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CONTINUED ASSESSMENT USING SHEWHART CHARTS: A PRELIMINARY INSIGHT INTO SUPERVISORY TECHNIQUE OF EVALUATING CUSTOMER SATISFACTION LEVELS

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ABSTRACT
Customer Satisfaction Levels and their measurement is significant for any Service Organization, especially keeping in mind the tangible nature of its products. Thus, the gradation, measurement and benchmarking of Customer Satisfaction is significant. In this paper the researchers have used the unearthed construct from an Exploratory Factor Analysis on data collected using SERVQUAL 22 item research instrument to create a set of Shewhart Control Curves on the Factors. The idea mooted by this research is a continued revision on the said curves, using contemporary data to create a model for continued assessment of customer levels.
KEYWORDS: *Shewhart Charts, Customer Satisfaction, Continued Assessment, LCL, UCL*

INTRODUCTION
Customer satisfaction is pivotal in driving retention and fostering long-term relationships with organizations. Research reveals that cumulative satisfaction, particularly before a customer decides to cancel, is strongly correlated with the duration of the relationship. This underscores the importance of consistently meeting or exceeding expectations throughout the customer journey. (Bolton, 1998) This research aims to decide on a preliminary framework for service organizations to continuously gauge customer satisfaction levels, identify outliers and revise constructs using Shewhart Charts.

METHODOLOGY, SCOPE & LIMITATIONS
Taking the path of generic diagnosticity, in order to introduce a framework, the research creates the initial set of Shewhart Charts using archived research, taking reference of data and an exploratory factor analysis, conducted by Datta Khan & Meel, 2021, creating a construct with the factors called "Health Precautions and Comfort", Service at Contact Point", "Travel Time Efficiency and Security", "Customer Care Efficiency", "Transparency in Dealings" and "24x7 Service", which we shall name F1, F2, F3, F4, F5, F6 respectively, representing vector $F=[Fi, I = 1, 2, \ldots, 6]^T{}_{6x1}$. The research had considered 35 varables, identified using a Focus group over the 22 multi item SERVQUAL instrument guaged using a Likert Scale over a simulated convenience sample of size 561. (Datta Khan & Meel, 2021) The original dataset, tested for reliability, depicted Chronbach Alpha Staistic of 0.962 and the simulated, pre-factor analysis data showed a Kaiser-Meyer-Olkin Measureof Sampling Adequacy of 0.9, hus lending genuinity to the unearthed construct. If we refer to the variables as vector $X = [x_i, I = 1, 2, 35]^T{}_{35x1}$ and consider the Component Score Matrix CSM_{6x35} (Table1) then we realze that F = CSM X (Hair, Black, Babin, & Anderson, 2019) The research thus, then accessed the unsimulated data of the research (Datta Khan & Meel, 2021), a convenience sample (S) of size 128 with relevant Factor Scores, making the matrix $F_{ij\ 7x128}$ and analysed them using $\bar{X}$ and CUSUM control charts (Datta, 2011) considering each 4 separate sub samples (S_k, k = 1, 2, 3,4), for the computation of the Upper Control Limit (UCL) and Lower Control Limit (LCL). (Datta, 2011) This is justified as the construct is unearthed using Varimax Rotation, emphasizing minimized correlation and the Factor Scores of all Factors reflect the satisfaction level of the consumer with respect to the respective Factor and the App Cab service in general. (Research Input) and the sub samples have been selected after reorganizing the said data, using random numbers. At this point, it may also be noted that assessment of service quality is reflected by a measure of customer satisfaction which is the very basis of the research. (Wirtz, Lovelock, & Chatterjee, 2018)

It may be noted that, initially, this research creates feasible Control Charts to measure the Customer Satisfaction Levels of App Cab services in Indian City during 2021, essentially the "pandemic period". It would thus guide in procedure the measurement of Customer Satisfaction Levels in other service industries during black swan events such as the pandemic apart from the creation of Shewhart Charts to assess customer satisfaction wholistically and longitudinally, inclusive of the pandemic period. The research methodology can thus be extrapolated to create a regular dashboard service, powered by the soft measure of service quality, the Customer Feedback. (Wirtz, Lovelock, & Chatterjee, 2018) However, the research is designed based on factors unearthed from a particular dataset, where the demographic details of the respondents are not explicitly considered, and actual implementation will need insight into data properties such as auto regression and normality considerations. The research output would be a generic proposal, which would further, be required to manage after consideration of the impact of extraneous variables. Thus, the results can guide generically; but for accuracy and reliability, the construct must be refreshed for the service industry and the environment.

