how and when it should be carried out
(Barish, 1962). Unfortunately, many who enter the realm
of economic competition are unaware of either its language
or its rules (Riggs, 1968). The belief that they possess
an innate ability to make successful financial decisions
gives them a false security in their rule-of-thumb
reasoning.

Common sense is an essential part of functional deci-
sion making. However, the competitor who makes the effort
to formally state and quantitatively define the bases for
his decisions holds an economic advantage. Common sense
reasoning, in this perspective, becomes the pragmatic
guideline that links the quantitative model to the decision
maker's goals, rather than serving as the sole basis for
his decisions.

The Supplier

Like any business, a supplier strives to attain maxi-
mum profits by maximizing his sales and production at the

lowest possible cost. Readily available information on such production functions as machines, men, and materials has been transformed into quantitative cost-reduction models. Standard cost systems are exemplary of such models, long useful in profit maximization.

The supplier, however, finds himself in a unique position. In addition to the minimization of production costs, his survival depends on the continual creation and satisfaction of customer needs (Druker, 1964). This requires improving the products and services that are of greatest concern to his customers. Suppliers are generally aware that the factors affecting their relationship with the user[1] are important to their sales volume. The loss of sales to a competitor is just as surely a cost to the supplier as are the machine hours he uses in production. However, cost information about the factors responsible for poor relations with the user is not readily available.

Some studies have been conducted on the importance of such factors as quality, delivery, price, and sales service.[2] These reports present rankings of the importance of certain factors but make no attempt to quantitatively relate the factors to the cost of lost sales.

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[1]The term 'user' refers to the industrial or large volume consumer and will be used from now on to distinguish it from the small volume consumer.

[2]Classified studies conducted by a major aluminum supplier.

Consequently, quantitative decision models were not developed to aid in the reduction of this cost, and improvements to products and services are still based on qualitative information.

The inability to quantitatively define the basis for decisions generally results in suboptimal alternative selection. When suboptimization occurs, opportunity costs arise (Starr, 1964).

Opportunity Costs

Definition. Starr (1964) defines opportunity cost as the difference between the potential reward, possible if the best alternative is chosen, and the present reward, obtained as a result of the alternative actually chosen. The effective selection of alternatives is then highly dependent upon proper recognition of opportunity costs. The following examples illustrate the presence of these costs in several business functions.

Various Types. An opportunity cost occurs when a purchaser does not take advantage of purchase discounts available in open account financing. Not taking advantage of a five percent cash purchase discount is the same as losing an amount of profit equivalent to meeting the additional financial charges (Brant, 1965).

The interest cost chargeable to a capital-investment proposal is an opportunity cost. Its value is the income

forgone because capital is invested in one proposal instead of another (Barrish, 1962).

Opportunity costs of delays and poor integration of elements may occur in planning cycles. Staffing and equipping a production facility before the research laboratory has determined the proper materials, results in such costs.

Opportunity costs are also found in inventory analysis. Carrying too much stock results in an opportunity cost of unused capital similar to the interest cost chargeable to any financial investment. In monopolistic competition the cost of an inventory stock-out is simply the selling price of the units demanded but not available. However, in any other marketing structure, the opportunity cost of a stock-out must also be defined in terms of its adverse effect on the sales relationship between the user and the supplier. If a user is dissatisfied he usually shifts a percentage of his business to some other supplier. This results in an opportunity cost equal to the present percentage of business less the decreased percentage of business allocated to the guilty supplier.

Treatment in this Paper. This paper deals with still another type of supplier opportunity cost. It too is concerned with the relationship between the supplier and his user. However, its cost is measured in terms of potential sales beyond the present level of business allocation rather than the cost of dropping below the present level.

Similar to Starr's (1964) general explanation, opportunity costs are treated as the difference between the maximum potential percentage of business that a user would be willing to allocate and the percentage of business that the user presently allocates to any one supplier in a single resource market. The responsibility for this cost rests on the supplier's ability to provide the user with products and services that are clearly superior to those of his competitors. However, as mentioned earlier, the supplier has lacked a quantitative basis to direct improvements in these products and services.

The User

Relation to the Supplier's Opportunity Cost. The user, like the supplier, strives to attain maximum value from his investments. Minimizing the supplier's opportunity cost by rewarding him with increased business allocations for superior products and services can enhance the value of the user's purchasing dollar. The key to this profit objective is the user's purchasing policy. The obvious requirement of sound policy is to detect a source that provides the best products and services at a minimum cost. A subtle result is the effect this policy has on the actions of the supplier.

The only unbiased source of information by which a supplier can evaluate his products and services is the

user's purchasing policy. When a user buys, he does so
because he feels he is getting the most for his money. At
least this is what the supplier must believe because he
has no other solid basis for comparison. Therefore, the
purchasing policy is the main channel of communication
between the user and the supplier; a flow of consistent
information will, in the long run, benefit both parties.

Giving 100 percent of his business to one supplier,
regardless of the products and services concerned, would
eliminate any benefits of competition. As a result, good
policy usually establishes a limit on the maximum business
that can be allocated to any one supplier from a single
resource market.

Any supplier's program to initiate product and serv-
ice improvements depends on receiving consistent feedback
in terms of business allocations. The user's obligation
is then to provide this feedback by maintaining a purchas-
ing policy that equitably allocates business to suppliers
based on accurate ratings of their performance.

The "Cost-Ratio Plan." Quantification of the value
of the products and services interface is much further
advanced from the user's point of view. The following
example, a "cost-ratio plan," is a numerical supplier-
rating system taken from a pamphlet prepared by the
National Association of Purchasing Agents (1963).

The plan attempts to attach a dollar value to each

of four major procurement factors: price, quality, delivery, and service. The supplier who can provide the required material consistently at the lowest total-value cost is the one most frequently selected. Five steps are required to calculate this total-value cost among the competing suppliers: (1) price quotation, (2) quality costs, (3) delivery costs, (4) incremental service value, and (5) summary cost comparison. Each of the steps is explained and then illustrated by the corresponding rating form.

Price quotations are recorded in terms of unit price as it is affected by discounts and various miscellaneous extras such as freight, insurance, and taxes. (See page 8.)

From price quotation alone, Beta or Gamma would be selected for the order.

Suppliers	Col. 1 Unit Price Quotation	Col. 2 Discount	Col. 3 Net Price	Col. 4 Freight	Col. 5 Insur- ance, etc.	Col. 6 Total Charges	Col. 7 Net Delivery Price
			(1-2)			(4+5)	(3+6)
Alpha	$114.30	$11.43	$102.87	$ .60	–	$ .60	$103.47
Beta	107.90	10.79	97.11	1.00	–	1.00	98.11
Gamma	108.20	10.82	97.38	1.00	–	1.00	98.38
Delta	110.10	11.01	99.09	.50	–	.50	99.59

Inquiry No.: X-10493   Prepared by: JH   Previous Purchase Price:

Part No.: 33-96-4816   Date: 7/23/68   Date Last Purchase:

Illustration 1:   Price Quotation

A quality record is derived from an accumulation of all the distinguishable costs as determined by the quality control department. These costs are separated and assigned by supplier responsibility. This presentation permits the inclusion of historical records to indicate future trends.

	Prior Year	This Year	Current Additions	Total Year to Date
A. Material Quality Costs:				
1.Qualifying Visits........				
2.Laboratory Tests				
3.Incoming Inspection..........				
4.Processing Inspection Reports.......				
5.Manufacturing Losses........				
6.Handling & Packaging Rejects				
7.Complaints......				
8.Spoilage & Waste				
TOTAL	$ 3,590	$ 1,455	$ 20	$ 1,475
B. TOTAL VALUE OF PURCHASES	$87,500	$66,000	$1,000	$67,000
C. QUALITY COST RATIO ($\frac{A}{B}$ above)	4.1%	2.2%	2%	2.2%

Supplier: Alpha   Recorder: JH   Date: 7/23/68

Illustration 2: Quality Costs

After receiving the quality costs for each supplier, a summary is prepared such as:

Supplier	Material Quality Cost	Total Value Purchases	Ratio Total Year to Date	Prior Year	This Year	Current	Change from Prior Year
	(1)	(2)	$(\frac{2}{1})$	(4)	(5)	(6)	(7)
Alpha	$ 1,475	$ 67,000	2.2	4.1	2.2	2.0	Decrease
Beta	12,220	260,000	4.7	3.6	4.8	4.0	Decrease
Gamma	4,290	110,000	3.9	7.3	3.4	5.2	Increase
Delta	3,080	237,000	1.3	2.4	1.1	2.3	Increase

Date: 7/23/68

Illustration 3: Summary of Quality Costs.

The purchasing department is responsible for devising a delivery cost procedure similar to the accounting for quality costs. An acquisition cost ratio is calculated by dividing acquisition and continuity costs by the same total value of purchases used for quality costs. The effect of the potential cost of a missed delivery promise is treated as a "promises-kept" penalty and assessed against the performance factor of a guilty supplier.

	Prior Year	This Year	Current Additions	Total Year to Date
A. Acquisition & Continuity Costs:				
1.Expended Labor				
2.Telephone & Telegraph.....				
3.Surveys & Visits				
4.Premium Transportation				
5.Other Progress Charts........				
TOTAL	$ 2,100	$ 800	$ 10	$ 810
B. TOTAL VALUE OF PURCHASES	$87,000	$66,000	$1,000	$67,000
C. ACQUISITION COST RATIO ($\frac{A}{B}$)	2.4%	1.2%	1.0%	1.2%
D. PROMISES-KEPT PENALTY (%)	.5%	0	0	0

Suppliers are ranked in order of performance and then penalized one quarter of one percent progressively (except first quarter)

E. DELIVERY COST RATIO (C+D)	2.9%	1.2%	1.0%	1.2%

Supplier: Alpha   Recorder: JH   Date: 6/23/68

Illustration 4: Delivery Costs.

As in the case of quality costs, a summary of all the suppliers might be:

Suppliers	Acquisition Cost Ratio	"Promises-Kept" Penalty	Delivery Cost Ratio
Alpha	1.20	0	1.20
Beta	1.40	.50	1.90
Gamma	1.58	.75	2.33
Delta	.65	.25	.90

Date: 7/23/68

Illustration 5: Summary of Year to Date Delivery Costs.

Service costs are determined from absolute ratings of the special considerations that suppliers offer in products and services. This rating is converted into a penalty percent and charged against the suppliers lacking these considerations. In this way, failure to meet certain standards costs the supplier just as poor quality and delivery do. The conversion of rating points to service cost ratio is simple. Anything under 60 total points is automatically one percent; points in excess of 60 are subtracted from 100 and the remainder is multiplied by .01 to obtain the ratio.

Maximum Points	Category	Rating
	A. Competence and Ability	
15	1. Product Development & Advancement	11
15	2. Product Leadership & Reputation	9
10	3. Technical Ability of Staff	9
10	4. Capacity for Volume Production	8
10	5. Financial Solvency and Profitability	8
	B. Attitudes and Special Considerations	
5	1. Labor Relations Record	2
10	2. Business Approach	8
5	3. Field Service, Engineering Change	2
10	4. Warranty Conditions	6
10	5. Communications of Progress Data	7
100	TOTAL POINTS	70
	SERVICE COST RATIO	.3

Supplier: Alpha   Rater: JH   Date: 7/23/68

Illustration 6: Service Cost.

A comparison summary of the suppliers' overall year-to-date costs is shown on page 14.

Beta would have received the order on price alone. Using the cost-ratio plan, the order was given to Delta at a total savings of $3,390 to the user.

The "cost-ratio plan" is one of many similar plans now in use or in the developmental stage (Berman, 1966; Dillon, 1966; Dowst, 1967; Farrell, 1967). The use of these plans is indicative of the user's ability and desire to quantify his business allocation decisions.

Suppliers	Col. 1 Net Del. Price/Unit (illus.1)	Col. 2 Quality Cost Ratio (illus.2)	Col. 3 Delivery Cost Ratio (illus.4)	Col. 4 Service Cost Ratio (illus.6)	Col. 5 Total Penalty (2+3+4)	Col. 6 Adjusted Unit Price (1x5+1)	Col.7 No. of Units	Col. 8 Net Value Cost (6x7)
Alpha	$103.47	2.2%	1.2%	.3%	3.7%	$107.30	1,000	$107,300
Beta	98.11	4.7	1.9	1.0	7.6	105.57	1,000	105,570
Gamma	93.38	3.9	2.3	1.0	7.2	105.46	1,000	105,460
Delta	99.59	1.3	.9	.4	2.6	102.18	1,000	102,180

Inquiry No.: X-10493   Prepared by: JH   Action Taken: Delta

Part No.: 36-96-4816   Date: 7/23/68

Illustration 7: Summary Cost Comparison

Scope of the Study

The user may allocate the greatest share of his busi-
ness to suppliers from several industries, but these sup-
pliers do not offer the same type of products and services.
The resultant confounding of product type requirements,
such as paper and steel or rubber, would provide no basis
for comparing the effect of product and service improve-
ments on the percentage of business allocated to one
supplier or another. Consequently, the scope of the study
was limited to a single resource market.

The aluminum industry was chosen primarily because
its highly oligopolistic[3] nature provides very few large
integrated suppliers (Samuelson, 1961). The major firms,
Alcoa, Reynolds, and Kaiser, and ten to twelve smaller com-
panies headed by Alcan and Harvey, make up the bulk of
the factory-direct[4] aluminum suppliers. Unlike industries
such as steel, a large proportion of the volume aluminum
business in the United States is factory-direct. Without
the presence of the warehousers[5], who have little or no
direct control over products and services, users must

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[3]In oligopolistic marketing structures a few sup-
pliers produce highly similar products.

