V. Vineet Kumar [1]

THREE DIMENSIONAL GRAPHICAL REPRESENTATION OF QUALITY

Abstract: Quality is an important aspect for every firm in modern era of competition. Every product has tough competition in terms of market reach. The factor, which actually makes any product long run in market, is quality and hence quality is the stepping-stone for success of any firm. For everyone meaning of quality is different. We have seen several economists who have defined quality by considering different factors, but what all of them have common in them is Customer satisfaction. Customer satisfaction is the ultimate result of quality. In three-dimensional graphical representation of quality, optimum quality is obtained by using three-dimensional graph by considering some important factors governing quality of any product, limiting factor, and customer satisfaction.

Keywords: Quality Management, Definition of Quality, Factors Affecting Quality, Three Dimensional Approach on Quality

1. Introduction

It has been several years industrialization has taken place and as an impact of it, world is now surrounded by several industries and their products. Some of them became giants and some are still creeping to stabilize its foundation. Take any product, we can get thousands of replicas of it in market, but the thing that actually matters is, what we choose being a customer? That has actually created tough competition among the industrial counterparts, to impress the customers. Customer always goes for quality, thus creating quality as a foundational factor for producers to focus upon. Every industry has been working very keenly on quality of their products, from the time they have established, just to make their

customers happy, as it is the only basis for survival in the market. With modernization and latest developments in the field of Science and Technology, industrial strategy has changed dramatically, as consumers have attained different standards in choosing their products. As competition is more, customers have wider options available in picking up the "Best One", and for every customer the scope of that "Best One" varies accordingly. Therefore, quality has varying norms with respect to different customers.

We have seen several great economists like Deming and Juran, they have defined quality as customer satisfaction. Higher quality adds some additional initial burden on consumer, So major target of any manufacturing unit is to obtain optimum quality. Three Dimensional Graphical Representation of Quality, is a three dimensional analysis of factors like Product Value, Scope of Product, Resale value, Performance and service of the

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[1] Corresponding author: V. Vineet Kumar
email: ivineet43@gmail.com

product to obtain optimum quality. Three dimensional graphical representation of quality is a plot which shows, how actually, the optimum quality has been imparted to the product and what optimum cost has been imparted to it.

2. History and Literature of Quality

Human started manufacturing, from the time immemorial and inspection of product has been core part of manufacturing process. Nearly all civilization focused on improving the standard of their life by producing quality products, which satisfied their needs. The ancient Egyptian displayed excellent commitment in painting quality to their architecture (Rocheleau, 2013). The Greeks have also adopted quality techniques in their architecture, long back in fifth century BC. In addition, they influence roman architecture to focus on improving quality in architecture. Thereafter every civilization improved their manufacturing and architecture with essence of inducing quality (Mitra, 2000). After several years when industrial revolution has begun during 19th century, there has been sharp increase in manufacturing processes and available competition and with that quality reform has widespread. Several institutes have been framed which focused on increasing standard of their product. During world war-II, due to increasing popularity of technology, Japanese industries started growing but since they focused on quantity, their product were not able gain praise in world market (American Society of Quality, 2013a). In addition, they have understood that they have to raise standard of their product and since then they have worked hard on improving quality of their product and then Deming and Juran, who helped Japanese to attain the position in world market in terms of quality, have joined Japanese (American Society of Quality, 2013b). In the mean time world has seen several people who tried to define quality and all of them were good. Everyone have different prospective towards quality. Juran defines quality as those features of products that meet customer's need and thereby provide customer satisfaction (Juran and Godfrey, 1999). Taguchi says quality of a manufactured product is the loss generated by that product to the society from the time it has come to the market. Quality is a loss function and is the measure of how far it performs from its actual target (Berger, 1985).

$$L_{(y)} = k(y - \tau)^2 \qquad (1)$$

Where L (y) is loss function, y is performance characteristic, and τ is performance level. Quality Guru Deming has defined quality wonderfully, according to him Quality can defined only in the perspective of person who is actually defining it. For a worker quality will be a different thing, while for a manager it will be different (The prevailing definition is that, "Quality is the ratio of performance to the expectation" (Kulkarni and Bewoor, 2009).

$$Q_{(s)} = \frac{performance}{expectations} \qquad (2)$$

Quality is just a simple expression, which indicates whether the product satisfies its intended utility, or not. According to American Society of Quality- It is a mixture of standards and quantitative perspectives for which every person has their own definition (Donovan, 2006).