REVIEW OF LITERATURE

Bolton, 1998 investigated the relationship between customer satisfaction and the duration of a customer's relationship with a continuous service provider. He developed a dynamic model to understand how cumulative satisfaction and service experiences impact underscores customer retention, with a focus on industries like utilities, financial services, and telecommunications. Bolton's (1998) dynamic model focuses on cumulative satisfaction as a key driver of customer retention. This model suggests that customer satisfaction builds over time through repeated interactions with a service provider. Positive experiences enhance satisfaction, while negative experiences can lead to dissatisfaction and shorten the duration of the customer relationship. The model highlights how the cumulative effect of service experiences impacts customer loyalty and emphasizes the importance of consistently meeting or exceeding customer expectations to foster long-term relationships. A particular note in this research is that negative experiences, especially during the nascent stages of the relationship, can significantly shorten its duration. For newer customers, such incidents are particularly damaging, as their trust and loyalty have not yet solidified. From a financial perspective, retention is directly linked to lifetime customer value. Enhancing customer satisfaction fosters loyalty and drives revenue growth, as satisfied customers tend to remain with the organization longer and contribute more over time. This research underscores this need to satisfy the customer in a continued manner and proactively address any service failures. By doing so, businesses can strengthen retention, maximize profitability, and cultivate lasting customer loyalty. (Bolton, 1998)

Resić & Somun-Kapetanović, 2009 professed the idea that understanding the quality of care for quality and complete system of quality applied in an organization had a direct impact on its market position. A product which was compliant with the needs, desires, expectations, demands and opportunities of consumers, provided a high level of satisfaction and a positive effect on consumer loyalty. This in turn, directly affected the competitive advantage of the organization as the costs of desired quality was less than the total costs arising due to costs of repairs and finishing, replacement and restorations as well as withdrawal and rejection of products. They attempted to use an actual example of companies from B&H to present suitable control map models for monitoring the quality of the production process. They utilized process data or measurement data of relevant quality characteristics during the production process of a manufacturing concern, based on which they observed that there was a need to improve the process supervision and reduce the risk of anti-coincidence with the specifications. On the basis of these, data proposals were suggested for improvements in the segment using the control chart. (Resić & Somun-Kapetanović, 2009)

Suchánek & Králová, 2019 investigated the interrelationships between customer satisfaction, loyalty, product knowledge, and business competitiveness within the food industry. It specifically focuses on customers with repeat purchase behaviour, exploring how these variables interact over time and influence one another. Customer satisfaction in this study is measured dynamically, combining transactional satisfaction (specific purchases) and cumulative satisfaction (overall experience from repeated purchases). It evolves, influenced by prior experiences, product quality, and loyalty. The dynamic approach, using Structural Equation Modelling, captures how satisfaction shapes and is shaped by expectations, loyalty, and product knowledge. The study reveals that customer satisfaction and product knowledge are critical drivers of competitiveness in the food industry. Satisfied customers exhibit greater loyalty, which in turn enhances their product knowledge. This reciprocal relationship highlights the importance of maintaining consistent product quality to meet expectations during repeat purchases. Moreover, while price sensitivity exists, a well-balanced price-quality ratio minimizes its impact on satisfaction and loyalty. The findings emphasize the need for businesses to engage customers directly—through strategies like product tastings—to improve knowledge, foster loyalty, and boost competitiveness. (Suchánek & Králová, 2019)

Samimi, Aghaie, & Tarokh, 2010 found that in the the-then highly competitive current business environment, the cost to attract new customers was much higher than the cost required to maintain the existing ones. They emphasized on striking a balance between the acquisition rate and defection rate through executing offensive and defensive marketing policies. They suggested to have real time information using an efficient method to monitor customer loyalty on a continuous basis. They put forward several control charts and classified the charts in two groups based on the scale used to assess customer loyalty. In the first group, customer loyalty was considered as a binary random variable modelled by Bernoulli distribution. In the second group, an ordinal scale was considered to report loyalty level. Performance comparison of the proposed techniques using ARL criterion indicated that chi-square and likelihood-ratio control charts developed based on Pearson chi-square statistic and ordinal logistic regression model respectively, were able to rapidly detect the significant changes in loyalty behaviour. Two illustrative synthetic cases were also explained to demonstrate how to apply the procedures and how to interpret their results,. (Samimi, Aghaie, & Tarokh, 2010)

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Gregorio & Cronemyr, 2011 attempted to develop a model to help service organizations to set the specification limits according to the customer expectations. They developed their model based on the Kano model, SERVQUAL, Taguchi loss function, Importance Performance Analysis (IPA) and a new model, "the Trade-Off Importance". Their study was carried out on a survey of 18 external customers and internal stakeholders of the Service Division of Siemens Industrial Turbomachinery AB in Finspong, Sweden. Their model was robust enough to set credible specification limits. Moreover, their model was also considered to be a very powerful tool for service quality measurement and to set strategic directions. (Gregorio & Cronemyr, 2011)