[4]A term meaning that the flow of products and serv-
ices is directly from the factory to the user with no
middleman in between.

[5]Holding firms that buy from several producers and
then sell to users; they are also referred to as dis-
tributors.

employ more homogeneous criteria in selecting their
suppliers.

Statement of Purpose and Questions to Be Answered

The purpose of this study is the development of a
method to assist the factory-direct aluminum supplier in
minimizing his opportunity cost of lost sales by providing
him with a quantitative measure of the cost of failing to
make improvements in his products and services. The ful-
fillment of this goal requires placing numerical values
on the range of opportunity cost and quantitatively re-
lating this cost to the factors or criteria that the
aluminum user employs to rate his suppliers' products and
services. To provide the necessary information, answers
were sought to the following questions:

1. What is the maximum percentage of business that
   the user will allocate to any one factory-
   direct aluminum supplier?

2. What percentage of his business does the user
   presently allocate to the factory-direct
   aluminum suppliers?

3. How does the user rate the performance of those
   suppliers on product and service criteria?

4. What relative importance does each of these
   criteria have in the user's business allocation
   decisions?

PROCEDURE

The Questionnaire

One of the basic problems of this study was collecting the required numerical data on both the user's factory-direct aluminum supplier performance ratings and the relative importance of the rating criteria. Underwood (1966) and Kerlinger (1964) provided the guidelines for the development of a mail questionnaire designed to provide the necessary degree of quantification.[6] Working with aluminum industry personnel in purchasing, quality control, industrial engineering, sales service, planning, shipping, and production control, lists of the factors affecting the relationship between users and suppliers were compiled and sorted into seven major categories. These consisted of delivery, quality, lead time, price, technical assistance, product range, and sales service. The categories were then used to represent the criteria that a user employs, either qualitatively or quantitatively, to evaluate his suppliers' products and services.

The questionnaire consisted of four major questions. Questions (1) and (4) ask the user for numerical values; (1), the percentages of his business presently allocated

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[6]The questionnaire and accompanying cover letter appear in the Appendix.

to each of his factory-direct aluminum suppliers, and (4) the maximum potential percentage of business he would allocate to any one factory-direct aluminum supplier. On questions (2) and (3), recipients were provided eight vertical graphs for which industrial personnel provided valid dimension anchoring. The first seven of these graphs required the user to rate the performance of his suppliers from 0 to 100 on each of the seven rating-criteria. On the eighth graph the user was to indicate the relative importance, also from 0 to 100, of each of the rating-criteria in his business allocation decisions. Questions (1) and (4) could be answered directly from purchasing facts and policy. Questions (2) and (3) re-quired the user to make absolute judgments on scales whose complexity lies between category and equal interval scaling.

Insurance of anonymity was found necessary to obtain an adequate number of questionnaire returns. Users were consequently instructed to refer to their suppliers by letter[7] and assured that all data would be used in strictest confidence.

Reliability tests of the questionnaire were con-ducted with purchasing agents from five aluminum

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[7]Explained in the general instructions of the questionnaire.

purchasers and reviewed for overall validity by each of
the industrial departments who aided in its development.

Sampling

A total of 150 users were sent questionnaires. Since
large users generally buy directly from the factory, a
volume account listing was employed to select the users,
further insuring against warehouse buying. Questionnaires
addressed to the department as a whole have a tendency to
drift aimlessly about.[8] As a result, the volume listing
was cross referenced with an order entry listing of
individuals within users' purchasing departments and the
questionnaires were addressed to particular individuals
whenever possible.

Thirty-five questionnaires were returned. The
overlapping nature of the questions provided an acceptance
criterion of consistent answering. Applying this cri-
teria left 30 usable questionnaires or 20 percent[9] of the
150 sent out.

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[8]A fact substantiated by purchasing agents when the
questionnaire was being tested for reliability.

[9]Lindsey (1964) showed that returns from six percent
to 15 percent are common for this type of questionnaire
and that 20 percent is considered clearly acceptable.

RESULTS

Tables 3-1 through 3-3 summarize the raw data from the 30 acceptable questionnaires. The performance ratings for each supplier level of business and the relative importance ratings of the decision criteria are shown in Tables 3-1 and 3-2 respectively. Table 3-3 lists the user's present and potential business allocations and the resultant opportunity costs for the supplier levels.

Figures 3-1 and 3-2 graphically show how the supplier's performance rating of each criteria varies with respect to the relative level of business allocated to the suppliers.

Based on the overall suppliers' performance ratings and both the present and potential distribution of business, the user would allocate his business according to the curve in Figure 3-3. Figure 3-4 converts the user's allocation curve into one representing the suppliers' composite opportunity cost.

The contribution of each criterion to one unit of the overall supplier performance rating at each supplier level of business is tabulated in Table 3-4 and is graphically shown in Figure 3-5. Figure 3-6 displays this contribution in terms of the percentage that each criterion contributes to the overall supplier performance rating.

Table 3-1. User's Average Ratings of Supplier Performance.

Criteria	A	B	C	D	E	Overall
Delivery	84.9	79.6	60.4	45.0	35.4	61.1
Quality	81.2	75.0	57.7	48.1	33.8	59.2
Lead Time	81.5	75.5	65.0	46.1	34.8	60.6
Price	85.6	81.9	68.8	50.7	36.0	64.6
Tech.Assist.	87.4	81.2	63.7	46.7	33.9	62.4
Prod. Range	90.0	83.2	63.4	44.5	34.7	63.0
Sales Service	86.0	82.9	64.9	52.1	37.1	64.6
Overall	85.3	79.8	63.3	47.6	35.0	62.2

Table 3-2. Users' Average Ratings of the Importance of Each Criterion in Their Business Allocation Decisions.

Criteria	Average Rating
Delivery	85.5
Quality	85.0
Lead Time	69.8
Price	78.0
Tech. Assist.	61.9
Product Range	50.5
Sales Service	64.0

Table 3-3. Average Business Allocations and Resultant Opportunity Costs to Supplier Levels of Business.

	A	B	C	D	E
Maximum Potential Business %	72.5	72.5	72.5	72.5	72.5
Present Business %	49.0	24.2	15.0	6.9	4.6
Opportunity Cost as the % of Business Lost	23.5	48.3	57.5	65.6	67.9
Percentage of the Opportunity Cost Incurred	32.4	66.6	78.3	90.5	93.7
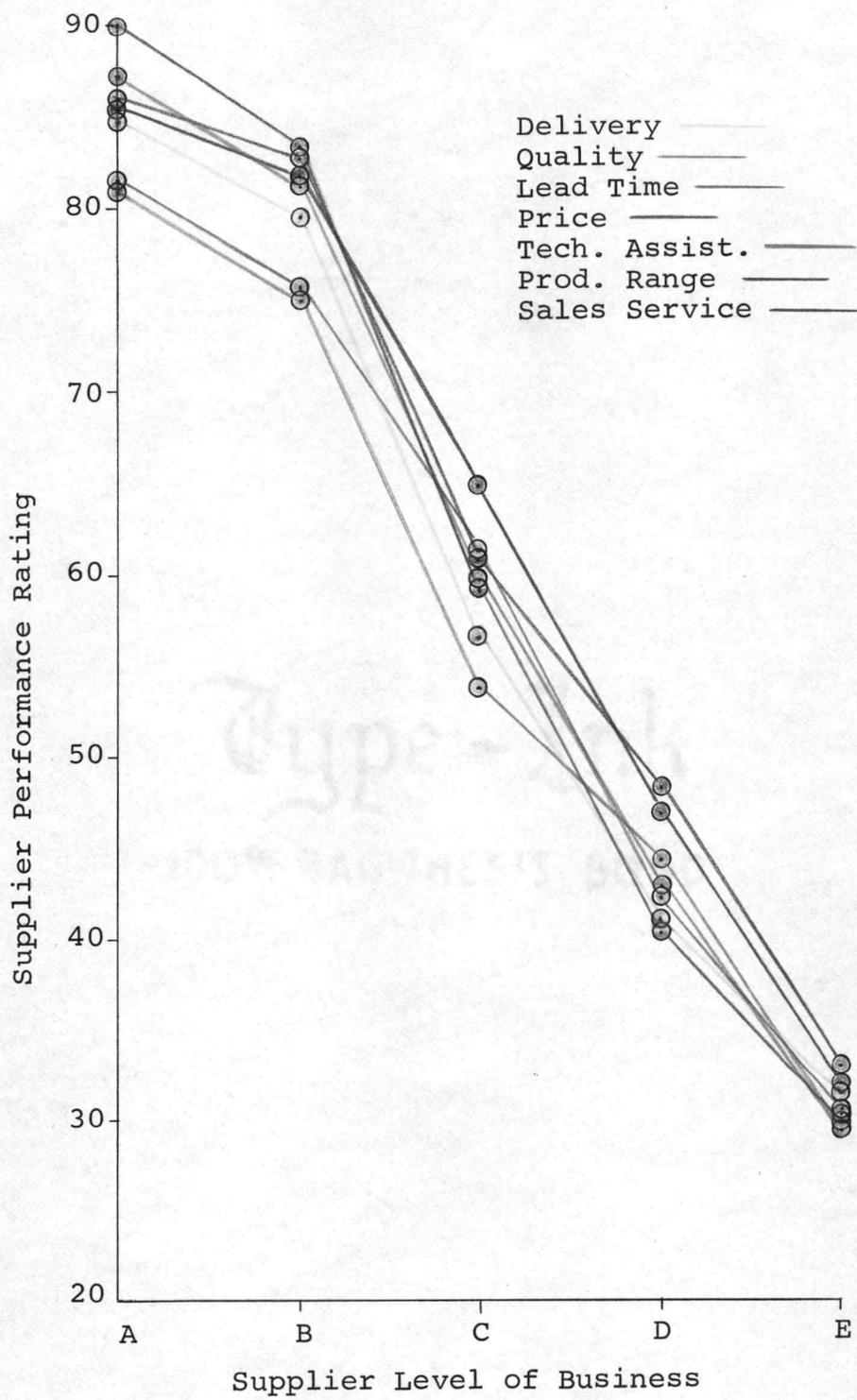
Figure 3-1. User's average rating of supplier performance.
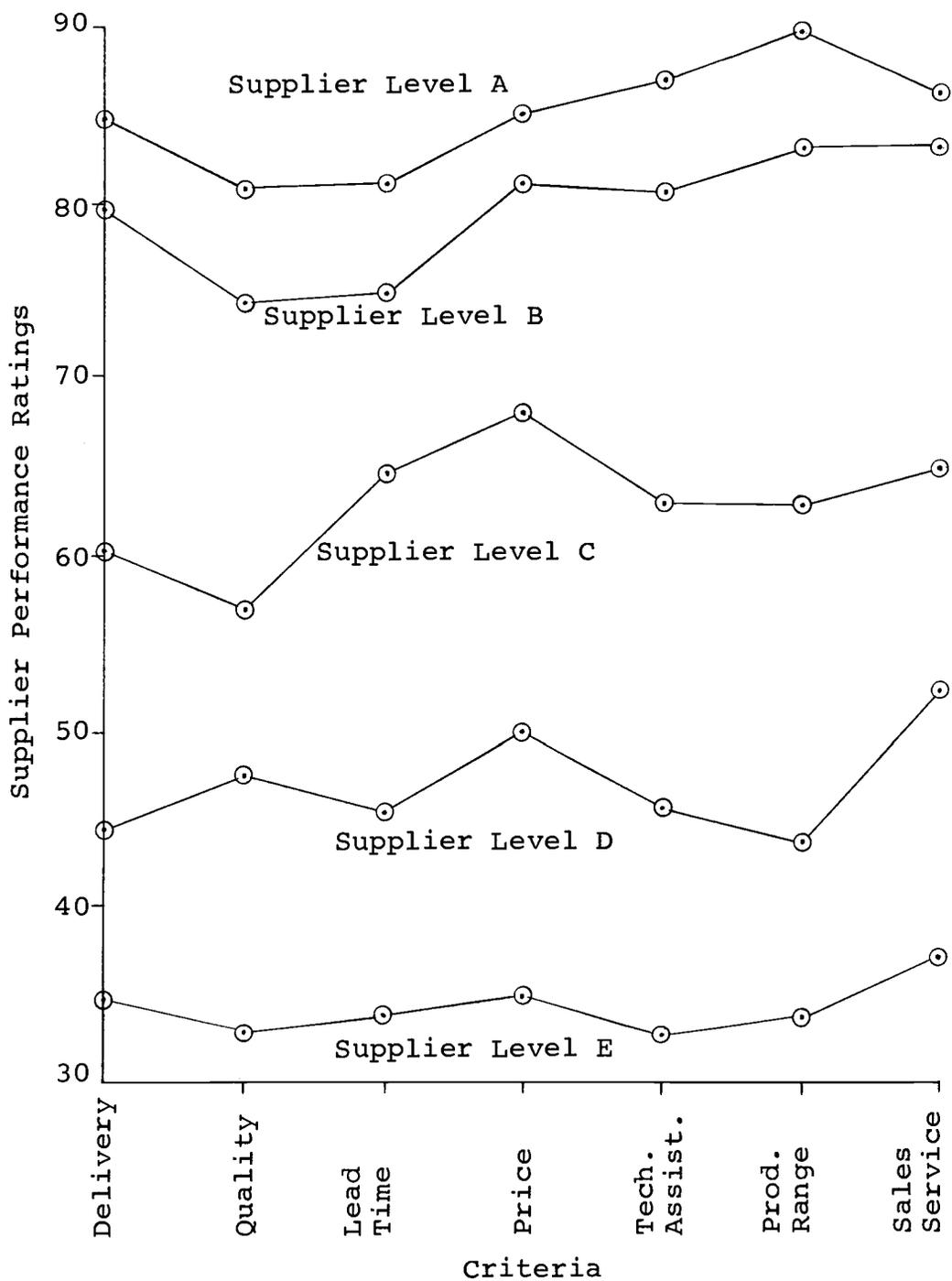
Figure 3-2.   User's average rating of supplier performance.
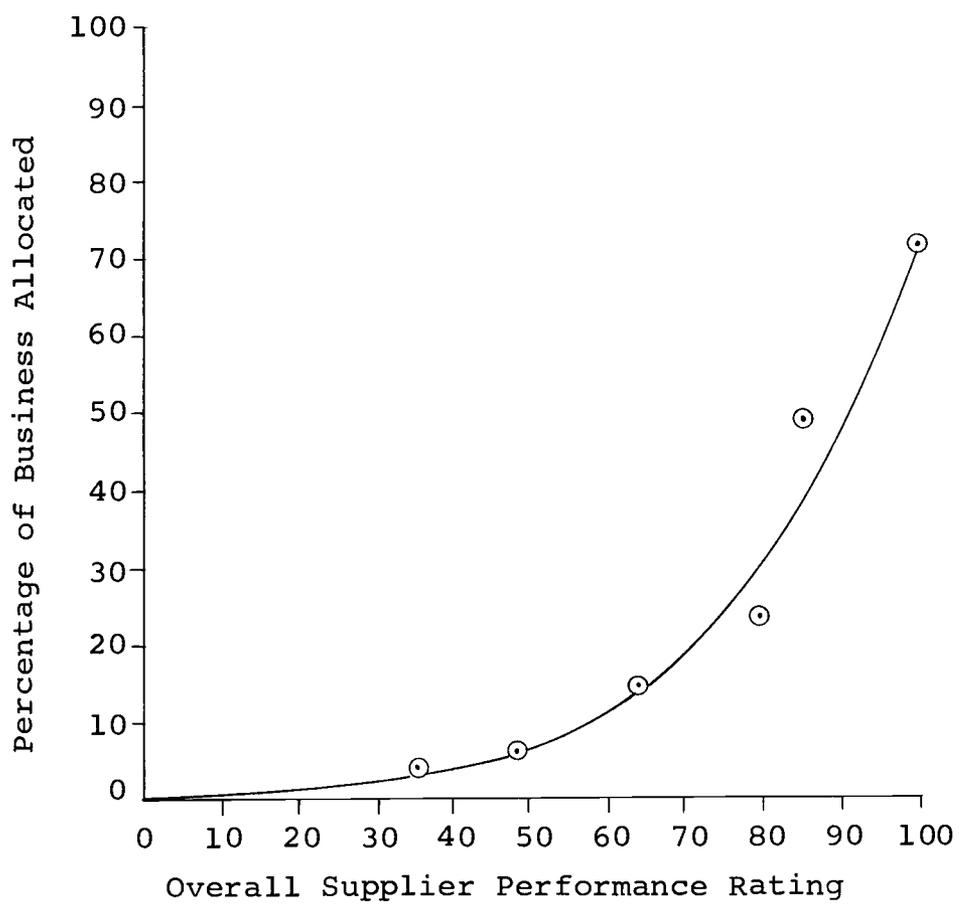
Figure 3-3. User's business allocation curve based on a composite of supplier performance criteria.
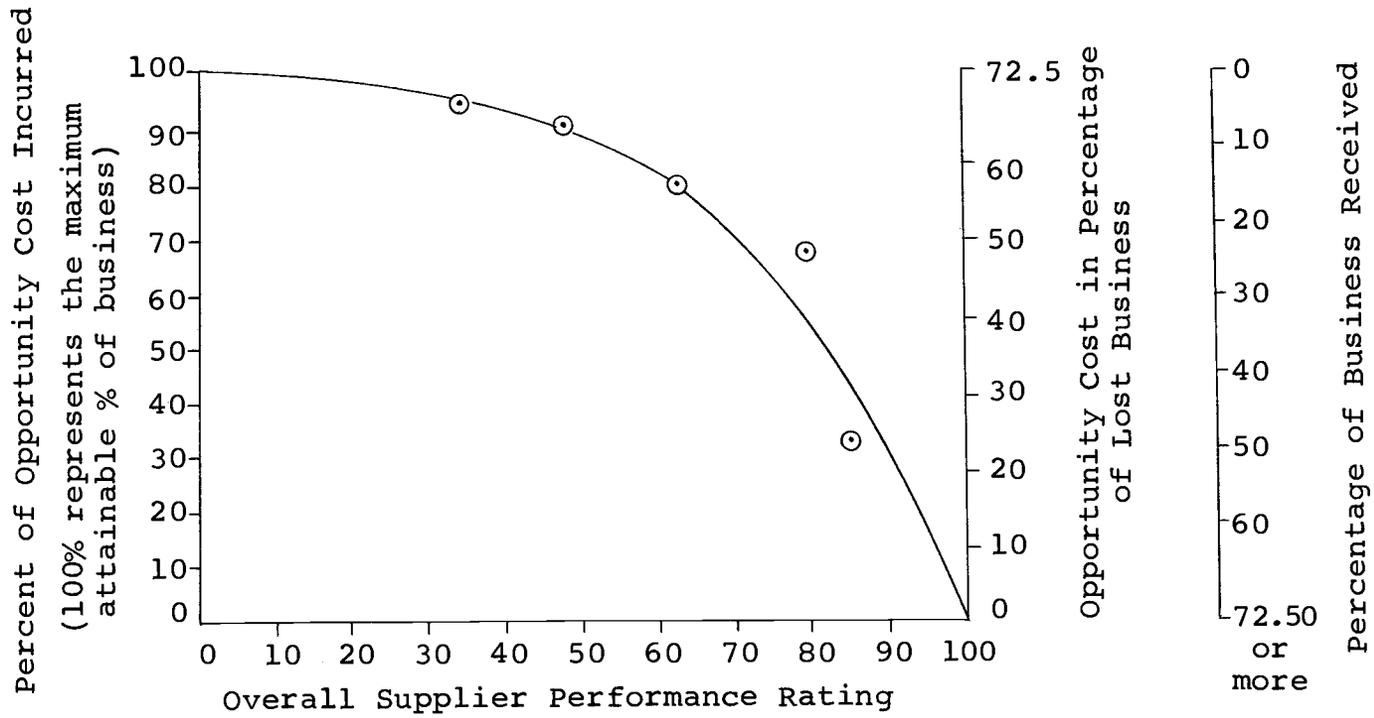
Figure 3-4.   Suppliers' composite opportunity cost curve
based on overall supplier performance.

