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# The Influence of Defective Production on Supplier Selection Considerations

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**Investigating the Relationship between Supplier Selection and Defect Rate**


## ABSTRACT

The purpose of this paper is to investigate the relationship between supplier selection and defect rate. In addition, a research model was developed. The method section will discuss the data and applications utilized in the study. The results section will discuss findings from the statistical analysis. The conclusion and limitations section will discuss the limitations of the study and future research opportunities. (this has to be done over but the gist of it is here)

## Investigating the Relationship between Supplier Selection and Defect Rate

### Introduction

The role of quality is vital to the relationship between manufacturers and suppliers. If there is a defect in a component of the finished product, the manufacturer can quickly lose their reputation for providing customers reliable products. One of the most notorious cases of defective parts from suppliers is the Firestone-Ford debacle of the 1990s.. Although Firestone tires were used on other vehicles, the tires were the cause of accidents involving the Ford Explorer. Causes of the accidents by the Firestone tires were tread separation, blowouts, and other failures, usually resulting in roll-overs, resulted in 174 deaths, over 700 injuries, and 6000 complaints.. Although there is evidence of faults by both Ford and Firestone, each company blamed the other for the accidents and the high number of deaths and injuries (Ackman, 2001). This example vividly illustrated why the supplier selection and defect rate of parts supplied is important.

Although there is a great deal of research on supplier selection and defect rate individually, the studies on the different issues are limited in scope. Accordingly, in the current research, we attempt to address this gap in the literature by examining the relationship, if any, between the defect rate and supplier selection. Previous studies, however, have not considered how the defect rate affects supplier selection. Therefore, we believe that examining the supplier selection and defect rate adds to the richness of the existing body of knowledge and may be of use to manufacturing firms. Thus, the purpose of this paper is to investigate the relationship between supplier selection and defect rate.

## LITERATURE REVIEW

Quality of parts is a major component of measuring the relationship between the supplier and the manufacturer. According to Ellram (1991), supply chain management (SCM) has combined the advantages of both Just-In-Time (JIT) and Total Quality Management (TQM). Currently, SCM is defined and categorized by several researchers as the planning and management of all activities, including coordination, and collaboration with suppliers, intermediaries, third party service providers, and customers to facilitate integration of supply and demand management within and across companies (Council of Supply Chain Management Professionals, 2004; Gibson, Mentzer, & Cook Robert, 2005; Stank, Davis, & Fugate, 2005). In addition, SCM encouraged quality systems from both suppliers and manufacturers because an organization can have the best quality internal systems, without high-quality defect-free materials, the process will be flawed (Romano, 2002). Quality is an important component of the supplier selection process. Without this measurement it is difficult to determine the relationship between the manufacturer and their supply partners.

### Supplier Selection (we need to define the supplier selection process in the 1st paragraph)

The supplier selection process has continued to become one of the major topics in production and operations management literature and manufacturing firms. Traditionally, the buyer-supplier relationship has often been deemed antagonistic. In today's global economy, there is a need to change this adversarial relationship to one of cooperation and seamless integration. In the past few years, a positive change has been observed. Trends, such as shortened product life cycles, increased rates of technological change, and foreign sourcing, have given rise to improved communication and cooperation between buyers and suppliers, with implications on

management practices, such as single source procurement (Bhutta & Huq, 2002). Generally, supplier selection is a lengthy evaluation process that is not always straightforward. When selecting suppliers, the industrial purchaser bases his/her decision on various decision variables, which can be divided in to two groups: supplier characteristics and bid characteristics (Hakansson & Wootz, 1975).

In the era of globalization, suppliers strive to develop exclusive partners with manufacturers. Partnering strategies that require closer ties between buyers and suppliers are becoming increasingly common for U.S. firms (Wilson, 1994). These strategies allow buyers and suppliers from the United States to compete more effectively with international firms abroad. An effective purchasing function is one of the competencies essential to supply chain success (Day, 1994; Fawcett & Fawcett, 1995; Giunipero & Brand, 1996; Porter & Millar, 1985; Reck & Long, 1988). Research suggested that nurturing the buyer-supplier relationship by effectively selecting and evaluating suppliers and managing their involvement in the supply chain can lead to better supplier performance, improved manufacturing, and product and process advancements; therefore, resulting in enhance customer satisfaction and firm performance (Epatko, 1994; Schilling & Hill, 1998; Shin, Collier, & Wilson, 2000; Tracey & Tan, 2001; Vonderembse & Tracey, 1999).