Chen, Chang, Wang, & Huang, 2015 opined that service industry was the principal driving force behind global economic growth. This obviated the importance of ensuring service quality. However, the service-providing process envisaged many variables that were complex enough to be controlled easily. In the past, scholars had mostly used the proportion of customers with complaints to propose an index for service performance to ensure proper evaluation of service quality. The authors considered that timely monitoring was a significant issue. Hence, they focussed on the number of customer complaints. Their study proposed a theory-based service quality control chart to assist company management in their job of timely monitoring of customer satisfaction to ensure that service quality is being maintained. On the basis of the characteristics of the service industries, they divided them into those with large sample sizes and those with small sample sizes. For each of the types, they developed an appropriate service quality monitoring model and explained the operating procedures of the control charts to provide managers with a means to comprehensively monitor service quality. (Chen, Chang, Wang, & Huang, 2015)

Kim & & Kwak, 2023 presented a novel framework for analysing customer complaints using review-based control charts and sentiment analysis. Their study addressed common challenges in customer feedback analysis such as limited review volumes and imbalanced attribute mentions, which they thought might have hindered effective decision-making. The proposed method proposed by them integrated sentiment analysis to evaluate customer reviews, categorizing sentiments associated with various hotel attributes. By employing lexicon-based sentiment analysis, the authors created a structured approach to assess the performance of hotel services based on customer feedback. The framework used in the study utilized review-based control charts to monitor complaint intervals, allowing for a clear visualization of service performance over time. The study also introduced a dynamic Importance-Performance Analysis (IPA) to prioritize attributes based on customer sentiment, enabling hotel managers to focus on areas needing improvement. The results of the study demonstrated the effectiveness of the proposed method in transforming qualitative customer feedback into actionable insights, ultimately enhancing service quality and customer satisfaction in the hospitality industry. This innovative approach provided a comprehensive tool for businesses to better understand and respond to customer complaints. (Kim & & Kwak, 2023)

Raji, Abbas, Abujiya, & Riaz, 2021 in their study proposed the detection of outliers based on the Stahel=Donoho Robust Estimator (SDRE) and Mahalanobis Distance measures when the process parameters are estimated from the initial phase. They used run length properties as performance measures. (Raji, Abbas, Abujiya, & Riaz, 2021)
Raji, Lee, Riaz, Abujiya, & Abbas, 2020 noted that Shewhart Control Charts often are affected by errors due to data in the initial phase. They proposed the Tukey based model and Median Absolute Deviation model for efficient detection of outliers in the initial phase. They used performance measures based on run length. (Raji, Lee, Riaz, Abujiya, & Abbas, 2020)

ANALYSIS

Prior to the computations of Upper Control Limits (UCLs) and the Lower Control Limits (LCLs), the researchers have used random numbers to randomize the order of existent sample 6 times (there are 6 factors) [Assign Random numbers to SNo of Factors (3) sheet-Copy values to SNo-Sort as per SNo. Do 6 times. S1 is SNo 1 – 32 and so on]
Process Average is shown as being monitored by the $\bar{x}$ chart. We assume that $F_{ij} \sim N(\mu, \frac{\sigma}{\sqrt{n}})$ where, F_{ij} = the quality characteristic measured by Fi and submitted by the jth respondent and μ, σ are the population mean and standard deviation respectively. Then again, since μ_i and σ_i are not exactly known, we assume that they are estimated by the Grand Mean $\bar{\bar{x}}_i$ of the matrix $F_{ij\ 1x128}$ and $\frac{R(i)}{d_2}$; where $R(i) = F_{ij}(max) - F_{ij}(min)$ over j = 1, 2, …, 128 or the range of the range of the complete dataset of F_i Now if the Relative Range W_k is computed as $w_k = \frac{R_k}{s_k}$ then d2 = Average (W_k)
The relevant Control Limits CL_i, UCL_i, LCL_i of F_i are given by
Control Limit = $CL_i = \bar{\bar{x}}_i$ and Upper Control Limit (UCL_i) and Lower Control Limit (LCL_i) are $CL_i \pm \frac{3}{d_2\sqrt{32}} R_i$ (Datta, 2011)
The computations are shown in Table 2 and the Control Charts superimposed by the dataset F_{ij} are depicted by Fig 1, .., 6 (X-bar and s Charts)

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Component Score Coefficient Matrix