As per Garvin, there are eight types of quality.

1) Performance (primary functional features) – which represents the basic intended function of the product. Considering the example of an Industrial Lubricant, the basic function is reducing friction i.e. providing lubrication.

2) Special quality features (secondary functional features) – It represents the extra added functionality or utility of the product apart from its basic intended function. For example, Industrial

lubricant can have additional feature of providing cooling effect apart from having lubricating property.

3) Reliability – probability that the product will function in desired and satisfactory way throughout a certain specified period under all defined operating conditions, which the product may have to face.

4) Quality conformance (accordance, i.e. conformity with standards and specifications) – It shows to what extent the product meets the established standards and specifications.

5) Durability - It is the measure of useful lifetime of the product it considers both economic and technical aspect.

6) After-sales service (maintenance service) – It consists of promptness, kindness, readiness to help, capability and ease during the repair work when the product is facing some breakdown.

7) Aesthetic quality – Besides recognized quality, this is the most subjective one because the product features constituting this dimension of quality are a matter of personal evaluation and validation by an individual (appearance, sensation, touch, sound, taste, smell, etc.). For an example a mobile phone, having shiny attractive color with outstanding design will be more preferred then an odd colored simple phone.

8) Recognized quality – quality based on the reputation. It is the pride of owner ship. Which can be easily understood measuring the difference in sense of pride while having an Apple I-Phone in comparison with having a simple phone of some local manufacturer. (Buntak *et al.*, 2012)

3. Quality and customer satisfaction

Earlier approach only focused on customer satisfaction as the only factor that defines quality of any product, but in actual case, Customer Satisfaction is the ultimate result of good quality, and there are other factors, which governs or defines quality of any product. It is very important to understand.

Brooks International clearly describes customer satisfaction and its importance as in following paragraph "Customer satisfaction is a clear evidence of how products and services supplied by any organization meet or exceed customer expectation. It's driving force is quality of the product or services, the meeting of delivery expectations, and user- friendly business policies and practices. Within organizations, customer satisfaction ratings can have powerful effects." (Brooks International, 2012)

Customer satisfaction is the most important factor that effects the growth of any company, if their customers are satisfied, they will spread positive reviews in the market, which will help to make more customers and boost up the sale. Customer satisfaction in general is the ratio of what producers gives to what actually customer expected (Kulkarni and Bewoor, 2009), and given by following equation.

$$customer\ satisfaction = \frac{obtained}{expe\ ctations} \quad (3)$$

If customer is getting more then what they have expected customer satisfaction will be greater than 1 (>1). If reverse happens then value will also reverse to less than 1(<1). If they are getting exactly what they have expected then the value will be one (1).

4. Cost of quality

To understand the role of Three Dimensional Quality Analysis in business excellence, we should first understand the importance of cost associated with Quality.

"Cost of Quality" is most common terminology in field of quality engineering but is the most vulnerable to be misunderstood. Cost of quality is not the price associated with imparting the quality but is the cost incurred due to lack of quality.

Cost of quality increases with services done to counterpart the effects of poor quality (Campanella, 2014).

As per American Society of Quality, the real time example of the incurred cost due to poor quality is as follows:

- Cost associated with reworking of a manufactured item.
- Cost associated with retesting of an assembly.
- Cost associated with rebuilding of a tool.
- Cost associated with correction of a bank statement.

Cost associated with the reworking of a service, such as the reprocessing of a loan operation or the replacement of a food order in a restaurant (Campanella, 1999).

As per American Society of Quality the Types of costs added in cost of quality

- Prevention Cost: It is the cost incurred for taking all such measures and preventive steps in order to avoid any fault figure from the product.
- Appraisal Cost: It is the cost incurred for quality audits, measurement, etc for conformance of the product to the set quality norms.
- Failure Cost: It is the cost associated with the fact when the product is not conforming to what customer is expecting out of it (Campanella, 1999).