Table 3-4. Contribution of Each Criterion to One Unit
of the Overall Supplier Performance Rating
for Each Supplier Level of Business.

Criteria	A	B	C	D	E	$\overline{\overline{X}}$
Delivery	.142	.143	.135	.135	.144	.140
Quality	.136	.133	.129	.144	.137	.136
Lead Time	.137	.135	.147	.138	.142	.139
Price	.143	.147	.155	.152	.147	.149
Tech. Assist.	.146	.145	.144	.140	.138	.143
Prod. Range	.152	.149	.143	.134	.141	.144
Sales Service	.144	.148	.147	.157	.151	.149
TOTAL	1.000	1.000	1.000	1.000	1.000	1.000

Figure 3-5.   Contribution of each criterion to one unit of the overall supplier performance rating.
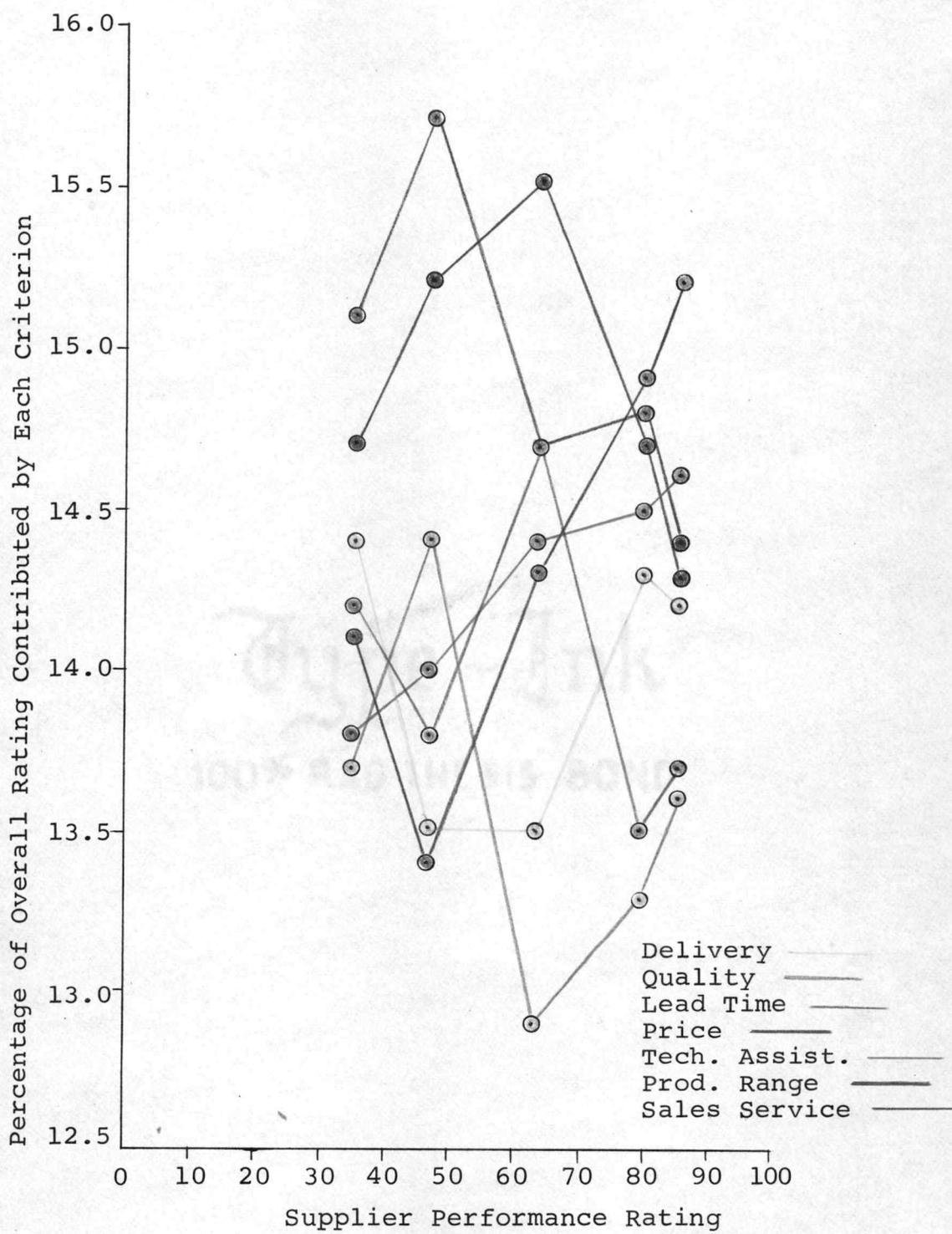
Figure 3-6. Contribution of each criterion to the
            overall supplier performance rating.

The supplier's opportunity cost incurred by each criterion at each supplier level is shown in Table 3-5. Figures 3-7 through 3-13 individually illustrate the opportunity cost of each criterion according to the over-all supplier performance rating. The diagram on page 39 illustrates how the results fit together in a meaningful whole.

Table 3-5. Opportunity Cost in Percentage of Lost
            Business Incurred by Each Criterion at
            Each Supplier Level of Business.