	Component					
	F1	F2	F3	F4	F5	F6
x1	-.047	.061	.125	.038	-.060	-.113
x2	-.044	-.026	.178	-.013	-.039	.004
x3	.007	-.082	.016	.335	-.122	-.031
x4	-.029	.031	-.094	.386	-.146	-.050
x5	-.005	-.180	.019	.298	.025	.091
x6	-.027	-.130	.118	.144	.209	-.207
x7	.176	-.168	-.011	.010	.121	.030
x8	.032	-.242	.310	.014	-.028	.020
x9	-.031	-.021	.236	-.077	-.065	-.016
x10	-.014	.061	.076	.084	-.038	-.150
x11	-.004	.025	.118	-.099	-.057	.112
x12	.003	.003	-.054	.170	.057	-.004
x13	-.020	.005	-.008	-.210	.449	.032
x14	.006	.055	.127	.000	-.184	.001
x15	.066	-.030	.218	-.160	-.011	-.053
x16	-.068	.169	-.106	.060	.062	.015
x17	.002	-.105	.046	-.024	.307	.010
x18	-.057	.144	-.043	-.105	.086	.134
x19	-.049	.205	-.095	-.112	.197	-.035
x20	-.056	.227	-.039	-.062	-.016	-.009
x21	-.088	.316	-.127	.039	-.095	-.052
x22	-.044	.174	-.073	.080	-.045	-.019
x23	-.050	-.051	-.028	-.051	.013	.482
x24	-.029	-.030	-.084	-.036	-.030	.520
x25	.061	.179	-.051	-.180	.006	.025
x26	.104	-.014	-.168	.048	.224	.010
x27	.137	-.098	-.062	.043	.194	-.015
x28	.173	-.049	-.090	.081	.059	-.060
x29	.060	.075	-.020	-.015	-.032	.017
x30	.013	-.061	-.059	.123	.249	-.046
x31	.157	-.096	.142	-.041	-.186	.080
x32	.218	-.055	.116	-.114	-.110	-.093
x33	.211	-.088	.037	.064	-.154	-.079
x34	.098	.001	.111	-.012	-.136	-.033
x35	.054	.189	.005	-.128	-.099	-.038

Table 1: Component Score Matrix CSM_{6x35}

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Sample	Parameter or Statistic	F1	F2	F3	F4	F5	F6
Sample S of size 128	Grand Mean, estimator of μ, CL	0.0648	-0.0773	-0.1177	-0.1167	0.0586	0.0123
	Standard Deviation, s	0.8999	0.9860	0.9816	0.9246	0.9156	0.9560
	Xmax	2.0308	2.9497	2.2020	2.7242	3.5497	2.3269
	Xmin	-2.9260	-3.8824	-3.9144	-2.6827	-2.7401	-2.7867
	R	4.9568	6.8321	6.1164	5.4068	6.2898	5.1136
Sample S1 of size 32	Mean	-0.0740	0.2611	-0.2110	-0.1803	0.2293	0.2568
	Sample Standard Deviation, s1	0.9088	0.9300	0.8607	1.0294	0.6975	0.8091
	Xmax	1.9027	2.9497	1.5599	2.3095	1.7165	1.8171
	Xmin	-2.1857	-2.2345	-1.8752	-2.4268	-1.0326	-1.4103
	R1	4.0884	5.1842	3.4350	4.7363	2.7491	3.2274
	s	0.8999	0.9860	0.9816	0.9246	0.9156	0.9560
	W1 = R1/s1	4.5431	5.2576	3.4994	5.1227	3.0025	3.3758
Sample S2 of size 32	Mean	0.0549	-0.1477	-0.2565	-0.1228	-0.2737	0.2642
	Sample Standard Deviation, s2	0.7873	0.8767	1.0871	0.8662	1.0480	0.7723
	Xmax	1.3951	1.4157	2.2020	1.3901	1.6837	2.3269
	Xmin	-1.3498	-3.7435	-2.5963	-2.6625	-2.6013	-1.4057
	R2	2.7449	5.1591	4.7983	4.0526	4.2850	3.7327
	s	0.8999	0.9860	0.9816	0.9246	0.9156	0.9560
	W2 = R2/s2	3.0501	5.2322	4.8883	4.3832	4.6799	3.9042
Sample S3 of size 32	Mean	0.2229	0.0122	-0.0460	-0.1726	0.3610	-0.2142
	Sample Standard Deviation, s3	0.7568	0.8147	0.7229	0.6958	0.8212	1.0224
	Xmax	2.0308	1.7317	1.0833	0.9370	3.5497	1.2859
	Xmin	-1.9782	-1.4052	-1.5042	-1.8115	-0.7862	-2.7867
	R3	4.0090	3.1369	2.5874	2.7486	4.3360	4.0725
	s	0.8999	0.9860	0.9816	0.9246	0.9156	0.9560
	W3 = R3/s3	4.4548	3.1814	2.6359	2.9728	4.7356	4.2598
Sample S4 of size 32	Mean	0.0552	-0.4347	0.0426	0.0089	-0.0822	-0.2575
	Sample Standard Deviation, s4	1.0847	1.1561	1.1619	1.0499	0.9183	1.0547
	Xmax	2.0191	1.5258	1.9764	2.7242	1.6106	1.5943
	Xmin	-2.9260	-3.8824	-3.9144	-2.6827	-2.7401	-2.6503
	R4	4.9451	5.4082	5.8908	5.4068	4.3507	4.2446
	s	0.8999	0.9860	0.9816	0.9246	0.9156	0.9560
	W4 = R4/s4	5.4950	5.4848	6.0013	5.8479	4.7517	4.4397
	d2	4.3858	4.7890	4.2562	4.5816	4.2924	3.9949
	R/d2, the estimator of σ	1.1302	1.4266	1.4371	1.1801	1.4653	1.2800
	R Average	3.9468	4.7221	4.1779	4.2361	3.9302	3.8193
	UCL	0.5420	0.4457	0.4028	0.3736	0.5442	0.5194
	LCL	-0.4125	-0.6002	-0.6383	-0.6070	-0.4270	-0.4947