**Defect Rate**

According to Burnett (2000), the defect rate for a test represented the best single indicator of analytical quality, as perceived by our customers. Prior research on defect rate has proposed a relatively consistent definition. Chen, Yao, & Zheng's (1998) study, which develops a model for inspection of end products, defined defect rate as the proportion of defects in a batch. A different study developed quantity control charts in the production process measured the defect rate as the

number of defects per unit quantity of product produced (Chan, Xie, & Goh, 2000). Two additional studies classified quality synonymously with defect rates, where one study contrast the characteristics of high and low performing supply chains in Japan, the U.S. and Europe (Oliver & Delbridge, 2000) and the other study on cellular manufacturing (Chakravorty, 1996). However, in this study we examine defect rate as (is this a connection with another sentence?) (we need to put what the defect rate will be defined in this paper)

Critics of traditional quality cost systems proposed supplementing financial measures with nonfinancial quality measures, arguing that nonfinancial measures provided a better indication of quality related customer goodwill losses. Luft and Shields (2001) found in an experimental setting that individuals can asses the future financial impact of quality more accurately using nonfinancial quality measures than using financial quality measures. Theoretically, Nanadakumar, Datar, & Akella (1993) demonstrated the advantages of nonfinancial quality measures relative to financial quality measures. Empirically tested by Nagar & Rajan (2001), improvements in defect rates are positively associated with future sales, suggesting that customers value quality.

Defects per million units (DPMU) and defects per million opportunities (DPMO) are directly related to production rates (Borror, Keats, & Montgomery, 2003). Projects such as Six Sigma are interested in both DPMU and DPMO because detecting an increase in the DPMU or DPMO is comparable to detecting a decrease in the number of good units produced between consecutive bad units or defects.. Six Sigma as a methodology for quality improvement is often presented and deployed in terms of the DPMO metric. In an effort to achieve high quality and low defect rates, many organizations (i.e., General Electric, Raytheon, Boeing, Caterpillar, IBM, and Xerox) attempt to achieve the important highly recognized six sigma status (Vaughan,

1998). For instance, the secret to General Electric's success is the implementation of the defect-reduction program called Six Sigma, which has contributed to the growth of the earnings from 13% (1996) to 14% (1997).

Currently, as product quality is a primary concern, manufacturers are striving for excellence. Acceptable defect rates may be as low as several parts per million (ppm) in high yield processes (Xie & Goh, 1992). Since zero defects are not realizable (David, 1990) in some industries, an acceptable defect rates has to be determined that can vary by industry and type of part being manufactured. A study conducted by the Japan Automobile Manufacturers Association of parts demonstrated that the defect rates for American imports was higher (0.35% to 2.6%) as compared to Japanese defect rates (0% to 0.01%) (Mitsubishi Research Institute, 1987). Therefore the manufacturers of Japan tended not to inspect incoming parts resulting in a reduction in labor cost allocated toward inspection and saved from possible losses from the cost of defects. On the other hand, American manufacturers allocate unnecessary amounts of money to detect errors after-the-fact, instead of trying to prevent the problem in the initial phase by disseminating quality responsibilities among all employees (Cusumano & Takeishi, 1991). According to Hahn, Pinto, & Bragg (1983), Japanese manufacturers' line-employees were authorized to halt the production process anytime they discovered a breakdown in the process; thus, subscribing to the quality at the source concept. In contrast, American manufacturers were not as open to diffusing quality responsibility to all employees (Cusumano & Takeishi, 1991).