It is very important to understand, what are the impacts of having and not having good quality on business?

Tutor2u gives very justifiable answer to a most common question "Why is quality so important in business?"

Quality is important because it helps the company to grow in following ways

1) Customer loyalty – they return, make repeat purchases and recommend the product or service to others.

2) Strong brand reputation for quality

3) Retailers want to stock the product

4) Fewer returns and replacements lead to lesser costs

Attracting and retaining good customers (Riley, 2009).

4.1. Impact of good quality

As per (zarate-consult.de, 2004):

1) Quality improvement reduces the overall costs. As the quality increases defect rate decreases and approaches zero, thus causing reduced scraps and wastages thus saving bugs in terms of raw materials, man power and processing time.

2) Lower investment costs allow lower sales prices. Quality improvement results in monetary benefits because of less investment cost. Part of this monetary benefit is utilized as gross profit rest is utilized to slash down the prices of the product.

3) Lower sales prices boost up and multiply the market share. Because of improved quality and lower selling prices market demand of the product increases. Thus the chance of product improvement and value addition increases to suit the need of the customer. This increases customer loyalty and enhances their competitive advantage, which translates into increased market share.

4) Increased market share causes increased scale benefits. The increase in market share brings several benefits for the firm. The increase in market share implies that firm has to increase the level of utilization of their production capacities to meet the hike in demand i.e. they can fully utilize their production capacities and thus spread fixed costs over a larger base, which causes the average cost of production to decrease. Increasing the value of production implies that people gain better experience of the production process. Subsequently, employees learn

how to produce the product more efficiently and effectively as per "learning curve effect". Thus, they save time and resources, which results in further cost reduction. Given that, learning is a function of experience. The larger the production quantity, the sooner the learning process takes place. In other terms, the faster the increase in production quantity, the faster the cost reduction that to without compromising with the quality. This causes customer satisfaction and customer retention. Manufacturer slashes down their prices due to enhanced market share and internal monetary benefit due to quality enhancement. Subsequently, organizations may offer lower prices, which, in combination with improved quality, within the virtuous cycle increase customer satisfaction and enhance the competitive advantage of the firm in the marketplace. (zarate-consult.de, 2004)

4.2. Impact of poor quality

Impacts of poor quality are

1) Increased internal losses, because of scraps reworks and wastages. This causes the internal price hike in production which is then transferred to customers only

2) Increased internal losses causes increased prices, thus losing an important factor for competitive status in the market place because when several similar items are present in market most of the customer will go towards the cheaper one.

3) Poor quality leads to frequent breakdowns and failures. Because of poor quality, reliability and efficiency of the product is reduced and may not perform as desired in most expected conditions.

4) Frequent Breakdowns, failures and increased price causes the customer unsatisfied. As they have already

invested a huge some in procuring the product, and if it is not working as desired it is mere wastage of their investment, which ultimately makes them unsatisfied.

5) Unsatisfied customer searches for alternatives, which causes loss of valuable customer. As there are several counterparts for any product, if one fails to perform to the expectation of customer, they will simply look for its alternative. Their reviews regarding the product can break the customer chain and prospect customer.

6) Loss of valuable customer causes loss of market share and ultimately causes business downfall. Customer is the king of market and if king is not satisfied, there is no reason of sustenance in market.

5. Three dimensional graphical representation of quality

Quality of product is customer-driving tool; hence, every firm tries to increase quality at every stage. Quality adds some initial burden on customer. So there is need to have products with optimum quality so that customer can get what they actually want within their economic range. For this purpose, Three Dimensional Graphical Representation of Quality will be very helpful. Three-Dimensional Graphical Approach is a graphical representation of quality in terms of factors affecting it, to find optimum cost assigned to each governing factor maintaining the optimum quality, to have increased level of customer satisfaction without throwing additional burden on them. In Three Dimensional Graphical approach, we will consider factors like product value, performance, service provided, scope of the product and its resale value. Considering these factors in terms with customer satisfaction, we will plot a three-dimensional graph, by taking Optimum cost to customer without affecting producer's required profit.