Table 2

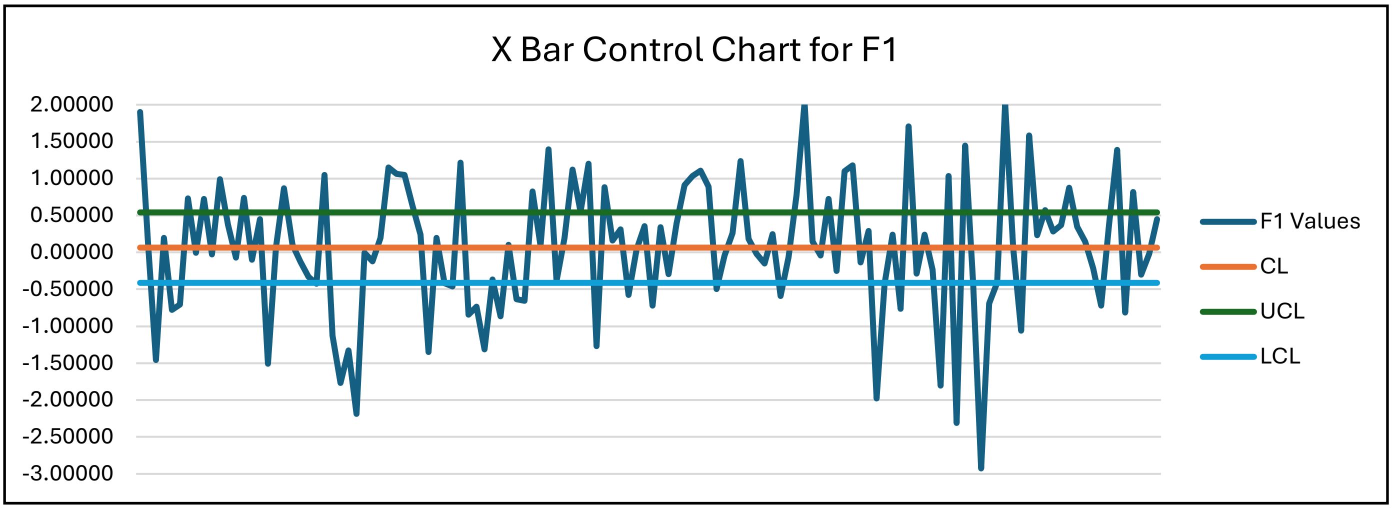

Fig 1

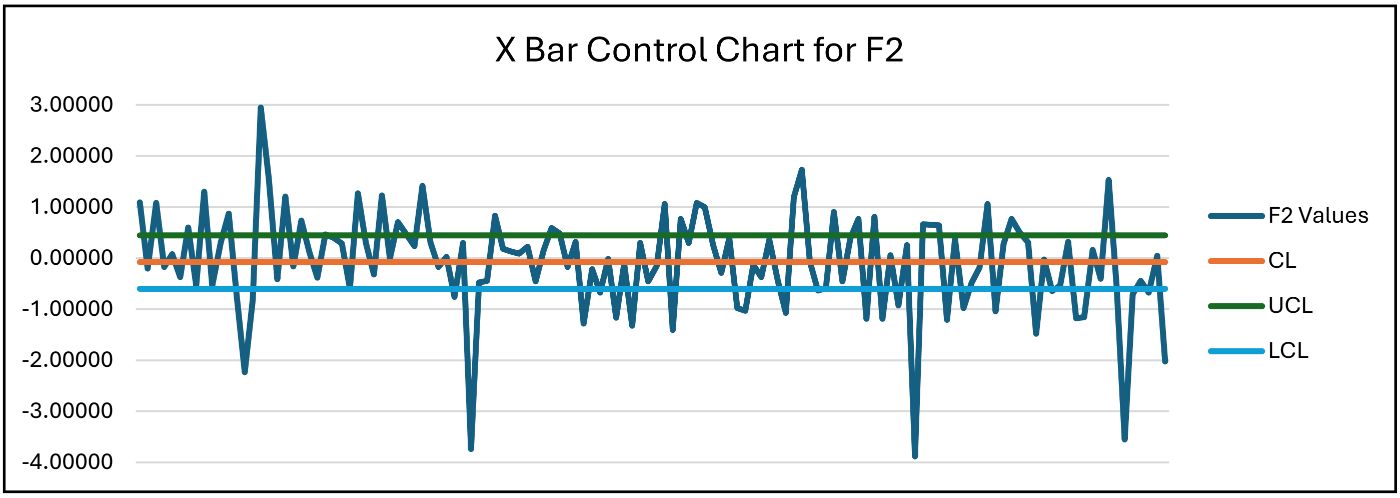

Fig 2