Achieving a low defect rates is not a stand-alone process, "...a defect-free product is only provided through a defect-free process" (Dedhia, 1990). This concept can only become a reality in a trustworthy and competent environment. Nissan attempted to achieve this with on-the-job training and off-the -job training (David, 1990). Many other organizations have similar processes

because lower defect rates ultimately help increase firm performance. Furthermore, "selecting suppliers based on Quality, Reliability, Performance (QRP) strengthens supplier performance in terms of lead-time and reliability, which enables the manufacturer to be more adaptable to customer needs regarding product features" (Tracey & Tan, 2001). The supplier's perception of a manufacturer and buyer-supplier relationship is vital to the supplier's standard of performance. In general, a defect-free product is provided only through a defect-free process (Dedhia, 1990). Therefore, if a product has a low defect rate, the performance, reliability, and durability will be higher and greater than or equal to the standard resulting in the selection of the supplier. Based on the previous discussion, we advance that a relationship will exist between defect rates and supplier selection and offer the following hypothesis:

***There is a positive relationship between low defect rate and supplier selection.***

## METHODOLOGY

The data to be discussed was derived from electronic and paper based surveys. The survey was submitted to regional chapters of the Institute for Supply Management (ISM), the Association for Operations Management (APICS), the American Society for Quality (ASQ) and the National Association of Purchasing Mangers (NAPM). The paper based surveys were collected within the states of Mississippi, Tennessee, and Arkansas. The researchers contacted the president or the communications liaison of chapters of APICS, ASQ and NAPM via telephone and email across the United States. The member of the chapter contacted submitted an electronic link to other members of the chapter with a message from the researcher inviting them to participate in the survey. In the regions of Arkansas, Mississippi, and Tennessee, the researchers contacted the president and communication liaison and requested to attend the chapter's monthly or regional meeting. At the meeting the researcher was given the opportunity

to invite participants who were present to complete a printed copy of the survey. The response rate was nearly 18%.

The measures used in the survey were abbreviated items. Supplier selection which consist of supplier quality and product quality were measured using seven items from Hsu et al (2006), three items from Tracy and Tan (2001), and one item from Subedi (2004). Defect rate was measured using four items from Gillon (2005). The items were measured using the five point Likert scale.

The resulting model for the study is as follows:

$$Y_1 = \alpha + \beta_1 x_1 + \varepsilon \qquad \text{(Equation 1)}$$

Where

Y = Supplier Selection

$x_1$ = Defect Rate

$\varepsilon$ = error term assumed to be 0

## RESULTS

The significance of the regression results for the one dependent variable is shown in Table 1. These results are interesting in that they show a significant model for the supplier selection variable (0.024). This indicates that the results are being driven at least partially by defect rate. Other values could be contributing to supplier selection. The remaining items in Hsu et al (2006) could identify more of supplier selection.

## Variable Definitions

| | |
|---|---|
| DRSATRT | The defect rate of products/parts of the organization's supplier is at a satisfactory level. |
| DRSNSTRT | The defect rate of products/parts of the organization's supplier is not at a satisfactory level. |
| ISSCRSUP | There has been an issue with our current supplier with the satisfactory level of defect rate of products/parts. |
| ISSRESOL | Issues involving satisfactory levels of defect rate of products/parts with our supplier were successfully resolved. |

## Factor Analysis

**Correlation Matrix**

| | | DRSSATRT | DRSNSTRT | ISSCRSUP | ISSRESOL |
|---|---|---|---|---|---|
| Correlation | DRSSATRT | 1.000 | .584 | .468 | .472 |
| | DRSNSTRT | .584 | 1.000 | .497 | .360 |
| | ISSCRSUP | .468 | .497 | 1.000 | .539 |
| | ISSRESOL | .472 | .360 | .539 | 1.000 |
| Sig. (1-tailed) | DRSSATRT | | .000 | .000 | .000 |
| | DRSNSTRT | .000 | | .000 | .000 |
| | ISSCRSUP | .000 | .000 | | .000 |
| | ISSRESOL | .000 | .000 | .000 | |

**KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .735 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 101.972 |
| | df | 6 |
| | Sig. | .000 |

**Communalities**

| | Initial | Extraction |
|---|---|---|
| DRSSATRT | 1.000 | .655 |
| DRSNSTRT | 1.000 | .607 |
| ISSCRSUP | 1.000 | .640 |
| ISSRESOL | 1.000 | .560 |

Extraction Method: Principal Component Analysis.

**Total Variance Explained**

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 2.462 | 61.556 | 61.556 | 2.462 | 61.556 | 61.556 |
| 2 | .681 | 17.018 | 78.574 | | | |
| 3 | .494 | 12.351 | 90.925 | | | |
| 4 | .363 | 9.075 | 100.000 | | | |

Extraction Method: Principal Component Analysis.

