⊠연구논문

공급자선정을 위한 품질척도

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A Quality Measure for Supplier Selection

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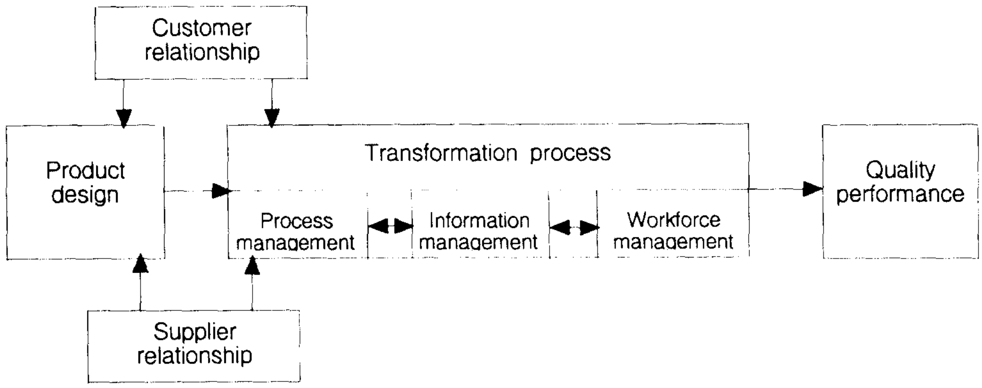
Abstract

Supplier quality plays a major role in the evaluation of suppliers, making it very necessary to develop a proper quality measure useful in selecting suppliers that is able to meet quality specification of the customer. In this paper, we present a measure of the overall quality performance which is a weighted geometric mean of the process capability indices of the quality characteristics of a supplier. This measure can be used both as a measure of supplier selection for the customer and as a measure for the self-analysis of the quality performance for the supplier.

1. Introduction

The practices that comprise effective quality management can be grouped into four primary dimensions: product design, transformation process, customer relationship, and supplier relationship (Flynn, et al.(1995)). These are summarized in <Figure 1>, which models the process of producing a product. As we can see from the figure, having a good suppier relationship is essential for a successful quality management.



< Figure 1 > Model of dimensions of quality management (adapted from Flynn et al. (1995))

Traditionally, there are three key elements which are considered to be important in supplier selection. They are price, delivery time, and quality. Purchasing decision was historically based on selecting the lowest-priced qualified bidders. Suppliers have been evaluated on price, rather than on a thorough evaluation of supplier worthiness. Of the three elements securing quality is the most demanding task. Ernst and Young(1990) emphasize that quality must be considered ahead of price and delivery. For many companies, purchases account for 60% of the sales and are the source of half of the quality problems (Burt(1989)), and up to 80% of quality costs in many companies is due to parts and materials coming from suppliers (Olsen(1993)). There are many cases where manufacturers claim the quality systems in their factories are great. But the same manufacturers have suppliers that fail to reduce defective parts in their manufacturing process (Hernandez(1993)). Therefore, supplier quality has a very high impact on total company performance. To ensure the quality of a supplier, it is necessary to check that the supplier's process is under control and capable, and meets functional requirements of the customer. Then, we need to form a new relationship, verify performance, and ensure that our suppliers adopt and maintain a philosophy and strategy of continuous improvement (Deming(1986)).

Any manufacturer working alone in a supply chain will always be constrained by the quality received from its suppliers. However, manufacturers working together in the supply chain will benefit in terms of mutual understanding and capabilities, since the quality of incoming materials greatly influences the quality of products sold to the next customer in the chain. The resulting synergism is essential to compete in the worldwide market. To build a competitive supplier base, we should select suppliers based on the capability to improve quality, delivery, and cost and the willingness to commit to become world class (Ernst and Young(1990)).

From the price-sensitive bidding argument, typical customers and suppliers were adversaries. However, as consumers are demanding higher levels of product quality, price competition should be subordinate to quality competition (Lascelles and Dale(1988)). Therefore, criteria for selecting suppliers extend beyond the tag price alone and recognize the suppliers' quality and future expectations of continuous improvement. Customers should also have long-term relationships with good suppliers. From this process they try to reduce the number of companies from which they purchase. Ford Motor Company, for example, reduced its 50,000 suppliers in the 1970s to 10,000 qualified vendors in the early 1990s (Tenner and DeToro(1992)), while Xerox reduced the size from more than 3,000 in the early 1980s to fewer than 400 in the late 1980s successfully (Clausing(1993)).

In this paper, we suggest a quality measure of selecting appropriate suppliers with high quality. Using this quality measure we can select suppliers that demonstrate the ability to make products of the highest quality. If suppliers receive preferential partnership standing, they can be entitled privileged business information, consideration for new purchases and programs, and single-source commitment. The customer benefits from single-sourcing in a number of ways; variation reduction of incoming materials and parts, reduced administrative costs, in-depth cooperation between the customer and the supplier, and enhanced total quality management system.