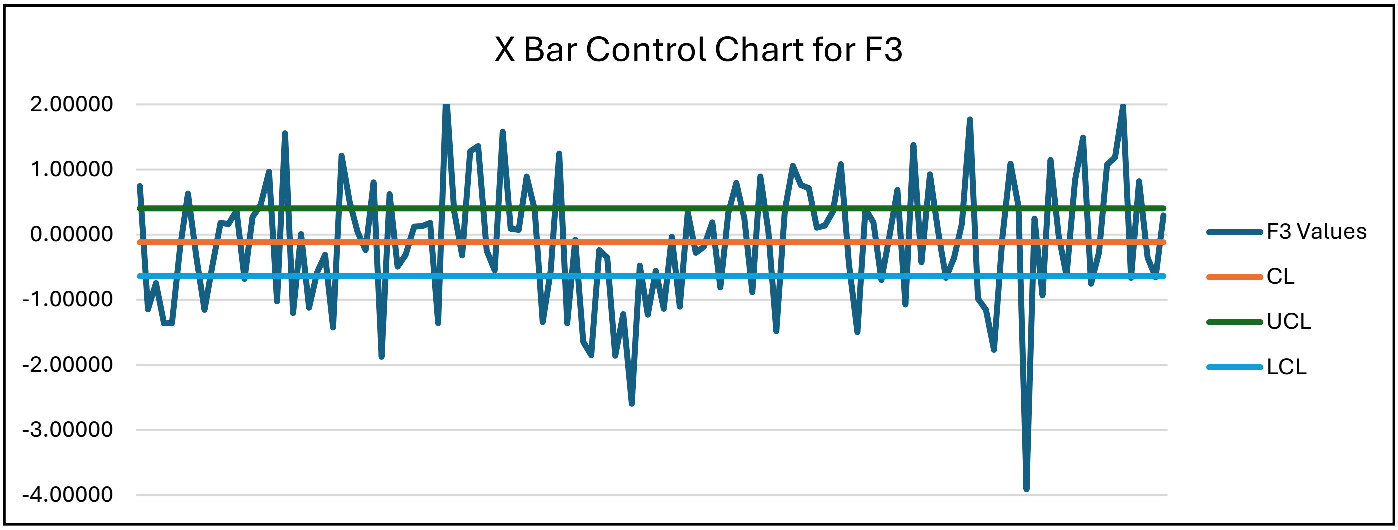

Fig 3

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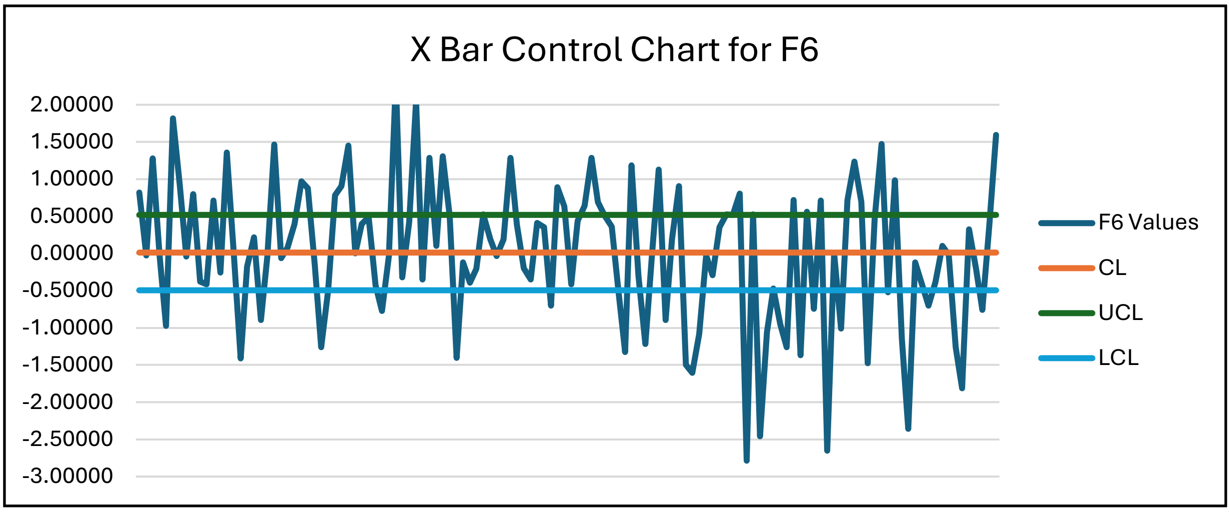