5.1. Factors affecting quality

5.1.1. Impact of good quality

It is the most important factor affecting the quality. Product value in the techno-economic sense and its functional relationship are given by A.Đurašević as the combined function of *functionality, technology, exploitability, market conditions.* (Buntak *et al.*, 2012)

Product Value in general, is the ratio of utility of the product to the cost and is an important factor that can help the product to have an edge over its competitor by attracting the customers, as the value creates a magnetic effect, which attracts them. It can simply defined as, number of features per unit cost of the product and is given by following equation.

$$product\ value = \frac{product\ 's\ functions}{cost\ of\ the\ product} \quad (4)$$

For three-dimensional representation, product value will be considered as the cost of imparting the desired and expected features to the product. Every man wants to have high value product and hence it is an important factor, which compels all manufacturer to produce and provide high value products for their customer. There are two ways to improve product value, either to increase feature of the product at same cost, or to make the product cheaper with same number of features. Distributing the overall cost of product, to its available features is an important factor to justify our investment over the product.

5.1.2. Peroformance

As per Business Dictionary performance is defined as "The accomplishment of a given task measured against preset known standards of accuracy, completeness, cost, and speed. In a contract, performance is deemed to be the fulfillment of an obligation, in a manner that releases the performer from all liabilities under the contract."

No matter how good other factors are if the product is not able to perform its intended function. Hence, performance of product is most important factor governing quality of the product. Every product is supposed to perform its intended function at right time with less or no breakdown period. For an example, basic function of pen is to write, if it is not able to perform that it is of no use. In three-dimensional graphical approach, Performance also includes Maintainability. Maintainability refers to how easily a product can restored to working condition after any breakdown. Product is of optimum quality if it can be repaired, maintained, restored with less effort at lesser time.

5.1.3. Service provided

It is the most important factor that counts on quality of the product. Customer service adds to the popularity of the product. When we are investing our money on some product, we expect good service from producer or manufacturer. It's sure before purchasing any product, services provided will be of excellent quality but what actually matters is do they provide same level of service afterward? There are two types of services, services for new customers and services for existing customer. Services for new customers include product display, financing, transportation, installation and training. While, services for existing customer include maintenance, repairing, product upgradation and resale support. Customers will be satisfied only if both services are of excellent level.

5.1.4. Scope of Product

It is most important to know that how long the popularity of the product will persist in the market. Everyone wants to have pride of ownership. When we are investing our money, we take every care to invest in some popular brand. Nowadays, what we own is far more important than why we own. When somebody invests, they want it be as an add-on to their social status, for example having any product of Apple and having same

product of some company XYZ, have lots difference but most important being former adds to social status more in comparison to later. This is because of the popularity of the product.

If any product is popular at present time, it does not ensure the same for future, as every day new technologies are coming and it is important for the product to run with technology rather to lag behind. Hence, Technology upgradation of product is very important for both new customers and existing customers. Product upgradation must be provided to existing customer at most affordable rate, which will increase the scope of the product.

5.1.5. Resale Value

With time and usage every product loses, its value, efficiency, performance. Hence