Criteria	Supplier Levels of Business				
	A	B	C	D	E
Delivery	3.34	6.91	7.76	8.86	9.77
Quality	3.20	6.42	7.42	9.45	9.30
Lead Time	3.22	6.52	8.46	9.05	9.64
Price	3.36	7.10	8.90	9.97	9.98
Tech. Assist.	3.43	7.00	8.28	9.18	9.37
Prod. Range	3.57	7.20	8.22	8.79	9.56
Sales Service	3.38	7.15	8.46	10.30	10.28
TOTAL	23.50	48.30	57.50	65.60	67.90
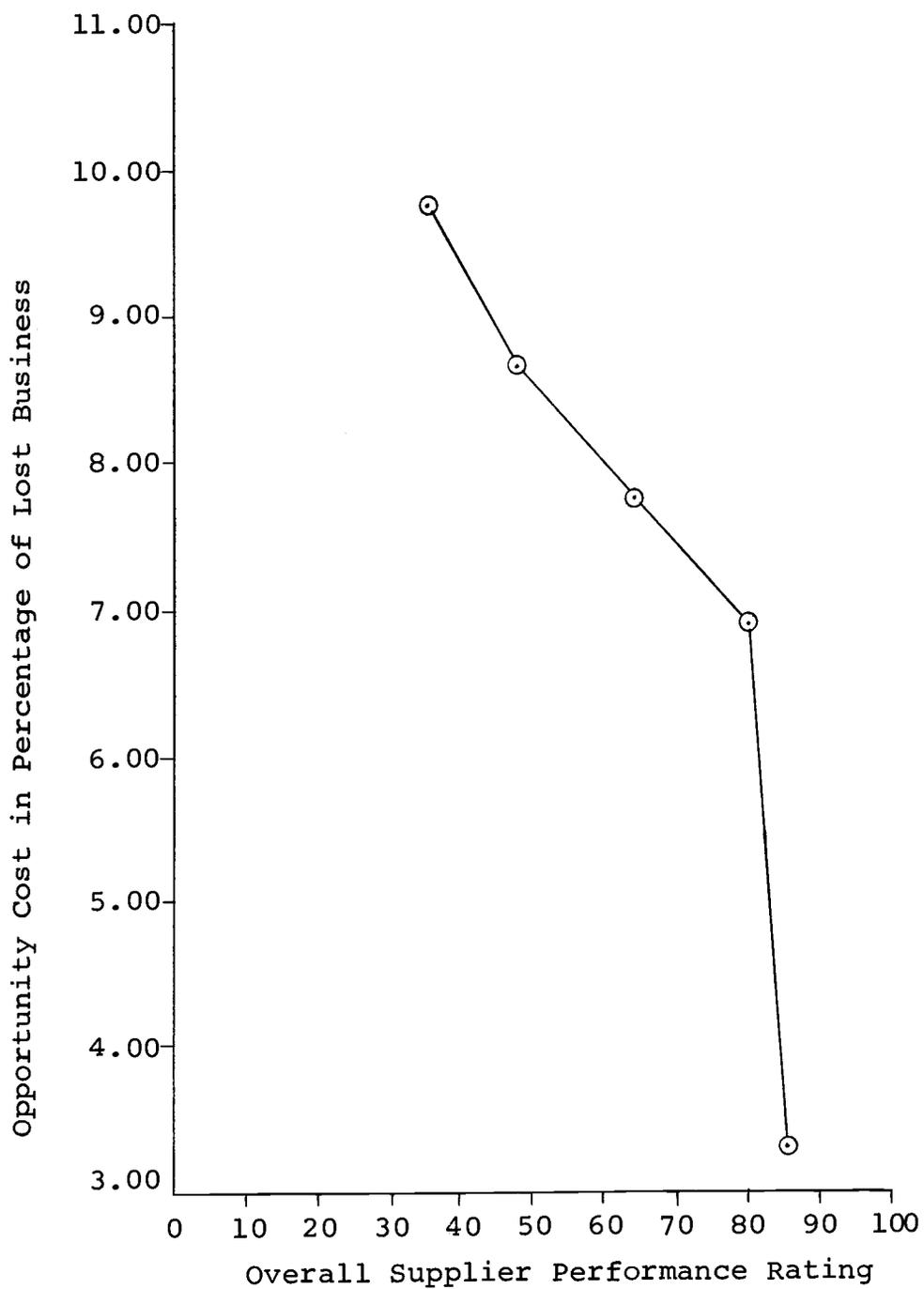
Figure 3-7. Opportunity cost of delivery for the overall supplier performance ratings.
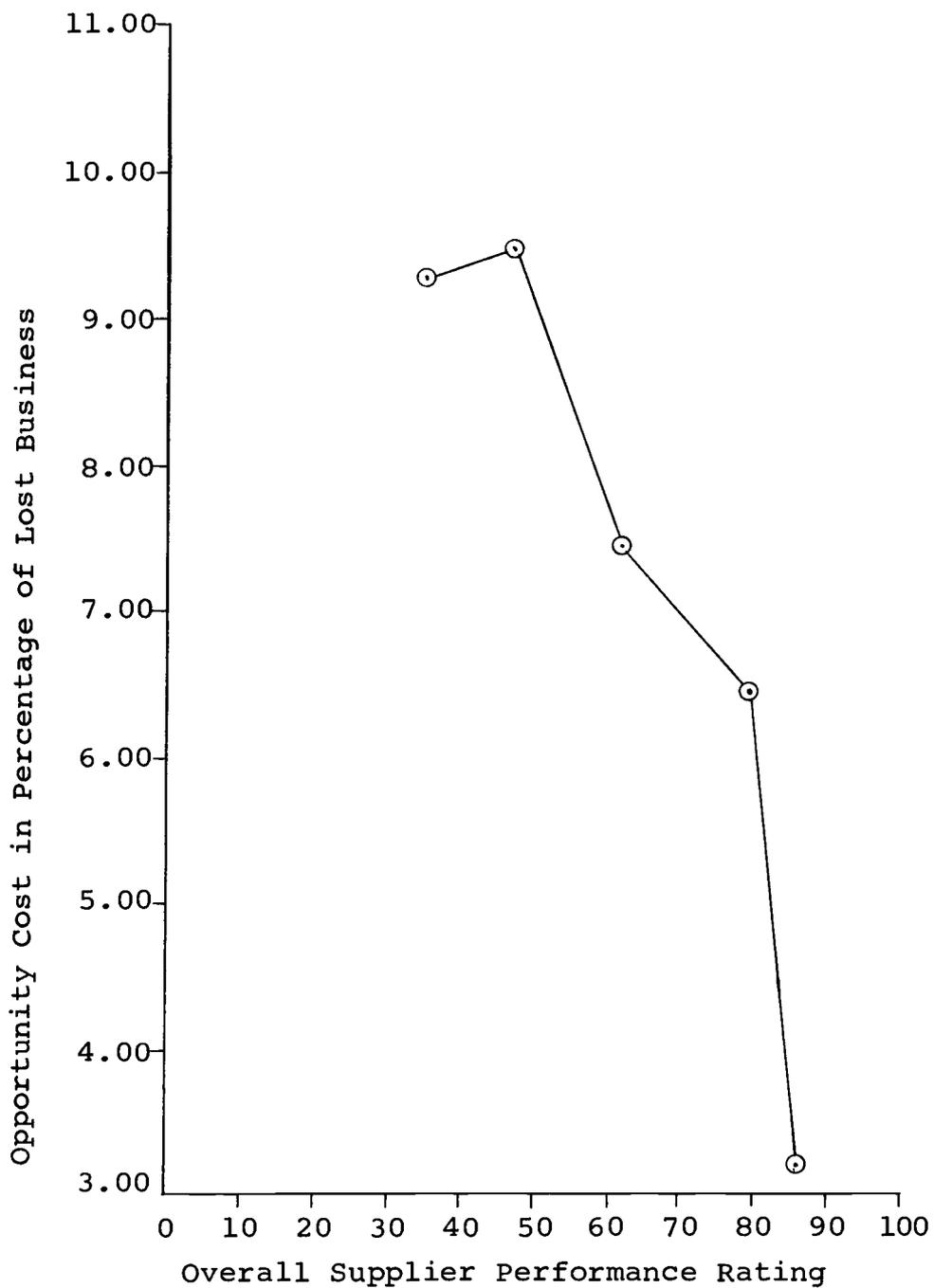
Figure 3-8. Opportunity cost of quality for the
           overall supplier performance rating.
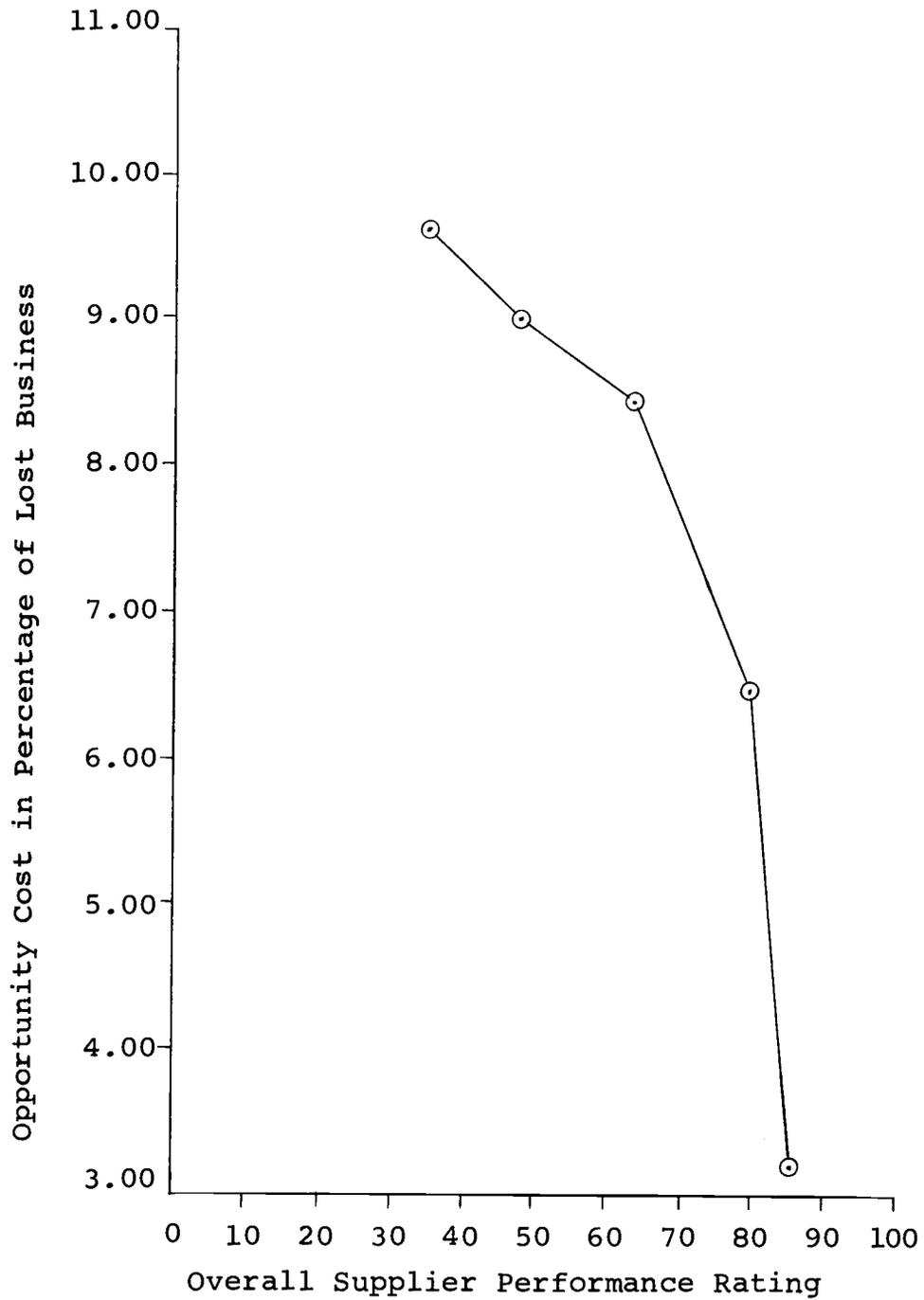
