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Customer satisfaction measurement and analysis using six sigma

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Introduction to six sigma

Zero defects is an approach which stresses the fact that all errors are preventable. The concept identified mainly with Philip Crosby, is more than three decades old. Many Japanese companies effectively implemented the concept during that period. Meanwhile, zero defects was introduced in the USA initially as a motivational tool, and failed. The concept of possible near-perfection returned in the mid-1980s in the form of a technical document at Motorola called "Six sigma mechanical design tolerance". Six sigma is a way to measure the probability that companies can manufacture or produce any given unit of a product (or service) with zero defects. The goal at Motorola is not just to manufacture defect-less products, but to eliminate defects throughout the organization. The six sigma crusade which began at Motorola has since spread to other companies continually striving for excellence[1-4].

Six sigma is the rating that signifies "best in class", with only 3.4 defects per million units or operations. The primary use of six sigma in measuring zero defects has been in the manufacturing industry. Most US manufacturing firms on average rate below four sigma. In 1990, IBM was at an average level of three sigma, while Motorola was operating at a level of four sigma. Comparatively speaking, whatever the industry, most companies averaged a level of four sigma at the beginning of 1990, with the exclusion of the domestic airline flight fatality rate at approximately five sigma. For example, airline baggage handling, doctor prescription writing, payroll processing, restaurant billing, and journal vouchers all rated four sigma[4]. Although six sigma is a common measure of defects in manufacturing, few companies have extended the concept of zero defects, measured by six sigma, to customer satisfaction.

Statistical significance of six sigma

In statistics, sigma denotes the standard deviation of a set of data. It provides a measure of variability which indicates how all data points in a statistical distribution vary from the mean (average) value. The normal distribution represents many data sets in business. When data follow a normal distribution, 99.73 per cent of the

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data points lie within ± three sigma from the mean (see Figure 1). Now consider that a company uses a single-stage (one-step) process with a natural variation from the mean to manufacture a product where the mean value is the ideal specification of the product. Consider that design specification allows for a ± four sigma variation about this ideal mean value. About 99.9937 per cent of the products fall within a ± four sigma range about this mean. That leaves 0.0063 per cent outside the range. This translates to a total of 63 parts per million (defects) which will fall outside the defined range, both above and below the specification limits.

The 63 defective parts produced per million products may not appear too large a number of defects (though it is not zero). But, in addition to the natural variation of a process, it has been found that the mean value itself is susceptible to a shift of up to ± one-and-a-half sigma (see Figure 2). When this happens, for