reselling that will not return the same monetary value that we have once invested to purchase it. In three-dimensional graphical approach, resale value is an important factor that defines quality of the product. It shows the competitive status of any product even though, they have been used for some period. Resale value is governed by the standards used in manufacturing stage, reliability of product, popularity in market and availability of spare parts and service. This parameter is not applicable to all consumer goods for an example Food Product have no resale value as they are made in form ready to consumption goods, while products like two wheelers have got resale value with them.
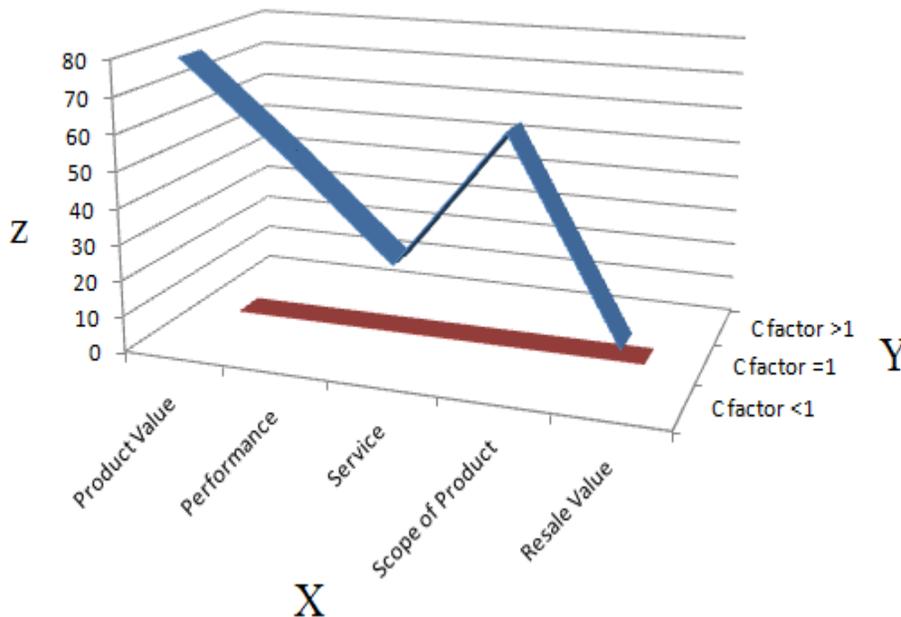
Figure 1. Three Dimensional Graphical Representation of Quality

5.1.6. Limiting Factor

Limiting factor are those, which limits other factors, here in Three Dimensional Graphical Representation, limiting factor is optimum

cost to consumer without altering producer's required profit. As we have discussed earlier, adding on quality will definitely adds on to cost, which has to be ultimately carried by

customer. We know cost is the most important limiting factor affecting purchase power of consumer. Hence, this additional cost will have some negative impact on producer's side.

5.2. Three dimensional graphical representation

As we have understood all factors to be considered, it is very important to understand the procedure for representing the factors on graph. Draw three-dimensional graph having X, Y and Z-axes. Where X-axis represents the Quality governing factors viz Product value, Service, Scope of the Product, Resale Value. Y-axis represents Customer Satisfaction factor (C-factor that stand with equation 3). Z-axis represents assigned cost. While assigning cost it must be paid attention that customer satisfaction factor lies on or above 1.

5.2.1. Interpretation of chart

Interpretation of the chart is very important. As shown in figure 1, all the governing factors has been plotted in x- axis , Y- axis shows three conditions shown by equation- , Z- axis Limited by Optimum cost without altering required producer's profit. Now increase the values of governing factors, one by one in such a way that it does not exceed the limiting factor and observe the affect on customer satisfaction. Repeat the process as many time, till we get optimum value of all governing factors which scales customer satisfaction equal to or greater than one (>=1). In this way, optimum quality of product can be obtained, without throwing additional burden on customer.

6. Real time application of three dimensional graphical representation of quality with example

Three Dimensional Graphical Approach can be used to assign cost to each feature (which includes number of utilities, transportation

cost and aesthetics increment cost) of the product as per markets demand without affecting the expected level of quality so as not to affect the competitive status of the product. Cost to utility must be assigned in such a way to get maximum share for principle function. For an example, an Industrial grade lubricant used in gearbox of machine tool has its principle function to reduce friction force between mating gears as to reduce wear rate but can have secondary functions of providing cooling effect between mating parts as well as acting as corrosion inhibitor when machine is not in use. So of the total cost major portion that will surely be above average value (Say 70%) should be assigned to lubricating property then to cooling effect (Say 20 %) and minimal (say 10%) for rust prevention effect. If product is going to perform only its principle function then obviously 100%, cost will be assigned for it, then in such case for keeping customer satisfaction factor above one either to keep same quality at lower cost or to keep higher quality at same cost. However, if additional utilities are provided then customer satisfaction factor will be above one even for higher marginal cost. To maintain competency of the product it is required that it must also perform certain secondary expected functions as discussed above. For Transportation, cost can be reduced by choosing the optimum mode of transportation. For example, if customer has an urgent demand for lubricating oil (practical example can be considered in case the consumer is adopting "Just in Time" policy for inventory management) in that case mode of transportation can be chosen as "By Air" if the increased cost can be handled to avoid excessive loss due to delay. Considering aesthetic affect, there is no importance on color of the oil but there is sure need that oil must not have unpleasant smell to cause irritation for workers working on nearby area.