Figure 3-9. Opportunity cost of lead time for the
             overall supplier performance rating.
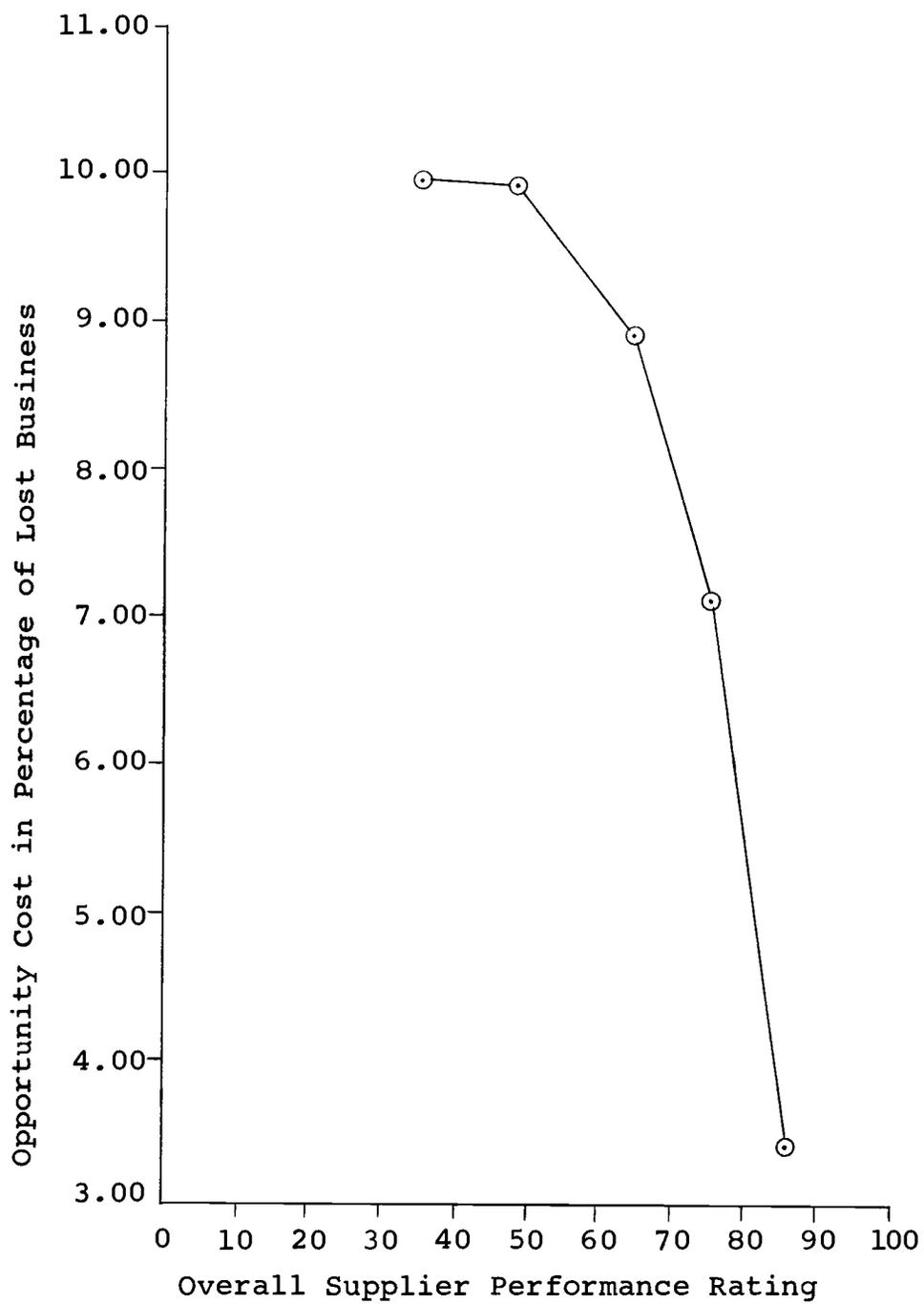
Figure 3-10.   Opportunity cost of price for the
overall supplier performance rating.
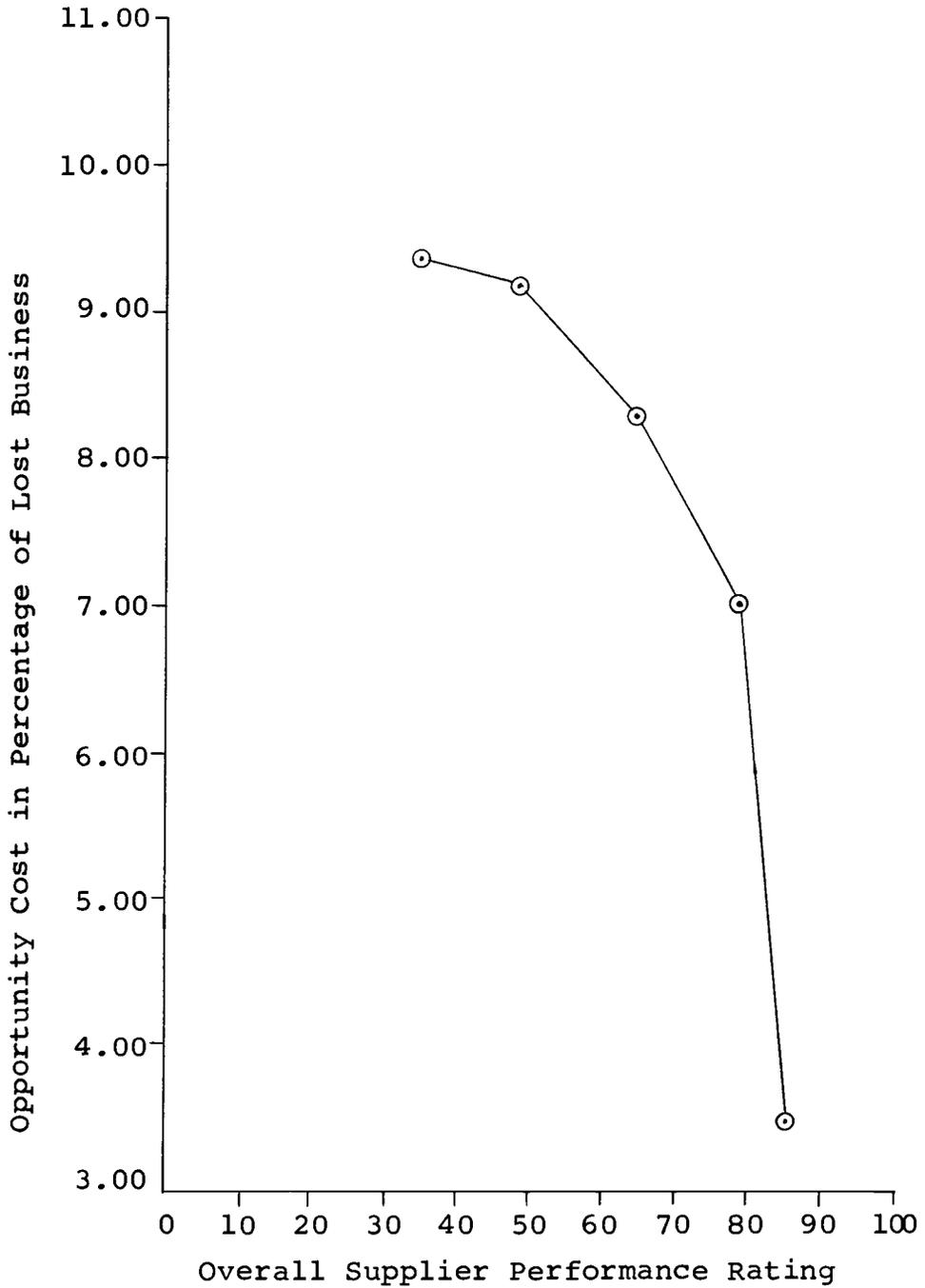
Figure 3-11. Opportunity cost of technical
assistance for the overall supplier
performance rating.
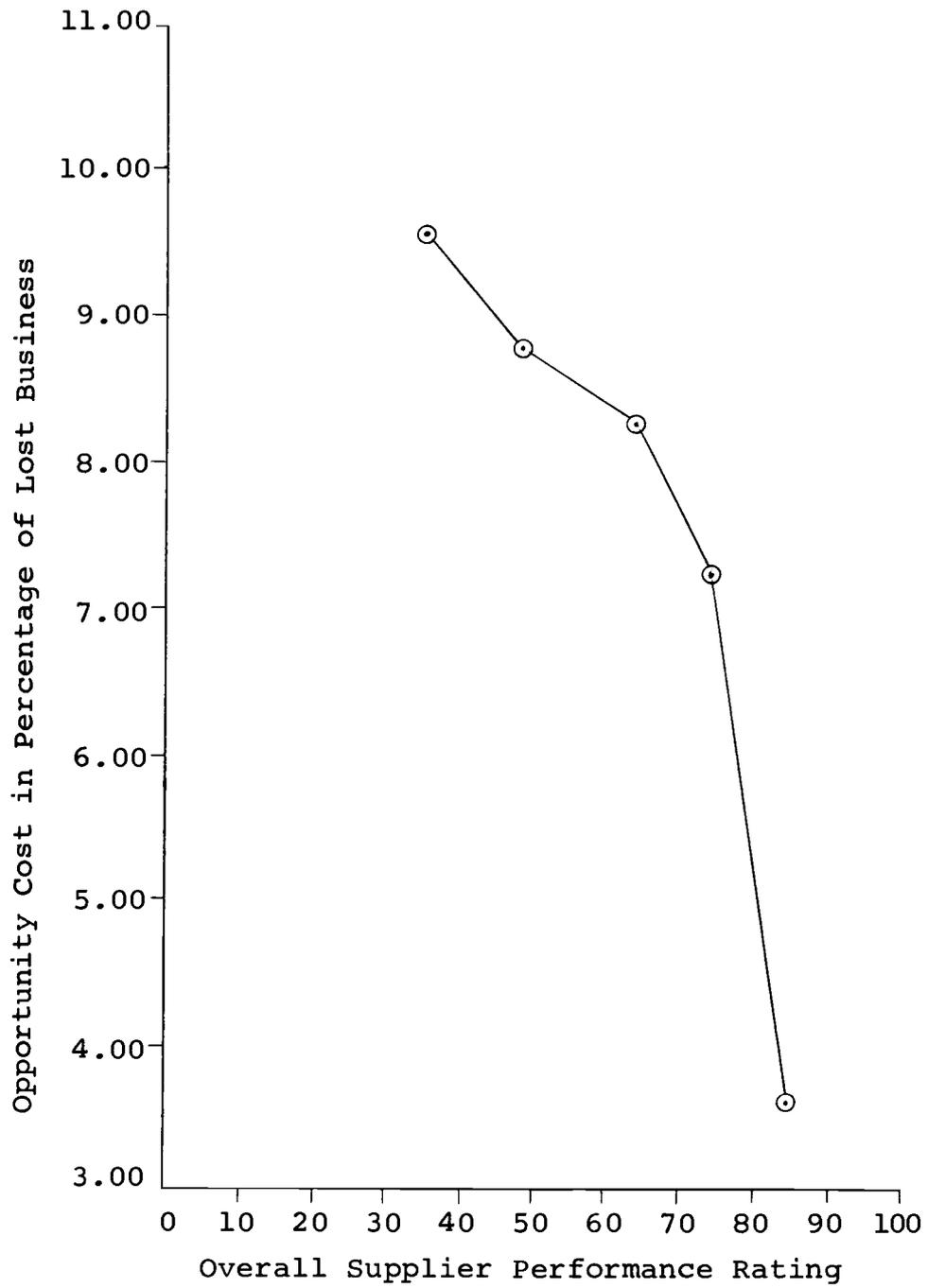
Figure 3-12. Opportunity cost for product range
for the overall supplier performance
rating.
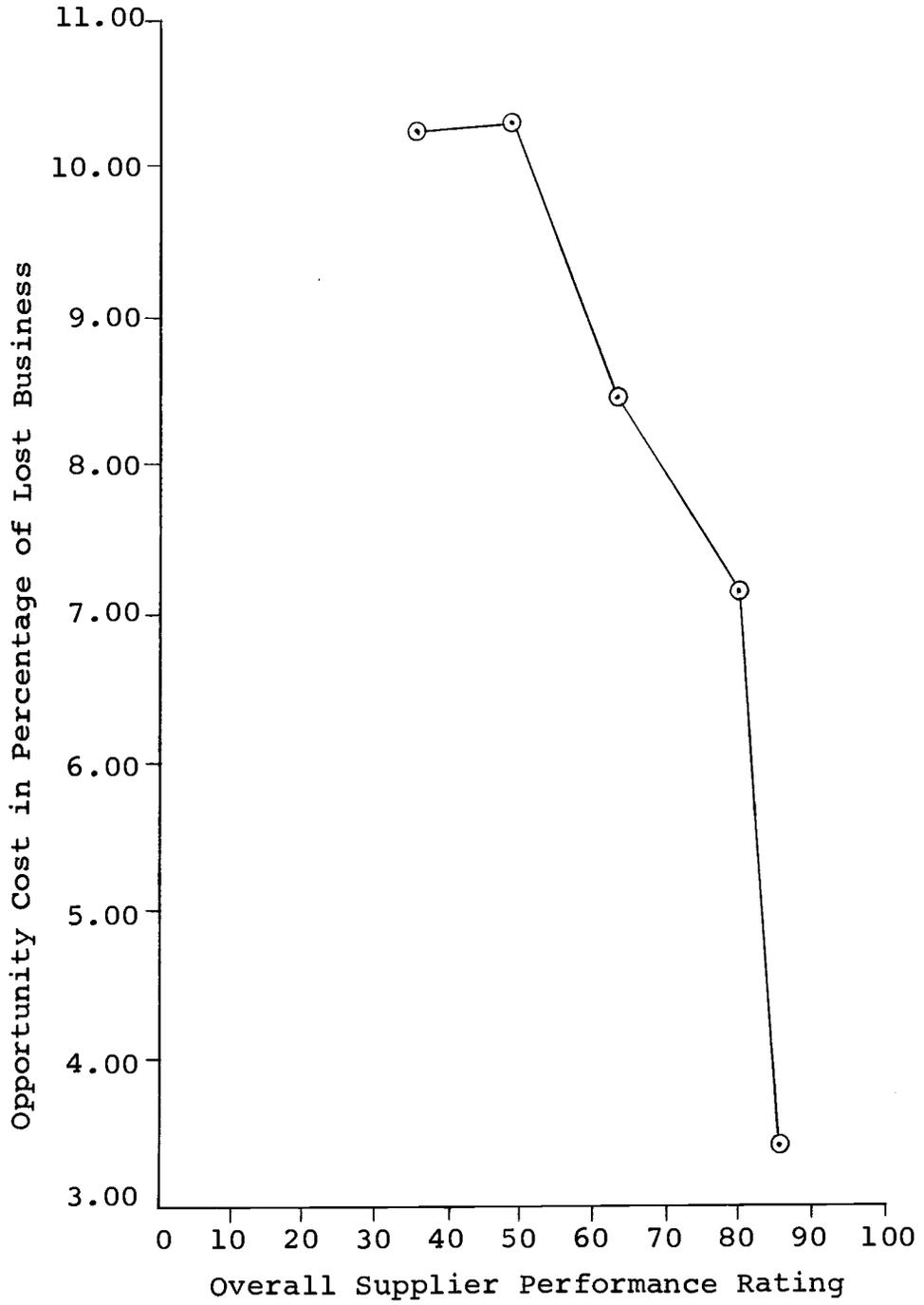
Figure 3-13. Opportunity cost of sales service
for the overall supplier performance
rating.