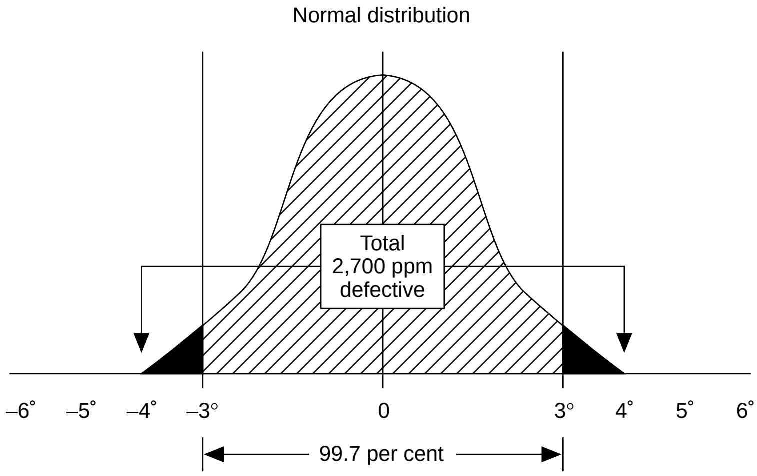

Figure 1.
Normal distribution curve

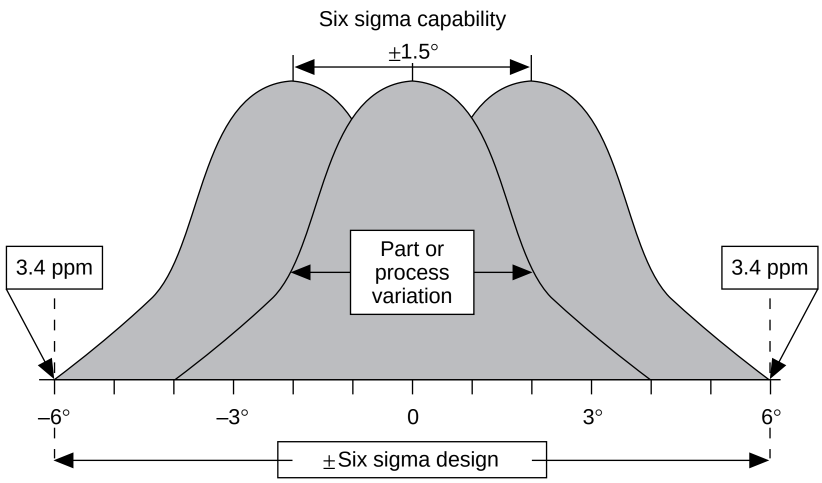

Figure 2.
Normal distribution curve with ± 1.5 sigma shift

the single-stage process discussed above, 99.379 per cent of the products fall within the ± four sigma range. This would leave 0.621 per cent or about 6,210 parts per million (defects) outside the specification limits (see Figure 2). The yield (non-defective parts) is now reduced significantly.

The above discussion is based on a single-stage production process. Real-world production is a multi-stage process and products consist of many components. Each stage of the overall process and each component of the product is subject to the levels of errors described above. The statistically independent yields for each stage or component are multiplied to get the overall yield.

Let us consider a 100-stage process, where each stage has a ± four sigma design specification range. The overall yield would be 53.64 per cent within the specification limits. That would leave 46.36 per cent outside the limits, or 463,600 defective parts per million products.

Most manufacturers use three sigma processes to meet four sigma specifications, resulting in a large number of defects. However, when specifications are set at ± six sigma, near zero defects result. This is true even when the process mean shifts and when multi-stage processing is involved. The overall yield at different sigma levels (specification limits), with multi-stage processes or multiple components is shown in Table I.

If a design can accept a ± six sigma variation of the process, i.e. twice the normal process variation, then 99.99966 per cent of the products will be within specification limits or there will be no more than 3.4 defective parts per million made (see Figure 2). This is true of a single-stage process. Even when there are 100 stages in the product manufacturing process, the defect rate will only be 3,390 parts per million. Table II shows that for any defect level there is an associated sigma level. These values are for a single part or process step.

Motorola's worldwide benchmarking in 1986 found that the best-in-class companies had six sigma quality, while Motorola had only four sigma quality. Many firms operate at three sigma levels (zero per cent yield at three sigma for 1,000 stage process) and have almost no chance of producing defect-free products. To compare these sigma levels consider the following example. When we consider spelling errors, three sigma corresponds to 7.6 misspelled words per page in a book. But, four sigma corresponds to about one misspelled word per chapter in a book, while six sigma would mean one misspelled word in all the books contained in a small library. This logarithmic relationship between

Number of stages/parts	± 3 sigma (%)	± 4 sigma (%)	± 5 sigma (%)	± 6 sigma (%)
1	93.32	99.379	99.9767	99.99966
10	50.08	93.96	99.768	99.9966
100	0.10	53.64	97.7	99.966
1000	0.0	0.20	79.24	99.661

Table I. Overall yield (distribution shifted ± 1.5 sigma)

Table II.
Defects per million and sigma levels

Number of defects per million opportunities	Associated sigma level
66,810	3.0
22,750	3.5
6,210	4.0
1,350	4.5
233	5.0
32	5.5
3.4	6.0

the number of sigmas and rate of errors implies higher sigmas lead to excellence in product quality.

Adapting six sigma to customer satisfaction: a case study

Customer satisfaction is rarely based on contact with only one person or one aspect of a company. Many facets of the business, such as customer service, product or service delivery, product quality, etc. impact on satisfaction. Therefore, customer satisfaction is a multi-stage process rather than a single-stage process. This means that it is even more difficult to reach a level of six sigma in the customer satisfaction arena.