To understand the method more clearly, Let us elaborate this with an example of a budding firm Hi-Tech International under

brand name "Rust-x". To analyze this we must be familiar with background and product framework of the firm. {Note- data to be used for representation is only dummy data, not actual}.

Hi-Tech International is a 30-year-old firm, having technical assistance from C. KNOOP Australia. They own four units and have marketing network all across the globe. They have well established their economic foundation in marketplace with the brand called "Rust-X", having more than 500 specialized product including Rust prevention solutions, self patented (Volatile Corrosion Inhibitor) Packaging system, all grade industrial lubricants and coolants, cutting oils, Desiccants, and EVA (Ethyl Vinyl Acetate) bags. They are market leaders in field of VCI Packaging Technology. They are having all giant OEM's (Original Equipment Manufacturer) like Maruti-Suzuki, Eicher and Auto- Component Manufacturer like Posco, NBC in their clientele.

As per Three Dimensional Graphical Approach, we will focus on following key points Product Value, Performance, Service, Scope, resale value, and limiting factor. Considering a machine industry where industrial lubricant is used in gearbox of machine. And our dummy product is Product –X, which is an Industrial Grade Lubricating Oil.

Product Value: As already discussed, product value is the ratio of utility to the cost and its inverse gives cost per utility, taking a specific product say Industrial Lubricant product value will increase if it gives additional utility under same cost. The basic purpose of lubricant is to reduce friction between two mating parts of machine. But it is the sure fact that customer is expecting certain other features like cooling property, rust preventive property while investing some amount on lubricant. Practically, customer will be ready to bear slight higher marginal cost for better product value.

At no pint of time, we can consider for customer satisfaction factor less than one, so the only options to have competency is to provide the product having just lubricating property at a rate lower than its prevailing counterpart which will keep customer satisfaction factor exactly equal to one . Alternatively, to impart other desired properties at same cost or slightly higher marginal cost, this will keep the customer, satisfaction factor above one. For three-dimensional representation, we will consider the optimum one, which is imparting additional desired features to it. As per present market condition, cost of imparting these additional features to the product is Rs 80 per liter. So in graph mark a point equal to 80 at Z –axis and customer satisfaction factor above one at Y-axis against product value in X-axis.

Performance: It is very important that the product must perform its intended function when required. When machine is running due to friction between gears localized heat is generated, and lubricating oil loses its viscosity with increase in temperature thus leaving no use of it. Hence, it is very much required from a lubricating oil to withstand its properties even at elevated temperature. Customer satisfaction factor will be less than one, if oil fails to perform at normal working temperature. It will be equal to one, if it works properly at normal working condition. It will above one only, if it maintains its property even at unpredictably elevated temperature. Our product maintains perform well even at such unpredictable conditions. Cost for imparting it with such property is Rs 30 per liter. So in graph mark a point equal to 30 at Z –axis and customer satisfaction factor above one at Y-axis against performance in X-axis.

Service: One can make new business with new attracting offers but retaining that customer is the actual task. This is possible only if service provided which includes customer service, maintenance, transportation, billing, ease of payment mode, installations etc to them is of optimum

level. If one want to be competent there should be no compromise with service to customer as we know customer is king in business place. The selected lubricant oil is accompanied with very flexible payment options, good maintenance service which will keep customer satisfaction factor above one but the freight charges puts a question mark for many customers. The cost assigned for this feature is Rs 30 per liter and customer satisfaction factor is one. So in graph mark a point equal to 30 at Z –axis and customer satisfaction factor above one at Y-axis against performance in X-axis.