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┌─────────────────────┐   ┌──────────────────────┐
│Average supplier     │   │Average present and   │
│performance          │   │potential business    │
│ratings;             │   │allocations and the   │
│Table 3-1            │   │resultant opportunity │
└─────────────────────┘   │cost; Table 3-3       │
                          └──────────────────────┘
            ┌─────────────────────┐
            │User's business      │
            │allocation curve;    │
            │Figure 3-3           │
            └─────────────────────┘

                              ┌─────────────────────┐
                              │Supplier composite   │
┌─────────────────────┐       │opportunity cost     │
│Contribution of each │       │curve; Figure 3-4    │
│criterion to the     │       └─────────────────────┘
│overall              │
│supplier performance │
│rating for each      │
│supplier             │
│level of business;   │
│Table 3-4            │
└─────────────────────┘

┌─────────────────────┐   ┌─────────────────────┐
│Contribution of each │   │Opportunity cost in  │
│criterion to the     │   │percentage for each  │
│overall              │   │criterion at each    │
│supplier performance │   │supplier level of    │
│rating; Figure 3-6   │   │business; Table 3-5  │
└─────────────────────┘   └─────────────────────┘

      ┌─────────────────────┐
      │Opportunity cost of  │
      │each criterion for   │
      │the overall supplier │
      │performance rating;  │
      │Figures 3-7 through  │
      │3-13                 │
      └─────────────────────┘