2. Product Quality Specifications

In order to have a successful supplier partnership we need to understand the quality requirements of the parts and materials supplied. (From now on, we will use the term "part" in a broad sense, meaning part, material, or product manufactured by a supplier.)

Design engineers tend to specifiy all requirements, including dimensions, thus making the suppliers comply the resulting requirements. But this type of requirements are not good. Like Japanese, it is better to simplify the specifications by relying more on performance requirements, allowing the supplier greater flexibility for innovation in deciding how to meet the requirements. Critical dimensions would be given, letting the supplier have flexibility as long as performance requirements are achieved.

Quality requirements should be put in writing as quality specifications. Specifications must be precisely defined and clearly understood by people involved in judging it, and should relate meaningfully to key quality characteristics. Suppliers should be able to have process capability to meet these specifications and strive to improve process capability by variation reduction effort on the quality characteristics. Although it is difficult, specifications must be clear enough for nonmeasurable quality criteria. Different people can have different opinions regarding the fulfilment of the criteria if the measurements are subjective. For subjective quality characteristics designers and quality engineers of the customer should specify the criteria in the clearest possible way to make sure workers of the supplier understand the differences between acceptable and unacceptable parts. Examples of subjective characteristics are surface finish, color matching, and taste of food. Although the manufacturing division of the supplier is responsible for quality, the part's designer of the customer is also responsible in specifying the quality requirements of the part.

Documents of the design engineers of the customer should be clear enough for the supplier to understand. For example, it is not possible to make a part using a machine which is not able to meet the tolerances specified. Poor quality in documentation is one of the most common causes of poor quality in a part. Poor documentation leads to waste and costly mistakes in manufacturing. It is mostly created by designer neglect or by the use of wrong standards. The problem may be lack of critical data making the part's poor functioning or too much unnecessary data confusing manufacturing people with too many unnecessary requirements and increasing manufacturing cost (Hernandez(1993)). By measuring relevant quality characteristics we can see which supplier has more capable manufacturing process.

It must be emphasized that the supplier's manufacturing and quality engineers should work closely with the customer's designers and quality engineers when defining product quality specifications. Designers should be flexible enough in changing the design, if it could improve the overall quality of the part. By inspecting the parts manufactured by candidiate suppliers, we can select the supplier having the best manufacturing process.

3. A Quality Measure

Quality systems that use subjective measurements are open to fraud and abuse. To eliminate the possibility of fraud and abuse, we need an unambiguous, nonsubjective measurement of quality (Windham(1995)). Evaluation of the supplier's manufacturing quality can be done through three approaches: past data on similar parts, process capability analysis, or an evaluation of the supplier's quality system through a quality survey (Juran and Gryna(1993)).

In this paper we consider process capability analysis of the current test data on the part under consideration. A part is designed by a customer to meet functional requirements. A supplier makes a sample of the parts based on the proposed part design. The supplier then tests the sample for qualification and submit test results to the customer. The evaluation can be accomplished by having a customer's representative visit the supplier's plant and observe the inspection of a random sample from the initial test production lot. For the test to be successful, the test results should be able to show that the design provides the functional requirements desired and the test procedure is adequate to evaluate the performance of the part. Data on important quality characteristics are collected from the sample and evaluated using indices for process capability.

In case it is difficult to have test data of the part under consideration, we can use past process capability analysis results on similar parts. Important quality characteristics are dimensions and performance requirements identified based on the engineering knowledge, safety-related considerations, or items related to government regulations. A review is made of process capability from the data of the lot. Suppliers' manufacturing processes are evaluated by checking capability analysis data of the quality characteristics of the part they are manufacturing.

As a measure of the quality performance of a manufacturing process, we consider a process capability index which is a measure of the ability of manufacturing process to meet specifications considering both the variation and the difference of the mean from the target value. There are several types of process capability indices (Kane(1986)). From these indices we can choose an appropriate one depending on the situation of the part manufacturing. However, it should be kept in mind that once an index is chosen for a quality characteristic, the same index should be used till the end of the evaluation process for the quality characteristic. In our paper we use Cpk, since it is the most widely used capability index in industry (Rodriguez(1992)).

Windham(1995) suggests a weighted arithmetic mean of the capability indices of the quality characteristics of the part manufactured, as a measure of the overall quality performance of a manufacturing process of a supplier. His idea is not appropriate, since arithmetic mean is not sensitive to small values. In this paper we use a weighted geometric mean of the capability indices as the overall quality performance measure, since geometric mean is very sensitive to small values of the capability indices and thus making suppliers with a small value of capability index less competitive. The usefulness of the weighted geometric mean was presented by Derringer(1994), who used this measure to optimize a product's multiple properties. Later, Byun et al.(1997) adopted this measure to compare product/process designs in terms of producibility vector which takes the performance quality and manufactuirng cost into account.