Fig 4

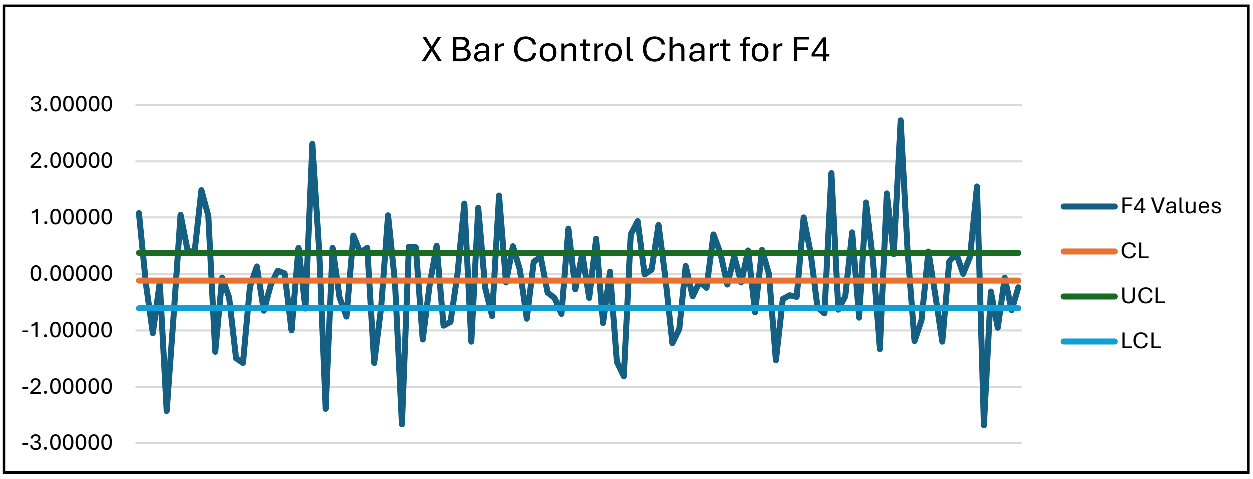

Fig 5

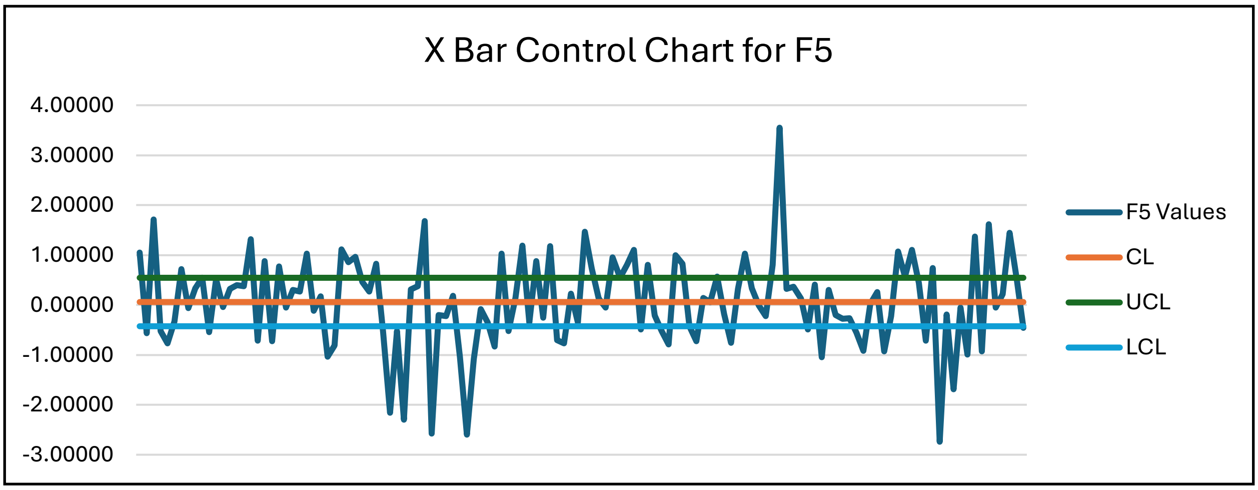

Fig 6

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Process Variability is monitored by the Control Chart for standard deviation, the s chart. As we compute s_i, we note that s_i is a biased estimate of an unknown σ. Assuming that the underlying distribution is normal, we compute the correction to the bias as the constant c_4 as a function of n, given by $c_4 = \sqrt{\frac{2}{n-1}}\frac{\left(\frac{n}{2}-1\right)!}{\left(\frac{n-1}{2}-1\right)!}$ (Schenkelberg)

The Variability Control Chart for Factor F_i is then given by Control Limit $CL(s)_i = \bar{s}_i$ and the Upper Control Limit, $UCL(s)_I$ and the Lower Control Limit, $LCL(s)_I$ are given by $\bar{s}_I \pm \frac{3\bar{s}}{c_4}\sqrt{1-c_4^2}$

We note that $c_4 = 0.5019$ (Schenkelberg)

The computations of the s chart are shown in Table 3 below.

Sample	Parameter or Statistic	F1	F2	F3	F4	F5	F6
Sample S of size 128	Standard Deviation, s	0.8999	0.9860	0.9816	0.9246	0.9156	0.9560
Sample S1 of size 32	Sample Standard Deviation, s1	0.9088	0.9300	0.8607	1.0294	0.6975	0.8091
Sample S2 of size 32	Sample Standard Deviation, s2	0.7873	0.8767	1.0871	0.8662	1.0480	0.7723
Sample S3 of size 32	Sample Standard Deviation, s3	0.7568	0.8147	0.7229	0.6958	0.8212	1.0224
Sample S4 of size 32	Sample Standard Deviation, s4	1.0847	1.1561	1.1619	1.0499	0.9183	1.0547
$\bar{s}$ i = CL(s)i		0.8875	0.9527	0.9628	0.9132	0.8801	0.9229
c4	0.5019						
UCL(s)i		5.4758	5.8781	5.9407	5.6342	5.4303	5.6943
LCL(s)i		-3.7008	-3.9727	-4.0150	-3.8079	-3.6701	-3.8484

Table 3

FINDINGS & CONCLUSION

It is seen here that the initial control charts show a process in control. However, the charts are depicting the initial phase wherein customer satisfaction data is examined from the construct created from the original feedback. Thus, the process would need to be repeated with revised data on the factors: F1, …, F6 and checked for control and detection of outliers using run length, Mahalanobis Distance or the Tukey Model. The fit of the model would need to be checked with the data. Also, in case of revision of the Control Charts on the said factors is made and yet the process does not remain in control, the organization could revise the initial construct based on a revised set of data, and the revision of an underlying construct after a re-examination of customer satisfaction with the 22 item SERVQUAL instrument. The simplistic suggested loop may be as depicted in Figure 7.

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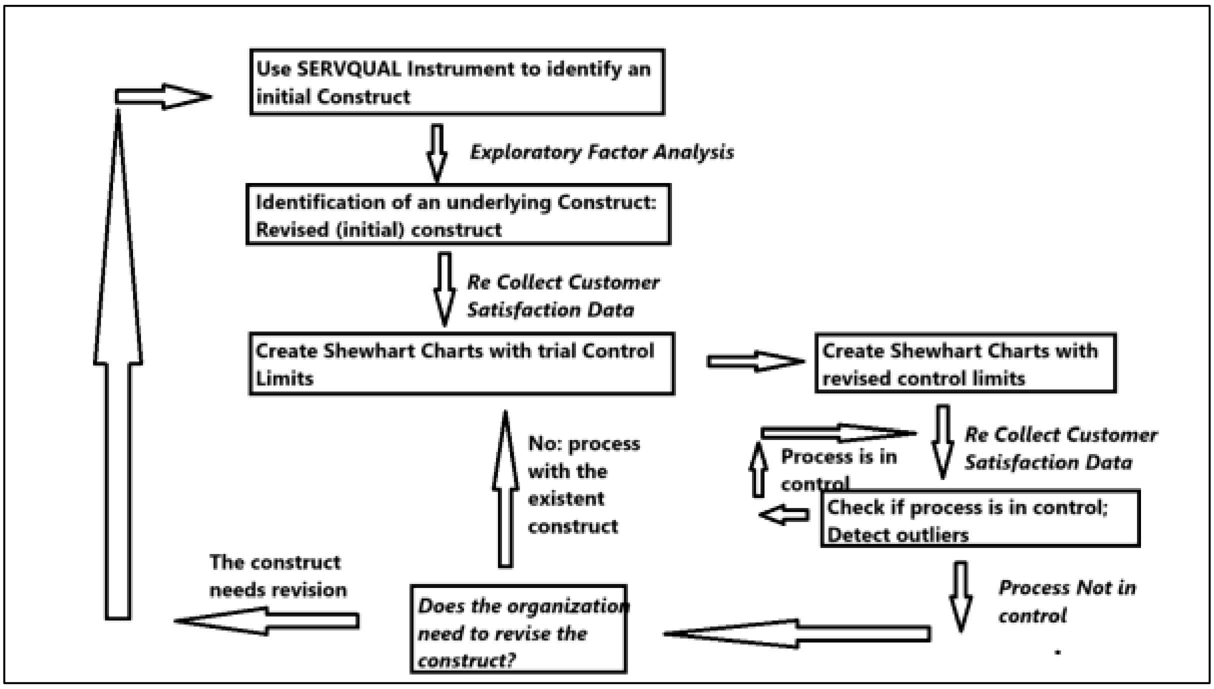

Figure 7

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