              ┌─────────────────────┐
              │Opportunity cost per │
              │criterion as a dollar│
              │value according to   │
              │the percentage of    │
              │business received;   │
              │Example Application  │
              └─────────────────────┘
```

DISCUSSION OF FINDINGS

A conscientiously applied program to quantitatively direct product and service improvements is of benefit to both the user and the supplier; beneficial to the supplier by enabling him to reduce opportunity costs, and beneficial to the user by increasing the ability of his suppliers to serve him. In spite of this mutual value, cooperation between aluminum users and suppliers to develop such a model was found to be limited. Several attempts were made to obtain information about the users' purchasing policies through the normal channels of a supplier's sales service department. In every case, users were reluctant to provide this type of information to the supplier's representatives. As a result, users were approached from a strict academic position; all correspondence was carried out on Oregon State University letterhead and complete anonymity was assured for all the information received.

The results obtained reveal the complex interrelationships that link and sometimes separate users and their suppliers. Composition of the suppliers' performance ratings was found to differ for supplier levels of business. Figures 3-1 and 3-2 graphically show how criteria having high ratings for one supplier level are not similarly rated for other levels. These interactions of criterion importance necessitated the quantification of

each criterion's opportunity cost over the entire range of possible business allocations.

As the first step toward this expanded quantification, the user's business allocation curve, Figure 3-3, provides a relationship between the supplier's overall performance rating and the corresponding percentage of business that he would allocate. This curve is closely approximated by a modified theoretical equation for exponential growth, $y = e^{\beta x} - 1$ ($\beta \simeq .04$; $0 \le x \le 100$). Consequently, as business allocations increase, the additional amount of supplier performance rating required decreases at an exponential rate. Advances in the supplier's performance rating exponentially lessen the amount of increase necessary to attain the same additions to his business allocations. This curve also explicates an inherent disadvantage of the small percentage supplier. In the range of business allocations below ten percent, it requires a large increase in performance rating to secure a relatively small amount of increased business.[10]

The composite opportunity cost curve, Figure 3-4, represents the next step toward quantifying the cost of inadequate products and services. Basically, it is an inverted mirror image of the user's business allocation

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[10]A complete expansion of this concept is beyond the present study but will be dealt with briefly in the recommendations for future study.

curve. It defines the composite opportunity cost in terms of lost business for the full range of both the supplier's performance ratings and the percentage of business that he presently receives. As would be expected, increases in the overall rating increasingly diminish the supplier's opportunity cost. Just as for the user's business alloca- tion curve, the large percentage suppliers are seen to have a distinct advantage over the supplier who has only a small percentage of the business.

The inconsistent contribution of each criterion to the composite opportunity cost curve still had to be iso- lated and shown for the full range of business allocations and performance ratings. Figures 3-7 through 3-13 were developed to relate this individual contribution to the overall supplier performance rating, which is a common axis with the composite curve. Using both the composite and the individual opportunity cost curves, the supplier can affix an exact cost[11] to each of the criterion defi- ciencies and direct improvements accordingly.

Another inconsistency revealed by the data concerns the relative importance that the user contributes to the criteria, shown in Table 3-2. The evidence suggests that certain traditional criteria, such as delivery and quality, have an idealistic importance to the user that is not

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[11]This point is explained more fully in the example application section.

warranted by the performance ratings he gives and the consequent business he allocates to his suppliers; compare Tables 3-1 and 3-2. While the information necessary to quantify the opportunity costs is, of course, taken from the actual supplier performance ratings and business allocations, this user inconsistency still has certain significance for the supplier. Users, as a whole, are advanced beyond the supplier in terms of quantifying the products and services interface, yet some are still not consciously aware of the actual bases for their allocation decisions. The supplier is consequently cautioned against applying these tables and graphs to a particular user until that user's purchasing function has been carefully scrutinized for just such inconsistencies.

Several other general limitations of this investigation should be reemphasized. The study and all the information collected applies solely to factory direct aluminum suppliers and their users. The oligopolistic nature and entire market structure of the aluminum industry precludes direct application to another field except in terms of the concept of opportunity costs as the percentage of lost potential sales. The primary application of the paper is intended for future planning of product and service improvements rather than the assignment of departmental guilt or the microscopic approach of many existing cost analysis programs. In this respect it

might serve to optimize the market involvement of the supplier whose business allocation percentage from some user may place him at too great an opportunity cost disadvantage. Used in matters such as these it is hoped that opportunity costing may become a tool for strategic profit optimization rather than tactical cost reduction.

AN EXAMPLE APPLICATION

A dollar value can be placed on the importance of product and service improvements by combining the composite and individual opportunity cost curves of the results with readily available information about the user's total purchasing investment in a single resource market. The following example demonstrates how this value is obtained.

Assume supplier Roe receives 25% or $625,000 of a user's OPCO's, business. Reference to the composite opportunity cost curve in Figure 3-4 shows Roe incurs a cost of 47.5% lost business or 65.5% of the total possible opportunity cost and receives a performance rating of 72.0 (see page 46).

The cost of failing to improve a criterion such as delivery performance is found from Figure 3-7 to be 7.38% (see page 47).

In terms of dollars lost the opportunity cost of inadequate delivery is then:

O.C. = (user's total dollar purchases of aluminum)

x (delivery opportunity cost in percent)

$$= (\frac{\$625,000}{.25}) \times (7.38\%)$$

$$= (\$2,500,000) \times (.0738)$$

$$= \$184,300 \text{ in lost sales.}$$
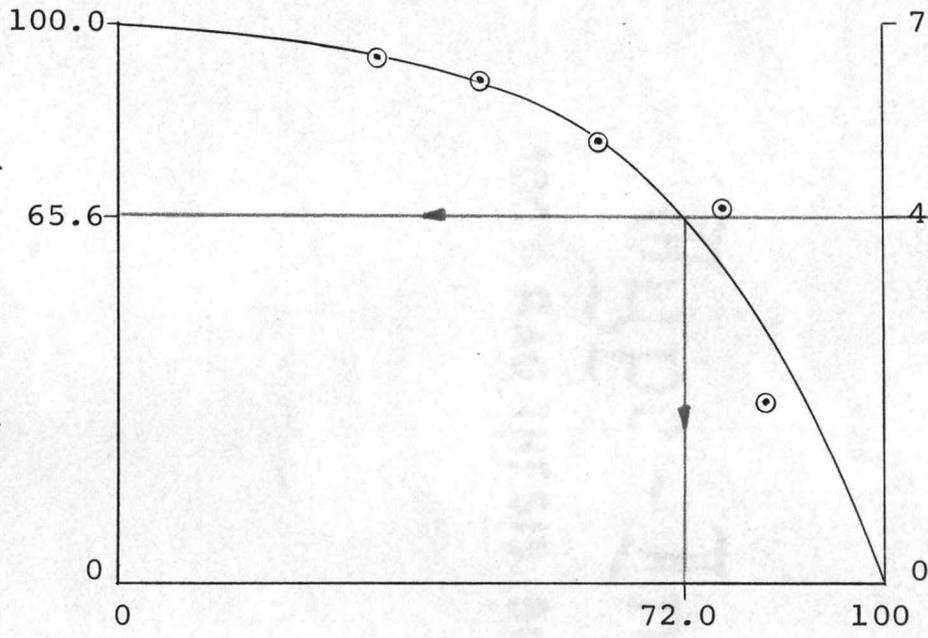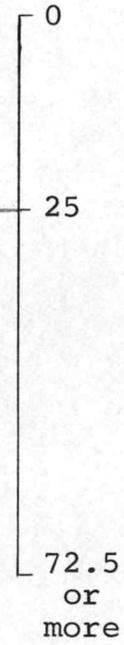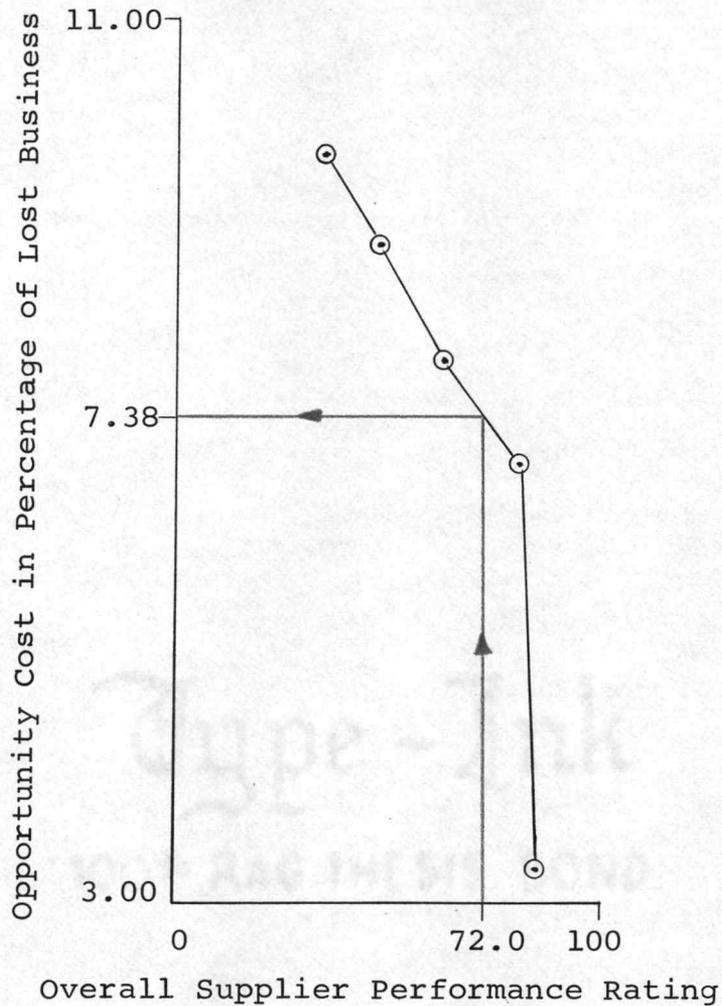
Continuing in a like manner, the dollar value of each criterion would be determined. These costs would then become the bases for directing capital expenditures to improve the products and services most beneficial to both the supplier and the user.

SUMMARY AND CONCLUSIONS

This paper extended the concept of opportunity cost to the aluminum industry's user-supplier relations in an attempt to provide a quantitative model to direct supplier improvements in the products and services interface depicted in Figure 7-1.

A mail questionnaire was sent to 150 major aluminum users in the United States and Canada. Thirty of the returns passed the acceptance criteria and were used as the basis for the study.

Opportunity costs in percent of business foregone were determined for seven criteria representing the products and services interface. An example application was included to explicate the conversion of this percentage to a dollar value.

The concept of opportunity cost is not new. Academicians have long recognized its theoretical applications but regarded them as quantitatively impossible. The primary contribution of this study is then the evidence that opportunity cost calculations and their practical application are possible and, in a cooperative effort, beneficial to users as well as suppliers.

USER   SUPPLIER

| Rate the interface performance for each supplier.	P R O D U C T S A N D S E R V I C E S I N T E R F A C E	Determine the importance of each of the factors making up the interface.
Quantitatively select the best suppliers and allocate business according to the net-value cost of their interface performance.		Quantitatively direct the interface improvements most effective in attaining greater business allocations (minimize opportunity cost).
Maximum return for dollar invested in purchasing.		Maximum return for dollar invested in interface improvements.

OPTIMAL POLICY

Figure 7-1. User-supplier relations.

RECOMMENDATIONS FOR FUTURE STUDY

Future study could be directed toward determining the expenditure necessary to make improvements in each of the criteria. A relationship could be found between the cost of improving each criterion and the corresponding increase in the supplier's performance rating, such as Figure 8-1.
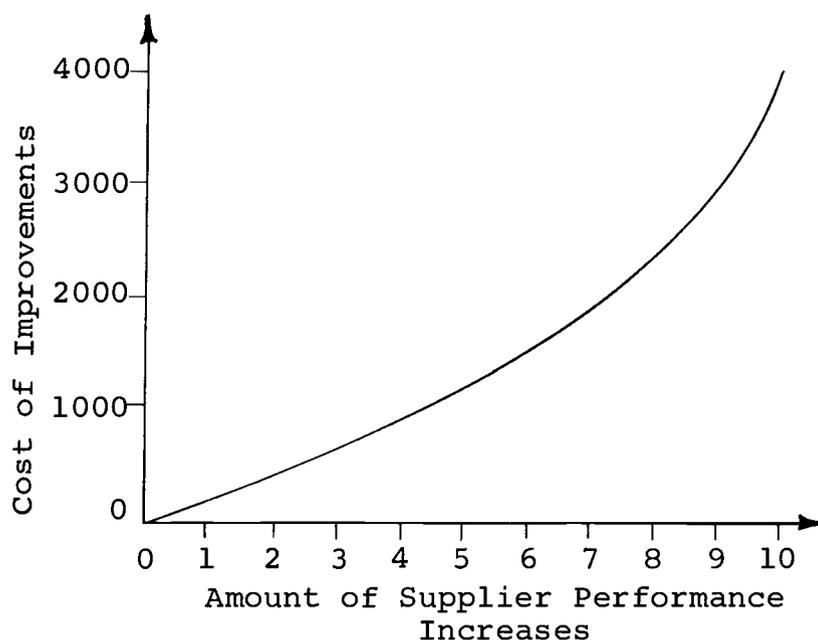
Figure 8-1. Cost of improving delivery.

The difference between the cost of improving a criterion and the opportunity cost of failing to make that improvement could be used as an even more powerful decision tool than opportunity cost of lost sales alone. Using a technique such as nonlinear, nonparametric programming, an optimal combination of improvement expenditures could then

be determined to minimize improvement and opportunity

costs.

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APPENDIX

OREGON STATE UNIVERSITY

SCHOOL OF ENGINEERING

**DEPARTMENT OF
MECHANICAL AND INDUSTRIAL
ENGINEERING**

Dear Sir:

I am currently conducting a research project dealing with the evaluation
of supplier performance under the aegis of the Department of Industrial
Engineering. Its purpose is to develop a method to improve a supplier's
products and services by objectively relating his performance to both the
percentage of business that he currently receives and the percentage of
business he could receive if he improved his performance.

Some large firms use a numerical technique to quantify or rate a supplier
on delivery, quality, price, and various services. Receiving a lower rating
than his competitor could cost a supplier money in terms of sales. Con-
versely the upgrading of this rating could represent potential income to
the supplier. The amount of this potential income not now being realized