Suppose there are p quality charateristics of interest $Y_1, Y_2, \ldots, Y_p$. Criticality factors $w_1, w_2, \ldots, w_p$ which represent the relative importance of the quality characteristics are assigned. Criticality factors are given by a consensus meeting including experts or representatives from all related functional areas of the customer and the supplier. We can also use the pairwise comparison for the assigment of the criticality factors (Yager(1977)). A minimum value of C_{pk} is then assigned for each individual quality characteristic. The minmum C_{pk} on each characteristic is the lowest C_{pk} the purchaser will accept on that characteristic. A supplier producing part with a process capability of a quality characteristic less than the minmum acceptable C_{pk} value will not be considered as a legitimate supplier. Capability indices C_{pk}'s and the criticality factors $w_1, w_2, \ldots, w_p$ are then put into the following equation to calculate a geometric mean of the C_{pk}'s:

$$C_{pk(overall)} = (C_{pk(1)}^{w_1} C_{pk(2)}^{w_2} \ldots C_{pk(p)}^{w_p})^{\frac{1}{\Sigma w_i}} \qquad (1)$$

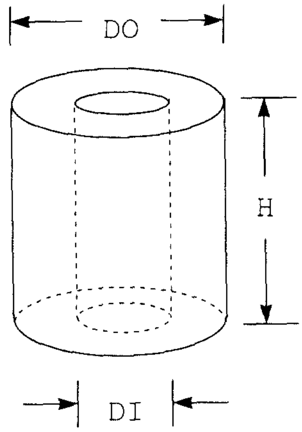
where $C_{pk(i)}$ is the C_{pk} for the i-th quality characteristics. $C_{pk(overall)}$ is a measure of the overall quality performance of the manufacturing system of a supplier producing the part.

4. An Illustrative Example

Let's consider a hollow cylinder, as described in <Figure 2>, which is very popular part in automobile manufacturing. Three dimensions are considered to be important features(quality characteristics) for the proper functioning of the part: height(H), outer diameter(OD), and inner diameter(ID).

H: 6.0 ± 0.01 cm

OD: 5.0 ± 0.005 cm
ID: 1.8 ± 0.002 cm



< Figure 2 > Hollow cylinder

Criticality factors are given by a consensus meeting to be 1, 2, and 4 for the height, outer diameter, and inner diameter, respectively. We have four candidate suppliers for this part. After inspecting the parts that suppliers submitted, we have the process capability indices C_{pk} as in <Table 1>.

< Table 1 > Capability Indices of four suppliers

Suppliers	$C_{pk}(H)$	$C_{pk}(OD)$	$C_{pk}(ID)$
1	1.20	1.50	1.10
2	1.10	1.25	1.30
3	1.92	1.70	0.92
4	0.94	1.30	1.20

We set minimum values of C_{pk} = 0.9, for the height, outer diameter, and inner diameter. Since all C_{pk} values of the four suppliers are greater than 0.9, all suppliers are considered to be legitimate. From the C_{pk} values of the suppliers we can obtain overall capability index $C_{pk(overall)}$ using Eq.(1). For example, $C_{pk(overall)}$ for supplier 1 is obtained as

$$(1.20^1 \times 1.50^2 \times 1.10^4)^{1/7} = 1.217. \quad (2)$$

For camparison, we also calculate the weighted arithmetic mean of the capability indices for each supplier. For example, we can calculate the weighted arithmetic mean for the supplier 1 as

$$\{1.20 + (2)(1.50) + (4)(1.10)\}/ 7 = 1.229. \qquad (3)$$

$C_{pk(overall)}$ and weighted arithmetic mean values for the four suppliers are shown in <Table 2>. If we use the weighted arithmetic mean as the supplier selection criterion, we select supplier 3. But supplier 3 is not appealing, since it has very low $C_{pk(ID)}$ which is four times as important as $C_{pk(H)}$. If we choose $C_{pk(overall)}$ as the criterion, we select supplier 2 which is shown to be better than any other supplier in terms of the overall quality performance. The use of the $C_{pk(overall)}$ as the criterion is more persuasive, since supplier 2 is more appealing to the customer than supplier 3.

< Table 2 > Comparison of measures of supplier quality

Suppliers	wt. arithmetic mean	$C_{pk(overall)}$
1	1.229	1.217
2	1.257	1.255
3	1.286	1.218
4	1.191	1.186

5. Conclusion

Supplier quality has a very high impact on total company performance. Therefore, it is essential to develop an appropriate quality measure which is useful in selecting suppliers that is capable of satisfying quality requirements of the customer in the best way. We present a measure of the overall quality performance of a supplier which is a weighted geometric mean of the capability indices of the quality characteristics. Geometric mean is very sensitive to small values of the capability indices, and makes suppliers with a small value of capability index less competitive than the arithmetic mean does. This measure can also be used as a quality measure of the suppliers' self-analysis of their own quality performance. Future research can build on the development of a more integrated performance measure including delivery time and unit price which are measured by historical performance of the candidate suppliers.

Acknowledgement

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