Scope of the Product: It is very important as every firm invest lots of labor, capital and time in product development so it obvious fact that they want to rule the market for long time without much modification. In this case, oil must have an expected level of tank life. In general, lubricating oil has an average tank life of 6 months. If tank life is below it, Customer satisfaction factor will be less than one. If it is equal to average tank life, customer satisfaction factor will be one. If it is above average tank life customer satisfaction factor will be above one. In this case, our selected product is an ever demanding; every time machine is run, there will be requirement of lubrication, cooling and rust prevention. In addition, product has large tank life (Life span from filling to flushing out) of about 8 months, which is more than that of normal counterparts. Cost of imparting the desired tank life in chosen product is Rs 30 per liter. So in graph mark a point equal to 20 at Z –axis and customer satisfaction factor above one at Y-axis against scope in X-axis.

Resale Value: It amounts to value of the product when it has been used for some time. For this case , resale value can be considered as replenishment/recycling option, as it is obvious that due to volatility of oil some portion gets evaporated, some gets off with metal part, so hundred percent recycling of this product is not possible. Volatility must be reduced to decrease the frequency of top-ups. For decelerating the volatility in chosen product, cost assigned is Rs 15 per liter and has top-up period of 1 month. In general top up period is 1 month for counterpart product thus Customer satisfaction factor is exactly one. To increase the customer satisfaction factor above one the Top-up period should be above 1 month and to impart such property cost assigned will be Rs 50 per liter but this cost cannot be justified. So in graph mark a point equal to 15 at Z –axis and customer satisfaction factor equal to one at Y-axis against Resale value in X-axis.

Limiting Factor: The obvious limiting factor for most of the product is its cost, there is already tough competition in market place, some big firms like Castrol, Bharat Petroleum is causing some hindrance to goal of becoming Giant Game Player. So beside value addition there is obvious need to cost reduction, which seems very critical at this point as if value addition is done, it accounts for cost addition also. The average cost of the counterpart product in market is Rs 200 per liter (Excluding Profit). After selecting the optimum values for each feature it must be paid attention whether the overall cost surpasses the limiting value. If it is within the range then the task is justified else, there will be requirement to reassign costs. Adding all the cost we assigned, we have a market value of Rs 175 per liter (Excluding Profit) which is less than average value of Rs 200.

Three Dimensional Representation of Quality: Plotting the graph as mentioned in 5.2 we get a three dimensional graph of quality for the dummy product –X.
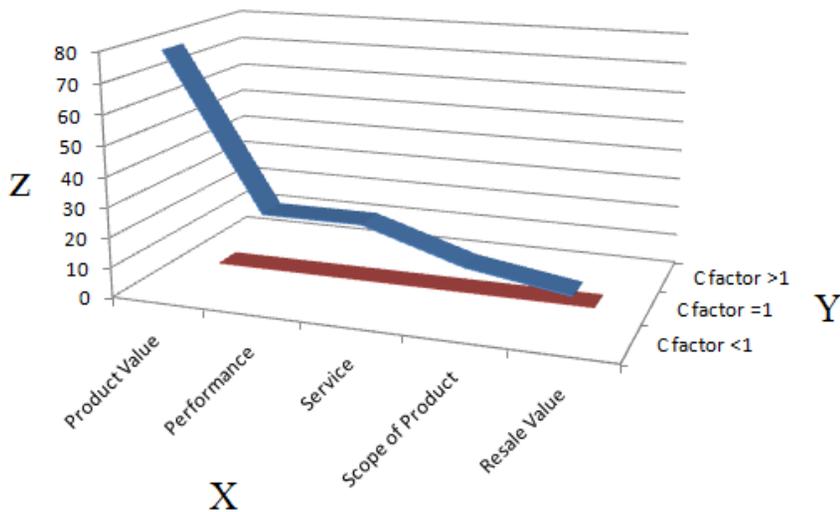
Figure 2. Three Dimensional Graphical Representation of Quality

7. Conclusion

Three Dimensional Graphical Representation of Quality helps to assign the optimum Cost to each quality-governing factor by maintaining the optimum quality, by giving an easiest way to find the cost-driving factor and ways to control factors affecting quality. Such that high quality products can be made available to customers without increasing the cost of the product and will ultimately result in increased customer satisfaction and increased sale. Overall with, Three dimensional approach, quality of the product can be represented in terms of factors governing it and hence also defines quality of the product in graphical manner.

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V. Vineet Kumar
Lovely Professional
University,
India
ivineet43@gmail.com