In independent customer satisfaction surveys conducted in 1991 and 1992, researchers at Service Strategies International, a Dallas-based customer satisfaction research company, measured the satisfaction levels of customers with various high-tech manufacturing firms. The customers rated their overall satisfaction with the companies as well as their satisfaction on specific attributes. Based on the responses of approximately 400 customers in each year, the researchers used a six sigma analysis to gauge the client's improvement from 1991 to 1992, as well as its performance against its competitors on overall satisfaction and on each of these attributes.

By providing ratings on 32 attributes related to quality of service, product performance, field service representatives, and company image, customers indicated what they expected of the ideal high-tech manufacturing company. Then, customers rated their satisfaction with the client company and/or one other competitor considered to be "best in class" on the same 32 attributes. Those customers who considered the client company to be "Best in Class" did not rate a competitor. All ratings were on a ten-point scale.

In conducting the six sigma analysis, any performance rating of five or less on the ten-point scale identified a dissatisfied customer. The proportion of dissatisfied customers, convened to per million customers, determined the appropriate sigma level assigned to each attribute. Figure 3 shows the comparative results of the client's six sigma analysis on selected attributes for 1991 and 1992 (assuming a single-stage process). The mean satisfaction ratings and the associated sigma levels for these attributes are shown in Table III. The

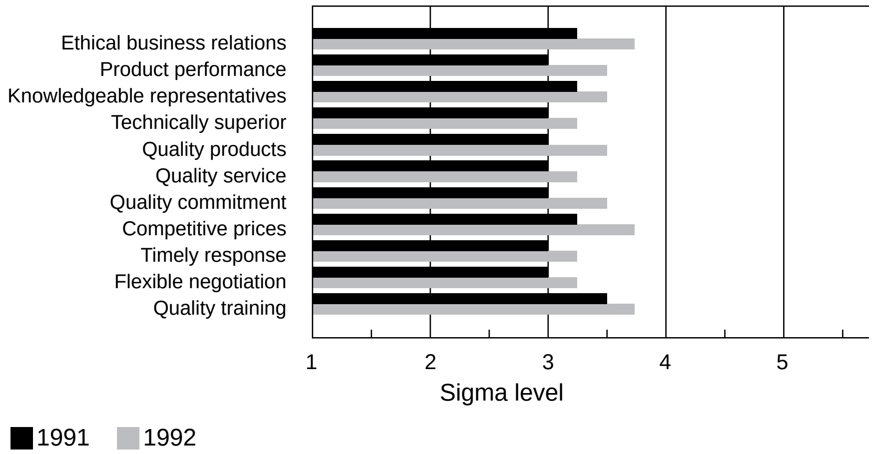

Figure 3. High-tech manufacturing firm 1991 versus 1992 six sigma analysis

Table III. High-tech manufacturing firm customer satisfaction ratings and sigma levels

Attributes	1991 mean score	1991 sigma level	1992 mean score	1992 sigma level
Ethical in business relations	8.3	3.25	8.6	3.75
Product performance	8.3	[a]	8.5	3.50
Knowledgeable representatives	8.5	3.25	8.6	3.50
Technically superior	8.2	3.00	8.4	3.25
Quality products	7.9	[a]	8.9	3.50
Quality service	8.2	3.00	8.4	3.25
Quality commitment	8.4	3.00	8.6	3.50
Competitive prices	8.9	3.25	9.0	3.75
Timely response	8.3	3.00	8.2	3.25
Flexible negotiations	8.0	[a]	8.5	3.25
Quality training	8.9	3.50	9.1	3.75

Note:
[a] Sigma value less than 3.00.

attributes shown are those on which the client improved their sigma rating in 1992. In 1992, the client company decreased or held constant the number of dissatisfied customers in all but two of the 32 areas examined. Also, the client company had fewer dissatisfied customers than its competitors in all but one of the 32 areas studied.

The client's customers also rated their overall satisfaction with the company on a four-point scale ranging from "very satisfied" to "not satisfied at all". In 1991, the client's associated sigma level on overall satisfaction was less than three – more than 77,000 dissatisfied customers per million. However, in 1992 with 44,000 dissatisfied customers per million, the client company raised its associated sigma level to approximately 3.2 indicating that 33,000 fewer customers per million indicated some level of dissatisfaction with the client company. Based on the findings of this six sigma analysis on customer satisfaction, the client company appears to be in accordance with an improved level of average sigma ratings. Although the client company continues to improve its customer satisfaction ratings, six sigma levels may be difficult to achieve as customers' expectations continually change (usually increasing).

The effect of customer expectations

While it is important to decrease the number of dissatisfied customers, decisions on how to do this should not be made arbitrarily. The customers should be the driving force behind such decisions and improvement strategies.

In the 1991 customer satisfaction study, customer expectations ranged from 6.42 to 9.69 on a ten-point scale. Obviously, those attributes with the highest expectation ratings are the ones that the client company should focus on for improvement.

Of the 11 attributes in which the client company decreased the number of dissatisfied customers in 1992, only five of them were among the ten attributes with the highest expectation ratings in 1991. (One of the 11 attributes did not have an expectation rating.) On four of the ten attributes with the highest expectation ratings, the client company maintained the same sigma level in 1992 while it decreased (more dissatisfied customers) on one. The 1991 and 1992 expectation ratings and their associated sigma levels for these 11 attributes are shown in Table IV.

Attributes	1991 mean score	1991 sigma level	1992 mean score	1992 sigma level
Ethical in business relations	9.68	3.25	9.69	3.75
Product performance	9.67	[a]	9.68	3.50
Knowledgeable representatives	9.49	3.25	9.56	3.50
Technically superior	9.25	3.00	9.31	3.25
Quality products	8.87	[a]	9.08	3.50
Quality service	8.53	3.00	8.77	3.25
Quality commitment	8.26	3.00	8.43	3.50
Competitive prices	8.60	3.25	8.58	3.75
Timely response	8.94	3.00	8.57	3.25
Flexible negotiations	6.42	[a]	6.32	3.25
Quality training	NA	3.50	NA	3.75

Notes:

NA = No expectation rating was measured for this attribute

[a] Sigma value less than 3.00

Table IV.
High-tech manufacturing firm customer expectations ratings and sigma levels

Ratings of overall customer satisfaction with the client company increased in 1992. By using customer expectations as a guide for targeting improvement areas, the client company could possibly satisfy its customers even more.

Focused improvements

Organizations are driven to achieving six sigma levels of performance to address customer expectations. Figures 4 and 5 are graphical representations of the performance (sigma) levels achieved by the client company corresponding to the different customer expectation levels for each attribute. (These data are given in Table IV for 1991 and 1992.)

Focused improvement requires an emphasis on attributes with high customer expectations. There is, therefore, a perceived need to attain higher sigma levels for these attributes. In 1991, many high expectation attributes had a low (three) sigma level of performance, while a definite overall improvement can be seen in

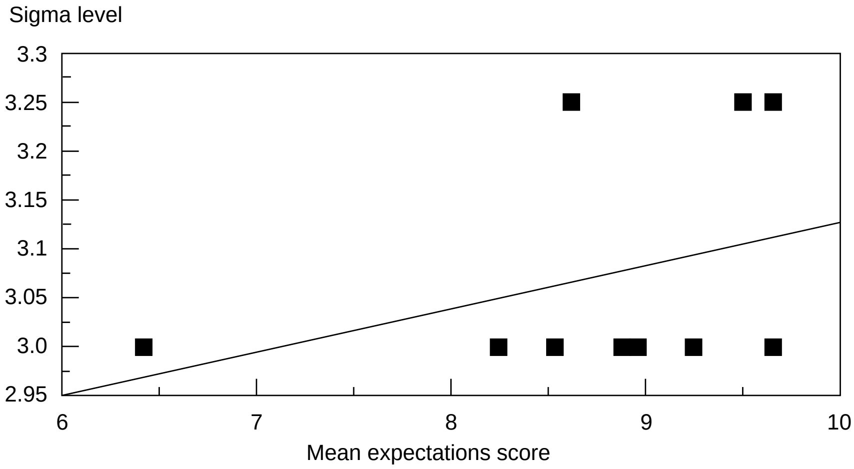

Figure 4. High-tech manufacturing firm 1991 expectations versus performance

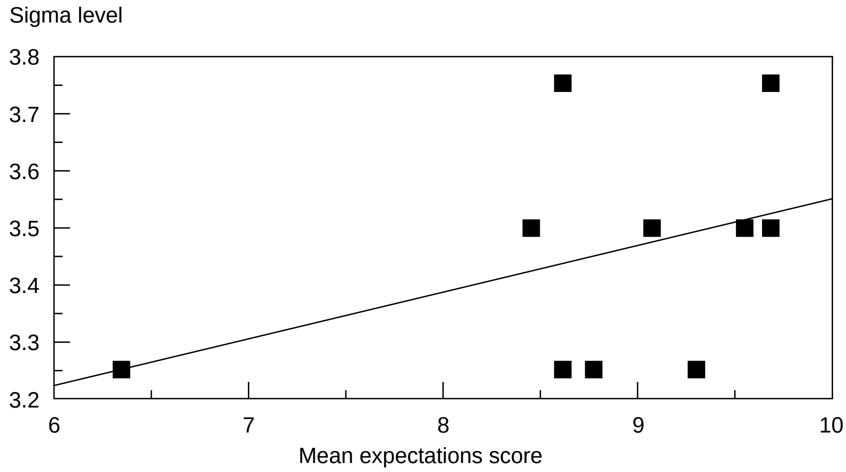

Figure 5. High-tech manufacturing firm 1992 expectations versus performance

1992 (see Figures 4 and 5). Such a graphical presentation can draw immediate attention to those attributes that have high customer expectations, but have lower performance levels. This facilitates focusing improvement efforts on customer-defined priorities.

Customer satisfaction is dependent on error-free performance. But, not all error-free performance translates to proportional gains in customer satisfaction. Conversely, in some cases, customer satisfaction can be gained even if high sigma levels of performance are not achieved. The performance (sigma) levels and corresponding customer satisfaction levels for the selected attributes at the client company for 1991 and 1992 are given in Table III. Their relationships are graphically represented in Figures 6 and 7.

Higher sigma levels are generally perceived by customers as improved performance by assigning a correspondingly higher satisfaction score.

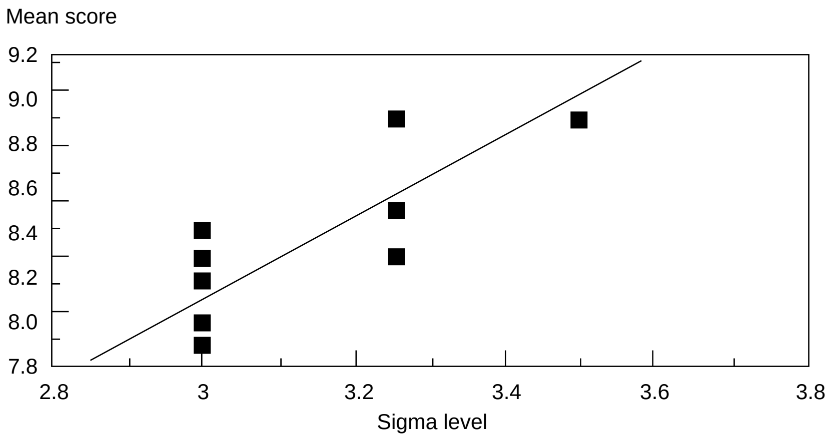

Figure 6.
High-tech manufacturing firm 1991 performance versus satisfaction

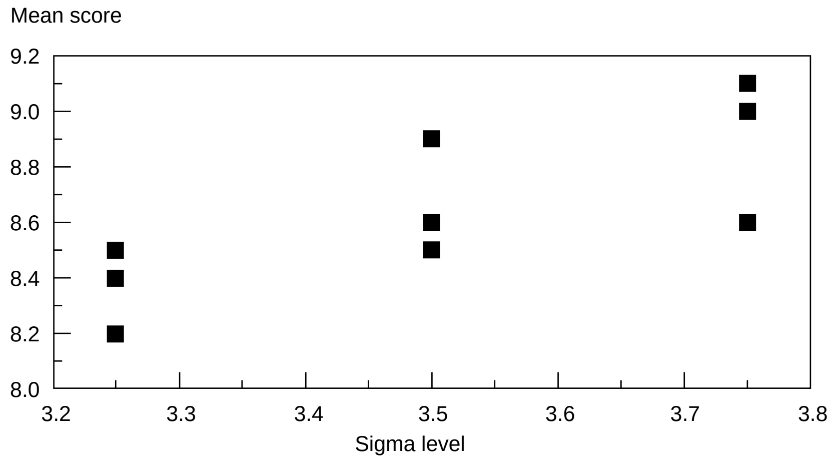

Figure 7.
High-tech manufacturing firm 1992 performance versus satisfaction

However, some issues that arise need further analysis. Higher sigma levels for certain attributes do not translate to correspondingly higher customer satisfaction scores; while some attributes with a higher satisfaction score do not necessarily have to be at a very high sigma level. The significance of the attributes themselves may need to be examined further in these cases.

The relationship between customer expectations, performance (sigma) levels, and the customer satisfaction scores for the different attributes needs to be analysed as outlined above. Such an analysis could be used in the development of a strategy for focused improvements.

Zero customer defections

While the client company makes products at near zero-defects level, its customers' satisfaction is also a function of support services such as product/engineering support. In addition, factors such as technical competence and industry knowledge are also relevant. Current sigma levels in these areas are well below six sigma levels. Yet, customer satisfaction is consistently high on these factors (see Table III). Hence, while zero defects have still not been achieved, high customer satisfaction leads to lower customer defections. Also, customer satisfaction is itself a moving target with constant changes in customer expectations.

A more significant goal on which a company could focus is to achieve six sigma levels in customer defections, that is to try to attain zero customer defections. The value of a loyal customer and the cost of a lost customer are two compelling reasons to pursue the goal of zero customer defections[5] This is especially important in the slow growth marketplace of the 1990s where companies survive (and grow) by keeping the customers they already have. Studies show that customer retention results in above-average profits and superior growth in market share[6]. For example, a typical shopper at a Home Depot store spends only $38 per visit, but since they shop 30 times annually, this totals to $23,000 in the customer's lifetime. This view of a customer helps to emphasize retention. This, in turn, has helped Home Depot's net income to rise 45.6 per cent in 1992 despite the economy, and the company averaged a 42.5 per cent annual growth in earnings per share for the past ten years[6]. While the client is not in the retail business, the significance of customer retention should not be lost, especially in an economy where budget cuts have become the norm.

Beyond six sigma

Six sigma is certainly not the finish line in the quest for zero defects. Like the client company, Motorola is now expanding the use of six sigma to non-technical areas of the company. Continuous improvement of the six sigma approach at Motorola has led to "six sigma centred", or a goal of two defects per billion. While this focus on technical quality continues, attention at Motorola is also being focused on other areas of organizational activity. Three specific areas of emphasis include administrative processes, customer-defined and -measured quality, and cycle time improvement for new product development and introduction. For instance, procedures for closing accounts at the end of each financial period have been shortened from two weeks to three days, with an ultimate goal of one day. Such company-wide efforts to improve quality will continue to have a strong positive impact on customer satisfaction[7].

Conclusion

The client company, like many businesses, does not have millions of customers. However, the concept of zero defects can be applied to any company regardless of the number of customers by using the percentage that falls outside the limits. For a company with only 1,000 customers and ten employees (or stages) who have an impact on customer satisfaction, the difference between ± three sigma (499 dissatisfied) and ± four sigma (60 dissatisfied) is 439 dissatisfied customers or nearly 44 per cent of the company's customer base. The chance of operating a business with no dissatisfied customers reduces dramatically as the number of employees who come into contact with customers increases or the number of aspects impacting satisfaction increases. It also reduces when the customer is made to go through a process with many stages. Therefore, there is a need for simplified processes with fewer stages. Process simplification is essential to reduce the number of defects and thereby increase customer satisfaction.

The use of six sigma analysis allows for the comparison of products and services of varying complexity on a common basis. Six sigma is a common metric that can be used across an organization, whether in production or customer satisfaction. It also provides for a common basis for benchmarking against competitors or best-in-class organizations or tracking improvements from year to year. Since a higher sigma indicates lower errors or fewer dissatisfied customers, it is a measure of how well an operation is performing.

The emphasis of the six sigma analysis of customer satisfaction discussed in this article was on the external customers of an organization. This approach can be applied equally effectively when analysing an organization's internal customer satisfaction. This will provide a method to measure improvements in internal processes which ultimately reflect in improved external customer satisfaction.

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