**Component Matrix**

| | Component |
|---|---|
| | 1 |
| DRSSATRT | .809 |
| DRSNSTRT | .779 |
| ISSCRSUP | .800 |
| ISSRESOL | .748 |

Extraction Method: Principal Component Analysis.
a 1 components extracted.

**ANOVA[b]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 72.966 | 1 | 72.966 | 5.274 | .024[a] |
| | Residual | 1203.754 | 87 | 13.836 | | |
| | Total | 1276.719 | 88 | | | |

a. Predictors: (Constant), SS

b. Dependent Variable: DR

| Model Significance Statistics and $R^2$ | | | | | |
|---|---|---|---|---|---|
| Dependent Variable | N | Adj. $R^2$ | p-value ANOVA | F value | Model |
| Supplier Selection | 89 | 0.239* | 0.24* | 5.274 | $\hat{y} = 3.336 + .230x1$ |

*** $p \leq .05$**

**Limitations & Directions for Future Research**

One limitation of the study is the small data set used in the study. According to Cook and Campbell, the size of the sample affects the statistical conclusion validity (1979).

A second limitation of the study is evidenced by the small $R^2$ on the model ($R^2 = 0.16$). The model is clearly not explaining all the variability in the data. As was mentioned earlier, Hsu et al (2006) have additional items that can be used to measure supplier selection.

Another limitation of the study includes the use of cross sectional design to measure supplier selection. Some future adaptation to the study could be a longitudinal study of supplier selection along with focusing on a specific category of purchasing managers can help determine the impact of defect rate on supplier selection. Other future research include comparing the defect rate of manufacturing and service organizations (Hospitality, Automotive, Emerging Technologies, etc), determine if defect rate can improve the perceived quality of the organization which improves competitive advantage, measure perceived and actual quality along with defect rate, and measure defect rate with new product/service development.

## CONCLUSION

Problems that occur with the final products are not necessarily the fault of the final producer. However, the company whose name that appears on the final product tends to be blamed by the customers. Manufacturing companies have seen the importance of providing quality products to their clients and have invested excessive amounts of money to ensure top quality and high ratings with their end customers.

Researchers have measured quality using different frameworks for manufacturers and service organizations (Ahire et al., 1996; Gopal & Alfred, 1998, 1999). Frameworks used to measure quality include Total Quality Management (TQM), Six Sigma, and the Baldridge National Quality Award. In this research, the authors will utilize the findings of Goetsch and Davis (1997) to define the dimensions of quality..

Goetsch and Davis (1997) asserted that firms producing high-quality products give far greater attention to developing partnerships with exceptional suppliers than on reducing price. Quality has been characterized into critical dimensions, two being perceived quality and performance (Garvin, 1987). Garvin (1987) suggested that “quality means pleasing consumers, not just protecting them from annoyances.”

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Appendix

## Supplier Quality impact on Supplier Selection

Please read each statement carefully and indicate your response on the scale given below with a “1” indicating ‘strongly disagree’ and a “5” indicating ‘strongly agree’ with the statement. The bold statement at the beginning of each section applies to each criterion in that section.

1. **Testing capability is important when selecting a key / preferred supplier for your organization.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

2. **The scope of resources is important when selecting a key / preferred supplier for your organization.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

3. **Technical expertise is important when selecting a key / preferred supplier for your organization.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

4. **Industry knowledge is important when selecting a key / preferred supplier for your organization.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

5. **Commitment to quality is important when selecting a key / preferred supplier for your organization.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

6. **The supplier's process capability is important when selecting a key / preferred supplier for your organization.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

7. **The commitment to continuous improvement in product and process is important when selecting a key / preferred supplier for your organization.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

8. **My organization selects and evaluates suppliers based on product quality.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

9. **My organization offers products that are highly reliable.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

10. **My organization offers products that are very durable.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

11. **My organization offers high quality products to our customers.**

**Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N / A**

**12. The defect rate of products / parts of the organization's supplier is at a satisfactory level.**

Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N/A

**13. The defect rate of products / parts of the organization's supplier is not at a satisfactory level.**

Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N/A

**14. There has been an issue with our current supplier with the satisfactory level of defect rate of products / parts.**

Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N/A

**15. Issues involving satisfactory levels of defect rate of products / parts with our supplier were successfully resolved.**

Strongly disagree Disagree Neither Agree or Disagree Agree Strongly Agree N/A