represents an opportunity cost to the supplier.

The informative value of such a project should be beneficial to both sup-
pliers and users; beneficial to the supplier by presenting him with a firm
financial basis to direct product and service improvements, and beneficial
to a user by increasing the ability of suppliers to serve him.

As the basis of this study, I must obtain the opinions of large industries
about their purchasing procedures. I would be grateful if you would com-
plete the attached questionnaire and return it to me in the prepaid, self-
addressed envelope.

If you have a formal supplier or vendor rating system, I would appreciate
all the information that you could send me describing the forms and/or pro-
cedures used for both the rating and the consequent allocation of business
of your suppliers.

The information received both from the questionnaires and your present rating
system will be strictly confidential and used only to develop a general
supplier improvement method.

- Page two -

If you would like a copy of the report when it is completed, just indicate so in the space from comments following question 4.

Please don't hesitate to write or call me at your convenience if you would like any additional information regarding the project. The department's phone number is 503 754-3441 Corvallis, Oregon.

Thank you for your cooperation in this matter.

Sincerely,

John W. Hudson
Research Fellow

QUESTIONNAIRE

General Instructions:

1. To limit unnecessary variables, please use only your factory
   direct suppliers of aluminum products as the basis for com-
   pleting the questionnaire.

2. To insure anonymity, always refer to your suppliers with the
   letter shown below:

SUPPLIER

A - Received the largest % of your factory
    direct aluminum business last year.

B - Received the second largest % of your
    factory direct aluminum business last
    year.

C - Received the third largest % of your
    factory direct aluminum business last
    year.

D - Received the fourth largest % of your
    factory direct aluminum business last
    year.

E - The remaining factory direct suppliers
    who received a part of your aluminum
    business last year.

Question 1: What percentage of your factory direct aluminum business did
            you allocate to each of the above suppliers last year?

SUPPLIER	% BUSINESS ALLOCATION
A	-
B	-
C	-
D	-
E	-
	100%

Question 2: How do you regard your suppliers on delivery, quality, lead
             time, price, technical assistance, product range, and sales
             service?

Instructions:
1. On the following seven graphs make horizontal marks in the
    appropriate columns for each supplier to show their perfor-
    mances on each of the above factors.
2. If you are forced to allocate business to a supplier because
    of his superiority on one factor rather than the composite
    of his performance on all factors, please explain the situa-
    tion in the space for comments on each graph.

DELIVERY PERFORMANCE

COMMENTS

Consistently ships as prom-   100%
ised with extremely rare
exceptions. Reacts swiftly
on exceptions. In short, he
is very dependable.

Usually ships material as   75%
promised with few misses.
Generally reacts well if
late or ships a partial.
Rarely gets us into serious
material shortages.

Has fair fidelity on making   50%
promised shipments but quite
often misses. Reaction to
missed promises is sometimes
good, sometimes only fair.

Misses promised shipments   25%
frequently to an extent that
supplier is considered very
marginal in this respect.
Reacts slowly when late.
Constant problem of expedit-
ing.

Unacceptable as a source   0%
because of constantly missed
promises.

     A   B   C   D   E
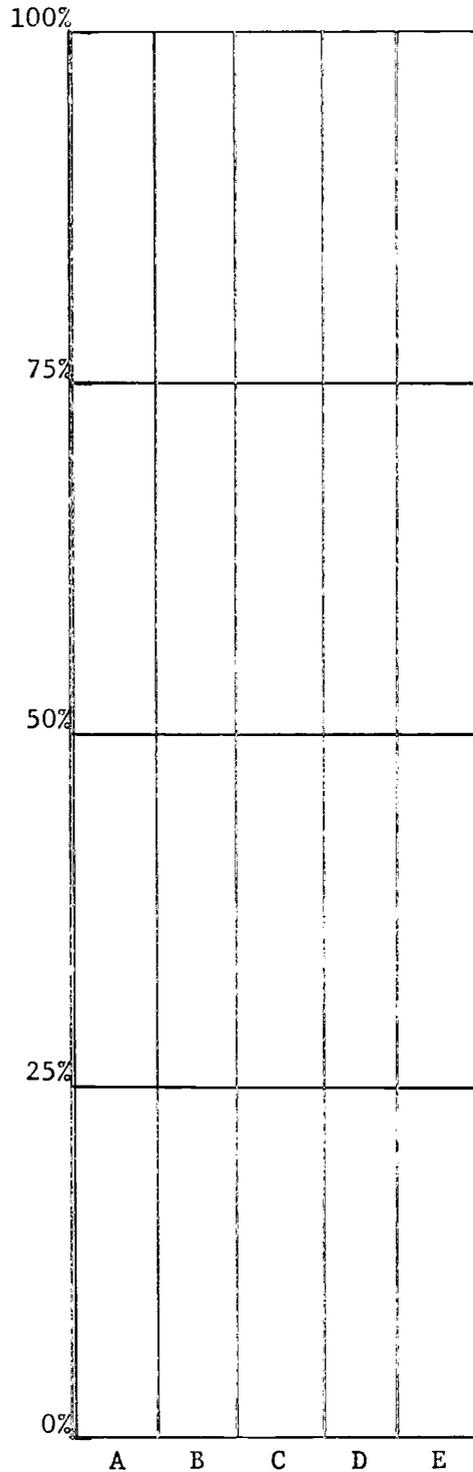
SUPPLIERS

QUALITY PERFORMANCE

Outstanding, supplier always exceeds minimum specifications requirements.

100%

Supplier usually exceeds minimum specification requirements.

75%

Quality is generally acceptable.

50%

Quality is marginal, often requires rework or rejection.

25%

Quality is unacceptable without additional working or excessive rejections.

0%

A   B   C   D   E
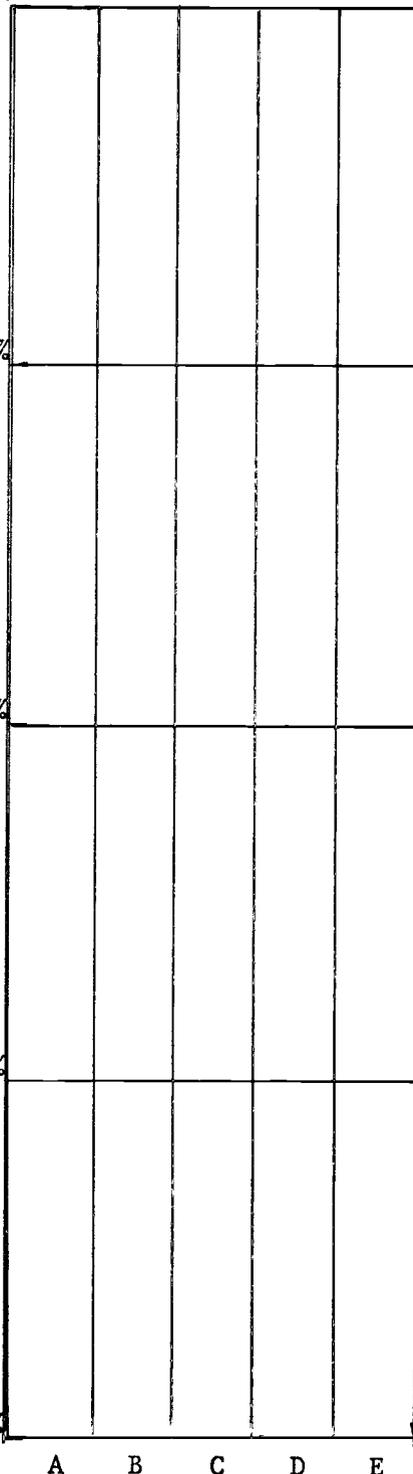
SUPPLIERS

LEAD TIME PERFORMANCE

Lead times are consistently
the shortest or equal to
any in the industry for made
to order materials. Has large
stocks of standard products
at own or distributor's
warehouse for immediate
shipment.

100%

Lead times are usually com-
petitive on made to order
materials. Distributor or
warehouse stocks are reason-
ably adequate.

75%

Lead times are sometimes not
competitive on made to order
materials. Distribution
system is only fair.

50%

Lead times are generally not
competitive. Distribution
system is poor.

25%

Lead times rarely are toler-
able. Supplier virtually
eliminated if lead time
concerned.

0%

A   B   C   D   E
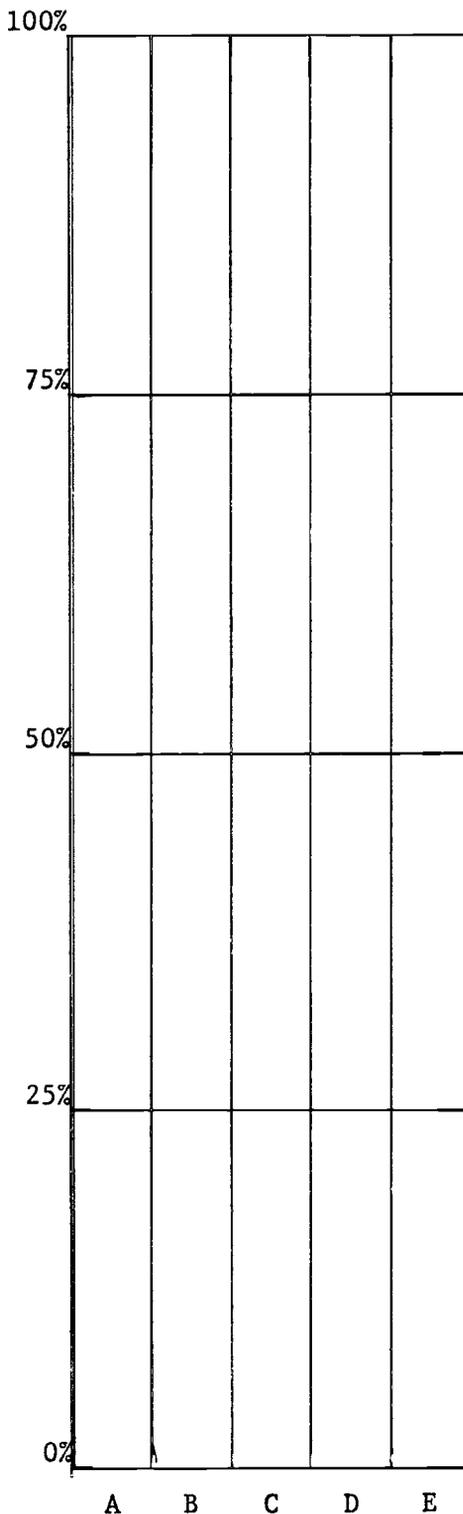
SUPPLIERS

PRICE PERFORMANCE

Supplier is always compet-
itive. Products are priced
fairly. We have complete
confidence in his pricing
policies.

100%

Supplier is usually compet-
itive. Normally prices
products fairly. His pric-
ing policies appear reason-
ably sound.

75%

Supplier is relatively compet-
itive but tends to take advan-
tage in some situations. He
is a price follower and not
a leader. His pricing policies
seem slightly eratic and our
confidence in him is limited.

50%

Supplier is competitive only
under pressure. Quite often
unfair and always takes advant-
age if he is the sole source.
We have little confidence in
his pricing policies.

25%

Pricing and pricing policies
are not tolerable.

0%

A   B   C   D   E
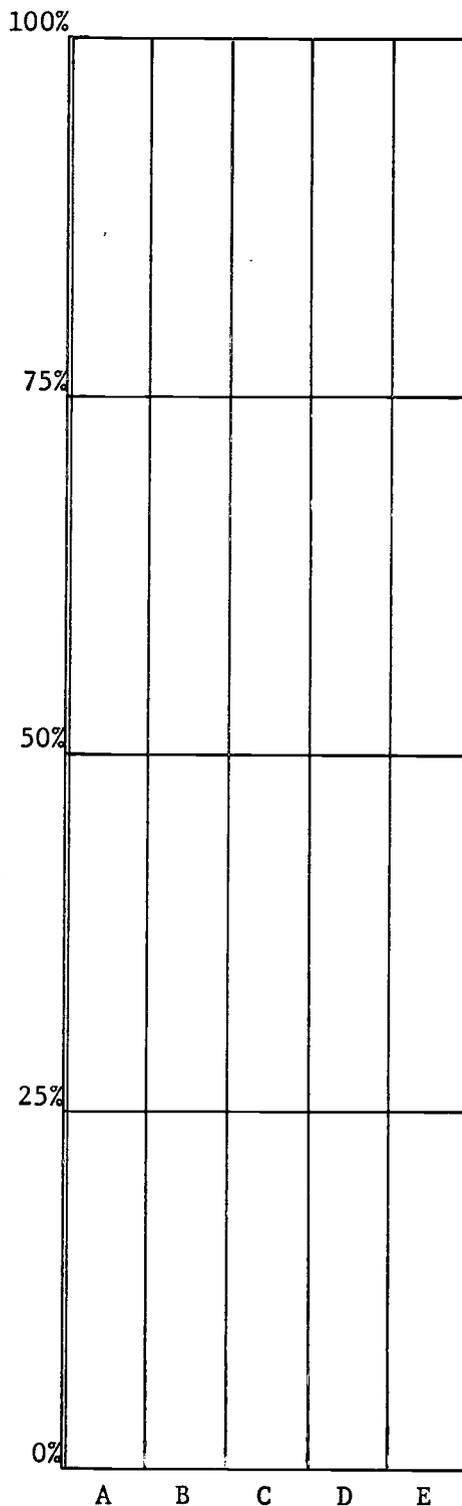
SUPPLIERS

TECHNICAL ASSISTANCE

Technical assistance is
always of highest quality and
prompt within problem scope.
Company has pioneered product
advancements. He has assist-
ed us willingly when asked
and volunteers assistance
on new products and methods.

Technical assistance is
good and usually prompt.
Representatives most always
seem to know their business.
He does a fair share of
research and development
in our area.

Technical assistance is
only fair, and often delayed.
Many of his representatives
lack information about their
product performance. Research
and development seem to
suffer.

Technical assistance is
usually poor. We have little
confidence in his problem
solving ability. He is quite
marginal in all facets of
research and development.

Technical assistance is
absent or too slight to be of
any significance to us.

100%

75%

50%

25%

0%

A   B   C   D   E

SUPPLIERS

63
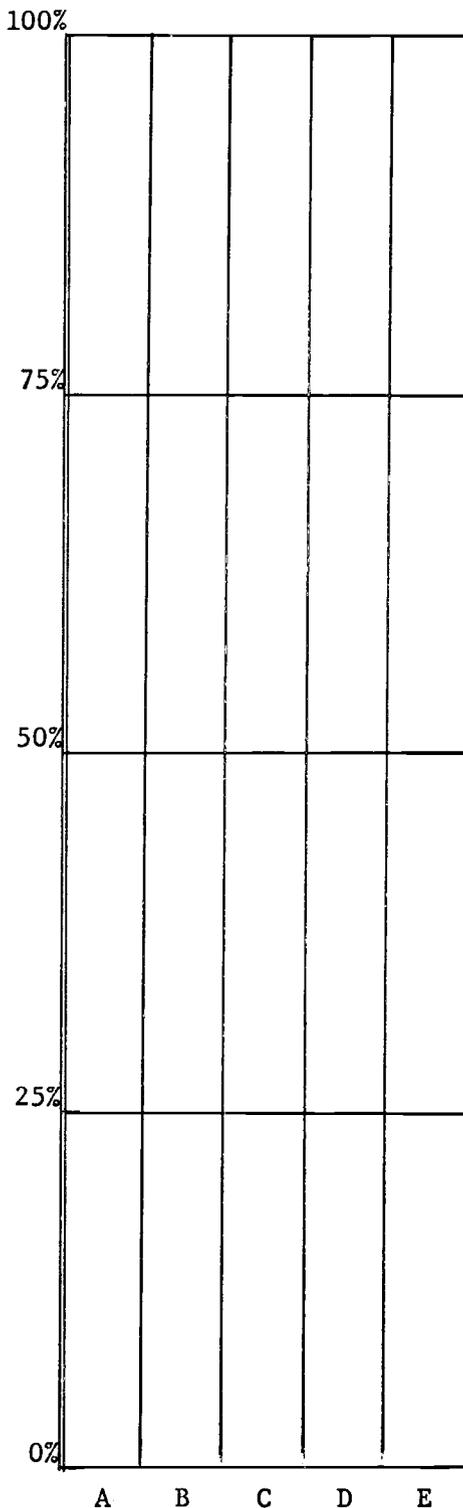
PRODUCT RANGE PERFORMANCE (AVAILABILITY)

COMMENTS

Supplier has very wide range
of products. He is known for
his complete product line.
Any factory direct aluminum
product can be ordered from
this source.

100%

Supplier has reasonably wide
range of products. He can
generally meet requirements
and has few really serious
deficiencies.

75%

Supplier has some limitations
in product range. We seldom
can complete a total require-
ment from this source.

50%

Supplier has real product
range deficiencies. Only a
few items can be ordered from
this source because of his
restricted line.

25%

Supplier is very seriously
restricted in product line.
He is limited to only a few
products which we seldom require.

0%

A   B   C   D   E
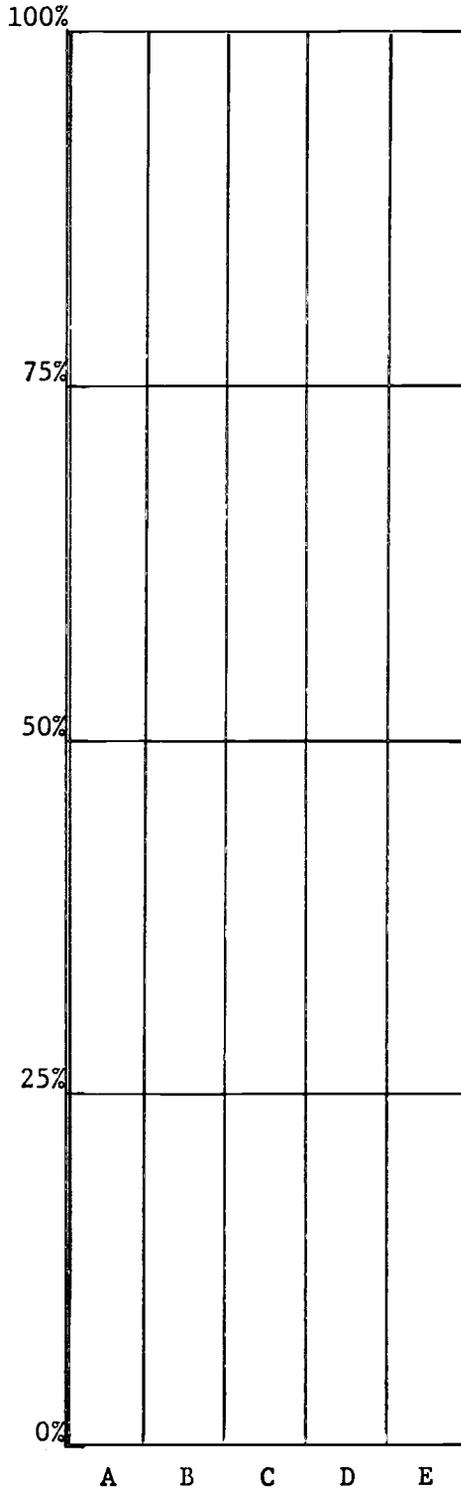
SUPPLIERS

SALES SERVICE PERFORMANCE

Sales relationship is excellent. Respresentatives always comply with all our purchasing policies. Orders are handled smoothly and quickly, order acknowledgements are prompt and meaningful and invoices are always on time, correct, readily understood and in required quantities. Both standard and special order instructions are always precisely followed. All possible assistance is provided in emergencies and he goes beyond our immediate needs for service and information. Exceptionally interested in obtaining a larger share of the available business.

Sales relationship is very agreeable. Rare lapses in service. Our purchasing policies are followed closely. Nearly all paperwork is handled expeditiously and accurately. Standard instructions are always followed and only rarely are there misunderstanding on special instructions. Supplier has the flexibility and the desire to assist in emergencies and special situations. He regularly goes beyond our immediate requests in providing service and information. Understands our problems and is willing to work toward their solution. Very evidently interested in a larger share of the available business.

Sales relationship is acceptable. Our purchasing policies are usually observed. Administrative efficiency is generally acceptable, but there is mishandling of orders, acknowledgements, and invoicing. Standard instructions are usually observed but performance is poor on special instructions. Supplier has some flexibility and provides some help in most emergency situations, but rarely goes beyond filling the immediate need. Only partially understands our problems. Seems uninterested in doing much to increase his share of the available business.

The sales relationship is barely acceptable. Often bypasses or ignores our purchasing policies. Handling of paperwork is erratic. Order acknow- ledgement, if sent at all, often provides no useful information. Invoices require needless correspondence. Standard instructions are regularly missed and special instructions are often ignored. The supplier is rarely interested in responding to emergency situations and he never goes beyond our direct request. He seems to have no interest in increasing his share of the available business.

Sales relationship is poor. Our purchasing policies are regularly ignored. Ineptly handles orders, continuously corresponding over claims and mistakes. Seldon complies with any instructions. Unable to provide any special or emergency service. Definitely uninterested in our business.

100%

75%

50%

25%

0%

A   B   C   D   E
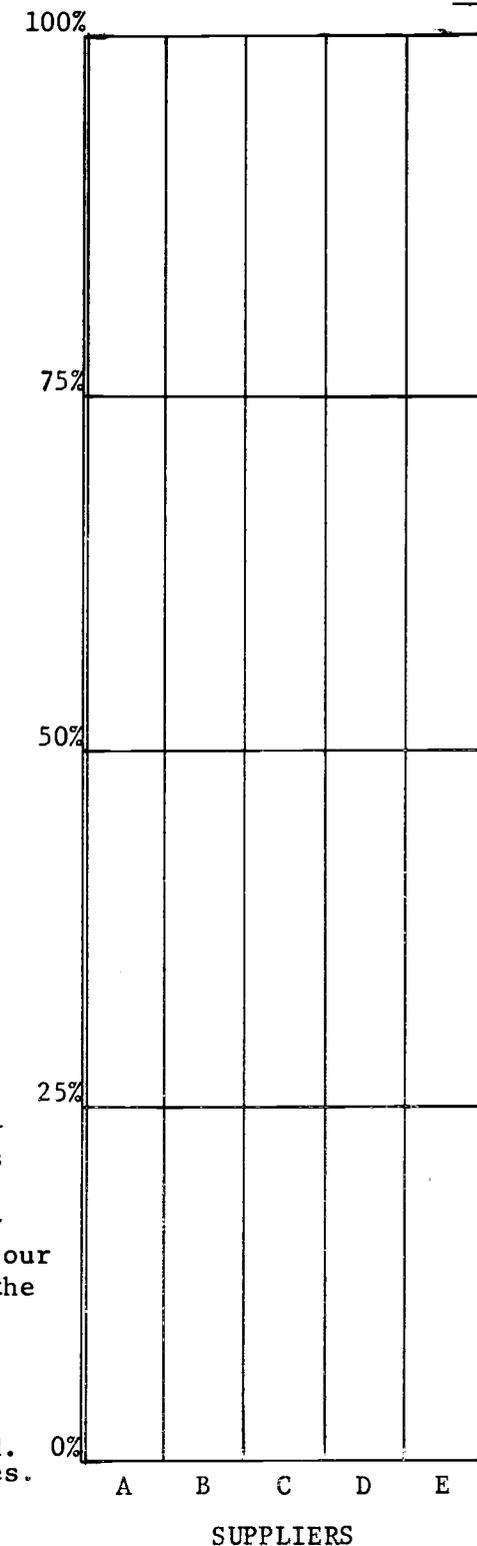
SUPPLIERS

Question 3: What relative importance do each of the factors have in
determining the percentage of business you allocate to your
factory direct aluminum suppliers?

Instructions:
1. Make a horizontal mark in the appropriate columns to show
each factor's relative importance.

RELATIVE IMPORTANCE

COMMENTS

Absolutely necessary to our   100%
operation. Most important
criterion or criteria used
to determine the allocation
of business to our suppliers.

Important to our operation.   75%
Weighs heavily on our decisions
to allocate business to sup-
pliers.

Fairly important to our opera-   50%
tion. We weigh this factor
or factors when determining
the business we allocate to
suppliers.

Minor importance to direct   25%
production but still has some
weight when we determine the
allocation of business to our
suppliers.

Of little or no importance   0%
to our operation. Exerts
only slight influence on
our buying decisions.

DELIVERY QUALITY LEAD TIME PRICE TECHNICAL ASSISTANCE PRODUCT RANGE SALES SERVICE

F A C T O R S

Question 4: What is the maximum percentage of business that you could give
any one factory direct aluminum supplier if he was clearly supe-
rior to all other competition?

_____% MAXIMUM POTENTIAL BUSINESS ALLOCATION

Comments: