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Measuring Supplier Service Quality in Indian SMEs using Factor Analysis and Graph-Theoretic Approach

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Abstract: This study uses a hybrid scale to identify the factors contributing to the service quality delivered by the suppliers working with small-medium manufacturing units in emerging economies like India. 120 executives working at top/middle management level in different SMEs situated in northern India responded to a questionnaire survey related to the assessment of services being performed by their suppliers on the 1-5 Likert scale. Application of exploratory factor analysis (EFA) followed by confirmatory factor analysis (CFA) revealed an interpretable latent structure comprising of five factors viz., Credibility, Relationship, Understanding, Alignment, and dependability with 17 indicator items. The graph-theoretic approach (GTA) developed a numerical measure of supplier service quality (SSQ) index. This paper thus provides a framework for the measurement of SSQ in a relatively less explored sector. The proposed scale can be used as a benchmark by SME practitioners for evaluation of their suppliers' service. The methodology used may be applied in more such situations so that generalizations can be contemplated.

Keywords: Supplier service quality; SMEs; EFA; CFA; GTA.

Introduction

The fierce competition of today's marketplace is driving small-medium manufacturing units to reshape their strategies to curtail overall cost and cut down inefficiencies. To ensure their operational and financial benefits, manufacturing enterprises are working closely and maintaining backward linkages with their suppliers and upstream partners (Gupta and Singh [1]). Purchasing is arguably the first goldmine for success for manufacturing units (Gandhi *et al.* [2]). Traditionally, in the context of SMEs, supplier management has been the practice of reducing the number of direct materials suppliers and forming strategic alliances with few select suppliers and committing resources to them (Corsten & Felde [3]).

Service quality (SQ) is a way of thinking about how to satisfy customers so that they hold positive attitude toward the service they receive (Jain *et al.* [4]). Delivering quality service is considered to be an essential strategy to succeed in a competitive business environment. Firms, which offer superior services, achieve higher growth in the market and increase profits (Gandhi *et al.* [5]). Supplier service quality refers to 'the manner in which staff of the supplier unit serve the requisitions made by manufacturing unit and what attitudes they hold towards the unit'. Suppliers need to keep costs of materials and other supplies low so that it results in low product cost thereby producing higher profits, which means more business for suppliers. This is akin to gain-sharing arrangements wherein everyone who contributes to greater profitability is rewarded (Carr *et al.* [6]).

SMEs occupy a position of prime significance in the financial growth of emerging economies. Earlier such units were in dormant stage shielded by the government policies of reservation, quota and license etc., but due to globalization, once flourishing SME sector is facing several problems and is passing through an extended phase of 'declining returns to scale' regions (Saranga [7]). Under the current complex and turbulent business environment, selection of best suppliers may help the manufacturers achieve good market share through the supply of good quality raw material at the right time, in the right quantity, at the attractive price (Gupta and Singh [8]). The quality services by a supplier may reduce cost, increase profit margins, improve quality of outgoing product and ensure timely delivery (Seth *et al.* [9]). Therefore, most organizations devote a considerable amount of time & effort for selection and evaluation of supplier (Ordoobadi and Wang [10]) and to measure their service quality.

It is thus realized that these units need a reliable metric to identify various attributes of SSQ, to integrate their quality strategy with the service strategy of a few select suppliers to yield synergy effect. To achieve this objective, an extensive review of extant literature, coupled with focus group discussion with practitioners was carried out to develop a 'structured interview schedule'. EFA, CFA and GTA were then applied to bring out an index value of SSQ. To gain the insights of relative importance of the dimensions contributing to overall service quality, regression analysis was also conducted.

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Methods

Literature Review

Since last two decades or so, 'management of suppliers' is established as a critical function for value addition across the service-profit chain for both products and services and hence has become the vital determinant to ensure the profitability and survival of industrial organizations (Benton and Maloni [11]). Consequently, manufacturing units are putting efforts to revitalize and streamline their procurement processes. Researchers have suggested that economical and efficient delivery by suppliers has a multiplier effect and enhances service quality of the whole channel. Table 1 presents a summary of the salient studies in the area of service quality at manufacturer-distributor relationships over the last two decades in a chronological manner.

It comes out from the literature that the services delivered by suppliers are a well-explored area, but very few studies have been carried out related to attributes and index value of SSQ in SMEs.

Selection of Hybrid Scale

Parasuraman *et al.* [12, 13] in their pioneering work identified five components of service quality *viz.* reliability, assurance, tangibles, empathy, and responsiveness (RATER). These five dimensions used to evaluate service quality are called SERVQUAL dimensions. Carr [14] pointed a significant limitation of SERVQUAL scale by stating that it does not consider 'equity theory' for selection of SQ determinants. It is though well established that small manufacturers do evaluate services of suppliers by way of fairness (in both treatments as well as terms & conditions) in business encounters as compared to bigger manufacturing organizations dealing with the same set of suppliers. The hybrid scale comprising FAIRSERV, in conjunction with SERVQUAL (RATER + F) is considered suitable for this study since its outcome parameters are satisfaction and loyalty intentions. The preliminary questionnaire based on 'five attributes of SERVQUAL scale' and 'Fairness' dimension of FAIRSERV model. Taking cues from both these scales to measure service quality, we have made a modest attempt at designing a new scale based on the combination of the two metrics. The study is conducted in exploratory framework using structured interview schedule.

Survey Design

A survey instrument was developed primarily based on an extensive review of the literature and focus group interview on different aspects of service quality measurement with a focus on suppliers using the RATERF hybrid scale.

The pre-test of the questionnaire was conducted during June-July, 2017 and the survey was administered during August-December, 2017. The questionnaire was refined after focus group discussion with five information rich and willing industry experts and three academicians serving in nearby universities with work published in the area of 'service quality'. The snowball sampling (Kureshi *et al.* [15]) was used for selection of industry experts and academicians. The industry experts highlighted the issues in practice that the researchers had missed. The academicians provided the feedback on the understandability of the contents of the questionnaire. From of the feedback received from these two groups, improvements were made in the questionnaire to enhance the comprehensibility and understandability of its items. Both groups finally concurred that the questionnaire accomplishes the study objectives.

Based on the review and synthesis of relevant literature and focused group interviews, an initial pool of 24 items (See Table 2) that explained the six dimensions of service quality.

Sampling Frame and Data Collection

Sampling frame in survey research covers the clear understanding of terms: population, sample, and subject (Forza [16]). In the present case, small-medium manufacturing firms in northern India can be attributed to the total population for the survey. The method of snowball sampling was adopted for reaching the right respondent and collecting the data. This subject being quite new to SME units, it is essential to reach the correct respondent, and therefore the use of snowball sampling for collection of data is justified. The individual respondent working at top/middle management level (Only one selected from each SME) formed the subject for conducting the survey.

Data was collected by personally visiting the respective units. Before the commencement of the data collection, introductory e-mails were sent out to plant heads of respective units. Plant heads referred the researcher to the key respondents, who could be contacted for filling in the questionnaires. Most of the respondents themselves filled-in the questionnaire at the time the researcher approached them, while other respondents kept the questionnaires, and returned them to the researcher in subsequent visits. The purpose of this approach was to enhance the response rate and improve the quality of data.

Table 1. Essential studies about service quality at manufacturer-supplier relationships

Author: Focus area and select contributions
Kelle and Miller [17]: Purchasing is one of the most crucial elements in establishing the value-added contents for the products and services and is a vital determinant to ensure the profitability and survival of the business organization in the dynamic markets. A close relationship between supplier-manufacturer channel participants shares the risks and rewards and has willingness to maintain the relationship over the long term.
Stank *et al.* [18]: An effective purchasing function is one of the competencies essential for supply chain success. Most industries recognize that the costs of raw materials and component account for more than 70% of a product's value.
Purchasing personnel today do much more than "buy things". They have become relationship managers; facilitating decision making by bringing together the pertinent parties-internal and external to the organization. As a result, many organizations are attempting to redesign and streamline their procurement processes.
Handfield *et al.* [19]: Effective planning and execution can help companies and their customers adapt to the market's demand shifts. When the company can purchase, produce and distribute the right products to the proper channels in the right quantities at the right time, both supplier and customer will increase revenue capture by channel and region.
Integration of suppliers, which are an external entity, with the focal organization requires considerable adjustment to internal attitudes and procedures.
Muralidharan *et al.* [20]: Purchasing arguably is a critical link to adding value in the supply chain because it has both internal and external customers and acts cross-organizationally as manager of external suppliers.
Looked at the relationships between supplier performance and firm performance, with attention to customer practices that organizations considered important.
Wynstra *et al.* [21]: Collaboration with key suppliers in the supply chain can help in new product development (NPD).
Collaborative NPD depends on the extent to which supply chain stakeholders share a cross-functional and process thinking and have internal coordination.
Wong [22]: Supplier involvement in early phases of product design can make the supplier-focal organization interface effectively.
Particularly for complex value-addition activities such as NPD, sharing of tacit knowledge in the supplier-focal organization relationship can smoothen the coordination of the relative expertise of each stakeholder.
Lee *et al.* [23]: Identified a more comprehensive list of criteria to measure a supplier's performance based on a survey of managers, buyers, customers and supliers.
The most critical qualitative, such as commodity knowledge, cultivation of qualified suppliers, and professionalism were the essential qualitative criteria.
Found that closer interaction with internal customers improved internal customer's perceptions of purchasing responsiveness, but technical knowledge was even more critical.
Kannan and Tan [24]: The supplier should be involved in the early phases of product design to improve communication.
Suppliers should assume additional responsibilities of various kinds, such as earlier participation in product development, managing inventory for customers, delivering smaller lot sizes to narrowing delivery windows, producing near-perfect quality, providing steady price reductions, and more.
Morris and Carter [25]: Highlighted that successful partnerships and relationship integration throughout the supply chain has the potential to render efficiencies, profits and service.
Focused on traditional measures of customer service such as availability, timeliness and delivery quality.
Seth *et al.* [26]: Developed dimensions of supplier service quality using EFA and CFA.
This research tool SSQSC offers managers with a practical framework for service quality improvements in manufacturing supply chains.
The work suggests the ways to achieve customer satisfaction and focuses on sustained growth.
Pressey *et al.* [27]: Emphasized the "fit" between buyer and supplier firms' competitive strategies and organizational culture.
Besides, it is probably rewarding if the commitment and attitudes of the suppliers, particularly of the top management, toward the development program, can be ascertained from an early stage to avoid supplier specific pitfall.
Amad *et al.* [28]: Along with the importance of supplier development goals, an identified manufacturing firm examined the types and extent of supplier development activities undertaken.
The use of support services by manufacturing unit and provision of supplementary services such as after sales support and total service capability reveal the value of relationships between two partners.
Tseng [29]: Selection of appropriate suppliers in supply chain management is a challenging issue because it requires a battery of evaluation criteria/ attributes which are characterized by complexity, elusiveness, and uncertainty in nature.
Muralidhar *et al.* [30]: Closer long-term relationship with suppliers implies the use of joint quality planning and joint production planning between buyer and supplier.
In the area of manufacturing, supplier selection is a crucial strategic decision that has a long-term impact on a company's profitability and efficiency.
Prakash [31]: Studied relationship of service quality with a competitive advantage and organizational performance.
Investigated role of service quality in three large automobile enterprises.
Prajogo and Olhager [32]: The contribution of suppliers in delivering values to customers, hence, building competitive capabilities (quality, delivery, flexibility, and cost) was well recognized.
Analyzed supplier related issues in supply chain practices.
Rajkumar [33]: Enumerated the roles of a supplier, e.g. improving transportation facilities, delivering performances; proper stocking & fulfilling the requirements timely; Inventory & finance management, and adequate communication with organization & market.
De Treville *et al.* [34]: Studied three different types of organizations and found that short lead time increases the market share through sales growth.
Gupta and Singh [1]: Considered five drivers of a two-wheeler manufacturer supply chain namely, supplier, organization, distributor, retailer and customer.
Used various MADM techniques to find the value of service quality of different drivers.
Kamakoty and Sohani [35]: Measured the SQ of both immediate upstream and downstream supply chain partner firms using EFA, CFA and SEM.
Gupta and Singh [36]: Found a strong relationship between the market response (purchase volume) and customer's perceptions of service.
Brought out index value of service quality across the supply chain using Fuzzy ANN.
Gandhi *et al.* [37]: Reviewed 28 popular service quality models in the light of ever-changing industrial scenario and analyzed them for suitability/ need for modifications in the context of small-medium manufacturing units.
PZB's SERVQUAL [12,13]model (using perception scale only) in conjunction with Carr's FAIRSERV [14] model proved a befitting yardstick for evaluating service quality at various echelons in the supply chains of manufacturing units under study.

Table 2. Item generation for questionnaire

Supplier service quality, SSQ	
Item	Literature support
Reliability	
Products of correct quality & quantity in time	Hazra and Srivastava [38]
Charges minimum price	Gandhi *et al.* [8]
Maintains confidentiality of transactions	Seth *et al.* [26]
Assurance	
Knowledge, expertise and skills	Parasuraman *et al.* [12]
Long-term collaborative relationships	Singh *et al.* [39]
Competent and technically sound employees	Parmata *et al.* [40]
Employees are consistently courteous and polite	Gandhi *et al.* [41]
Share work-related information and knowledge	Meena and Thakkar [42]
Honest in providing information/access	Prakash [31]
Strong market reputation	Alves and Vieira [43]
Financial strength	Ahmad *et al.* [44]
Flexibility to change product design	Vesel and Zabkar [45]
Flexible in terms & conditions	Bustinza *et al.* [46]
Innovative and strive for continuous improvement	Ramseook *et al.* [47]
Easily approachable and at a convenient location	Lightfoot *et al.* [48]
Has latest IT infrastructure	Singh [49]
Tangibles	
Right tools/equipment/technologies	Lepmets *et al.* [50]
Modern, adequate & certified physical facilities	Moussa and Touzani [51]
Empathy	
Understands the requirements of your unit	Seth *et al.* [26]
The suppliers care for your convenience	Singh [49]
Responsiveness	
Willingness to work for your organization	Ganguli and Roy [52]
Quick solutions to failures/ complaints	Ladhari [53]
Fairness	
Fair treatment	Carr [14]
Fair terms & conditions	Kelkar [54]

Table 3. Demographic distribution of respondents of questionnaire

Section-1 i.e. Supplier related part (N = 120)					
Experience		Qualification		Functional area of work	
Distribution	n	Distribution	n	Department	n
2- 5 years	42	MBA/M.Tech/M.Sc.	16	Procurement	48
6-10 years	24	BBA/ B.Tech./ B.Sc.	43	Inventory/ store	28
11-15 years	26	MA/ BA/ B.Com.	24	Marketing/ sales	20
16-20 years	16	Technical diploma	22	Production	14
above 20 years	12	Intermediate/below	15	Quality control	10

Table 4. Type of product being manufactured by respondent units (N = 120)

Type of manufacturing unit	Small scale	Medium scale
Number & percentage	87 (73%)	33 (27%)
Type of product		
Auto parts	26 (≈22%)	9 (≈8%)
Hand tools	15 (≈13%)	5 (≈4%)
Casting components	12 (≈10%)	4 (≈3%)
Valve manufacturing	9 (≈8%)	4 (≈3%)
Rolled products	6 (≈5%)	4 (≈3%)
Machine tools	6 (≈5%)	3 (≈2%)
Sheet metal components	5 (≈4%)	2 (≈2%)
Fasteners	4 (≈3%)	2 (≈2%)
Multi products	4 (≈3%)	Nil

The researcher approached 165 respondents serving in different small-medium manufacturing units and was able to elicit data from 120 respondents, thus fetching a response rate of 73% which was quite encouraging. Majority of the respondents belonged to the top/middle management of units including Proprietors, CEOs, MDs, Unit Heads, Chief Works Managers, GMs, Purchase Managers, Executive Engineers, Heads of different departments and sections etc.

Appropriateness of Sample Size

Since conducted EFA on the collected data, the number of observations must not be fewer than 50 while samples of 100 or more are preferable (Hair *et al.* [55]). In the present case, since the sample size (N = 120) exceeded 100 observations, hence is suitable for data analysis.

Demographic Distribution of Respondents

The demographic distribution of respondents is presented in table-3. The respondents have been categorized by the number of years of experience, qualifications, and functional area of work. We find that most of the respondents have work experience in the range 2 to 10 years, hold engineering qualification, and work in varied operational areas. Table 4 shows the type of manufacturing activity carried by the respondent units.

Results and Discussions

Since all the 24 questions to measure supplier service quality are synthesized from the literature; the imperative is first to assess this scale through reliability test, and EFA, before applying CFA and GTA.

Reliability Test

Reliability indicates dependability, stability, predictability, consistency and accuracy, and refer to the extract which a measuring procedure yields the same results on repeated trials. Reliability can be measured by Cronbach alpha. The output of this analysis ($\alpha = 0.897$) is provided by IBM SPSS v21 and indicates significantly high reliability of data.

Exploratory Factor Analysis (EFA)

EFA of the data is carried out through a sequence of steps. First, Bartlett test of sphericity is used to verify appropriateness of factor analysis is assessed by analyzing correlation matrix of the data (Hair *et al.* [55]). Simultaneously, assessment of data sufficiency (N = 120, in this case) is judged by Kaiser-Meyer-Olkin (KMO) statistic which ranges from 0 to 1. The KMO value of above 0.6 is considered significant and indicates the suitability of factor analysis. The

obtained score of Bartlett test of sphericity (Approximate Chi-Square = 2221 for dof = 231, and significance value = .000) and the KMO value (= 0.880) provided by SPSS v21 indicate the suitability of factor analysis (Hair *et al.* [55]).

The objective of EFA is to summarize the information asked in the 24 questions into a smaller set of new attributes that attempted to bring out the constructs for measurement of service quality delivered by suppliers. This resulted in the extraction of five factors, explaining 73.301 percent of the variance. The individual factors explained 22.524, 17.014, 12.375, 11.494 and 9.893 percent of the variance respectively. These factor loadings are consistent with the suggested factor structure of the scale. The output of EFA using is presented in Table 5.

Based on the subjective opinion of the researcher in consultation with a group of experts, the factors have been named as *Credibility*, *Relationship*, *Understanding, Alignment*, and *Dependability*. The communalities express the proportion of the variance of the 24 items extracted by the five factors of the scale. All the items have significant communalities (not less than 0.50) (Hair *et al.* [55]). The factor-item loadings represent the correlations between each item with their underlying factors. All the items have significant factor loadings (not less than 0.55) (Prakash [31]).

Internal reliability of the items of the various factors of the scale is examined using the Cronbach alpha coefficients. In this analysis, the reliability score for each factor ranges from 83.6% to 95.1% as shown in Table 5 and hence is acceptable (Hair *et al.* [55]).

Confirmatory Factor Analysis (CFA)

CFA confirms the factor structure by testing the fit of CFA model. CFA model is run using SPSS AMOS v21, for five individual factors with respective items. Based on the methodology of Gandhi *et al.* [5], the model fit was examined for each factor. Table 6 shows the key model fit indices for the model.

Table 5. Communalities, factor structure and loadings for items of scale for measuring SSQ principal components method with varimax rotation loading ≥ .53*****

S. No.	Factors and associated items	Communalities	Factor structure & loadings				
			F1	F2	F3	F4	F5
Credibility (F1)							
1.	The supplier has a strong market reputation	.707	.766				
2.	The supplier has a financial strength	.854	.866				
3.	The supplier has a flexibility to change product design	.792	.864				
4.	The supplier has required knowledge/expertise/skills	.794	.843				
5.	Has competent & technically sound employees	.813	.846				
6.	The supplier is innovative in operations	.745	.797				
7.	The supplier has the latest infrastructure	.792	.872				
Relationship (F2)							
8.	The Supplier has the long-term relationship with your unit	.677		.622			
9.	The supplier agrees to flexible terms & conditions	.736		.702			
10.	The supplier has a willingness to serve your unit	.645		.646			
11.	The supplier's employees are polite & courteous	.689		.698			
12.	The supplier is fair in dealings with your unit	.720		.700			
13.	Terms & conditions with your unit are fair	.763		.686			
Understanding (F3)							
14.	The supplier understands requirements of your unit	.689			.778		
15.	The supplier values your convenience	.726			.827		
16.	Shares work-related information and knowledge	.682			.801		
17.	Honest in providing information/access to you	.646			.753		
Alignment (F4)							
18.	The Supplier uses right tools/equipment/technology	.712				.812	
19.	The Supplier has modern & certified facilities	.775				.859	
20.	The Supplier is easily approachable	.695				.815	
21.	The supplier has quick solutions to failures/com-plaints	.706				.884	
Dependability (F5)							
22.	Delivers right quality and quantity in right time	.848					.857
23.	Supplier charges the minimum price for supplies	.812					.849
24.	Supplier maintains confidentiality in operations	.766					.836
Reliability (Cronbach alpha# value) of identified factors			.894	.951	.861	.836	.872

*Cutoff point for loadings is 99 percent significant and is calculated by 2.58/√n (Prakash [26]) where n (= 24) is the number of items in the scale. F1-F5 represent individual factors.

α values ≥ 0.70 are acceptable (Hair *et al.* [55]).

Table 6. Key fit indices for measurement model of scale for measuring SSQ

Factors	Cmin/df	RMR	GFI	NFI	CFI	RMSEA
F1: Credibility	.496	.007	.987	.994	1.000	.000
F2: Relationship	.968	.018	.982	1.000	1.000	.000
F3: Alignment	3.232	.018	.974	.972	.980	.037
F4: Understanding	.529	.013	.996	.994	1.000	.000
F5: Dependability	---	.000	1.000	1.000	1.000	---

All the GFI values are above 0.9, which provides validation of individual factors of CFA model (Hair *et al.* [55]).

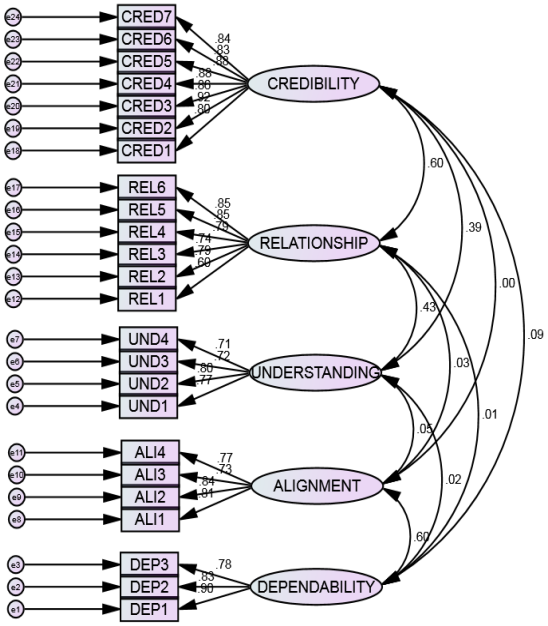

Figure 1. Theoretical framework for development of Supplier Service Quality Scale

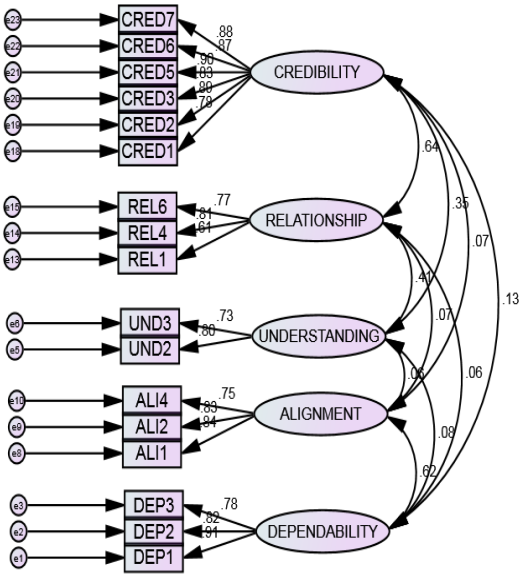

Figure 2. CFA model development for measuring Supplier Service Quality

Scale Purification

In order to develop the measurement scale, the covariance matrix between the five identified factors was created as shown in Figure 1. Three iteration runs of CFA were performed to obtain satisfactory goodness of fit indices. During this process, the following 7 out of initial 24 items were deleted owing to the low amount of explained variance. The lower the amount of explained variance for any item, the more poorly it is loaded in the model, thus making it a choice for deletion from the model (Ahmad *et al.* [44]).

Table 7. Summary statistics of factor cores of supplier service quality (N=120)

Factors underlying SSQ	Measurement on 5-point Likert scale		Measurement on 9-point Likert scale (for GTA matrix)	
	Mean (Scale 1-5)	Factor mean (scale 1-5)	Mean (scale 1-9)	Factor mean (scale 1-9)
Scores of supplier service quality				
Credibility (CR)				
Financial strength (FS)	3.54	3.43	6.37	6.17
Market reputation (RP)	3.63		6.53	
Innovation (IN)	3.80		6.84	
Flexibility (FX)	3.48		6.26	
Infrastructure (IF)	3.05		5.49	
Expertise (EX)	3.09		5.56	
Relationship (RL)				
Long-term contract (LT)	2.72	3.01	4.90	5.42
Politeness & courtesy (PC)	3.26		5.87	
Terms & conditions (TC)	3.07		5.53	
Understanding (US)				
Sharing information (SI)	2.56	2.65	4.61	4.77
Value convenience (VC)	2.73		4.91	
Alignment (AL)				
Right tools (RT)	3.82	3.44	6.88	6.19
Quick solutions (QS)	3.78		6.80	
Modern facilities (MF)	2.71		4.88	
Dependability (DP)				
Right quality at right time (RR)	2.64	2.77	4.75	4.99
Minimum price (MP)	3.18		5.72	
Confidentiality (CO)	2.51		4.52	

The supplier has required knowledge/expertise/skills
The supplier agrees to flexible terms & conditions
The supplier has the willingness to serve your unit
The supplier is fair in dealings with your unit
The supplier is easily approachable
The supplier understands requirements of your unit
The supplier is honest in providing information/ access to you.

The decision for deleting items above was taken in consultation with the members of the focus group. All members concurred that remainder 17 items with five associated factors were sufficient to capture the construct of supplier service quality.

The final model consisting of 5 factors and 17 sub-factors is depicted in Figure 2.

Model Fit

Various goodness-of-fit indices are obtained by running the model using AMOS v21. The Normed Chi-square value for this model is 1.342, which represents a good fit. The acceptable ratio of Normed Chi-square value is up to 3 or even 5. The Goodness-of-Fit Index (GFI), the Comparative Fit Index (CFI) and the Normed Fit Index (NFI) values for this model were 0.911, 0.977, and 0.918 respectively. The RMSEA value of 0.054 indicates a reasonable fit. From these values, it is inferred that model represents an adequate fit (Singh and Khamba [56])

Descriptive Statistics

Mean scores of factors of 17 items and five underlying factors are calculated using MS Excel and are depicted in Table 7. The mean values are also extrapolated for using GTA methodology on the 1-9 scale.

It comes out from the analysis that managers working in the surveyed units under study believe that suppliers are quality services to their organizations. These findings are in line that of Yoo and Donthu [57]; Seth *et al.* [26]; Christiansen [58]; Kamakoty and Sohani [35] who compared quality management practices of Indian supplier firms with those of global firms. They also found that Indian firms do not lag behind these industrialized countries in term of value-adding services.

At this point, it is essential to offer a caveat that survey has suggested that SME managers, still adhere to practices such as competition between suppliers. Grant [59] has suggested that in the case of logistics based services, there is often a dichotomy in what manufacturers say that they consider as desirable (relationship with suppliers), and what they practise (transaction-specific behaviour). However, this dichotomy has so far not been resolved in research or practice.

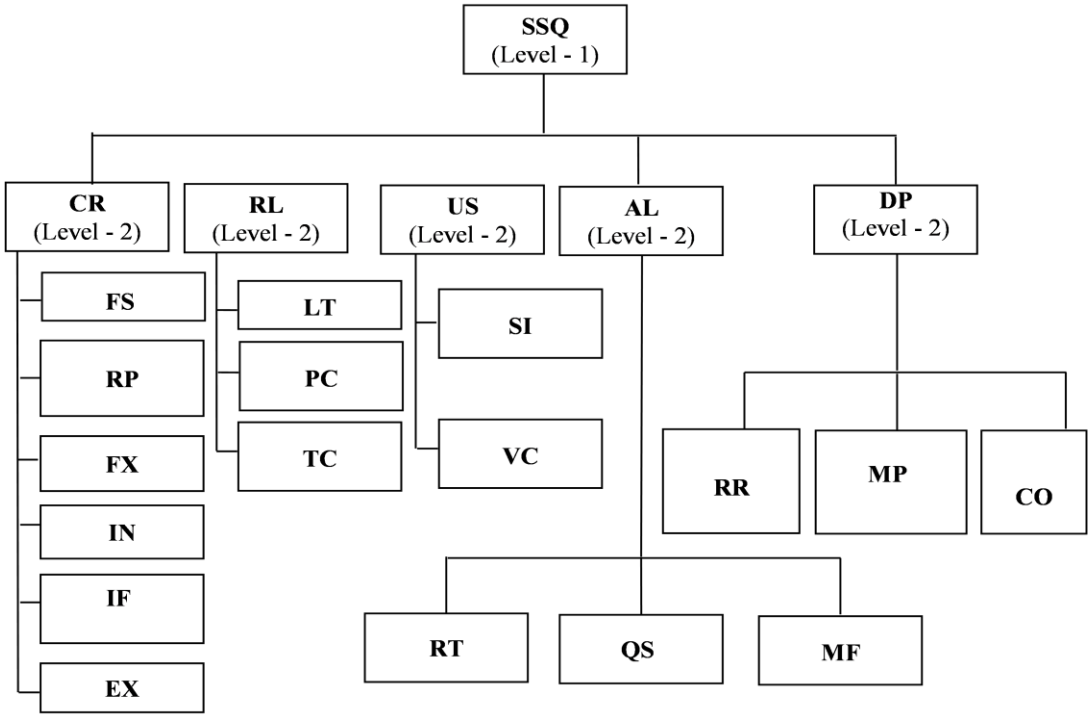

Figure 3. Tree diagram showing factors of supplier service quality

Graph Theoretic Approach (GTA)

GTA consists of the formation of a digraph, matrix and permanent function representation to calculate the single numerical index for any issue. GTA is simple, easily understandable, less time-consuming technique and has been suggested to quantify the presence of factors affecting service quality (Gupta and Singh [1]). Graph theory is a systematic methodology consisting of digraph representation, matrix representtation & permanent function (Singh *et al.* [60]). The permanent function is obtained in a similar manner as determinant with a difference that all negative signs appearing in the calculation are replaced by positive signs (Faisal *et al.* [61]).

The graph-theoretic approach is used in this study to evaluate SSQ in terms of a single numerical index. GTA takes into consideration the inheritance effect of factors and their interdependencies. The algorithm of the proposed approach is presented below. (i) Develop a digraph between the factors of various groups and sub-groups depending on their interdependencies. The nodes in the digraph represent factors while edges represent interaction among factors. (ii) Develop group and sub-group variable permanent matrix (VPM) with diagonal elements representing inheritances and the off-diagonal elements representing interactions among them. (iii) At the sub-system level, compute numerical values for the inheritance of attributes and their interactions with the help of experts. (iv) Find the value of VPM which is known as the permanent function (PF) for each subgroup, which can be obtained in a similar manner as determinant with only difference that all the negative signs of determinant are replaced by positive sign. (v) Find the value of PF for the system i.e. SSQ in this case.

The tree diagram of SSQ along with factors and subfactors is shown in Figure 3.

The interdependence among the factors of SSQ was developed in consultation with experts from SMEs and academia. The same is represented in the form of the schematic diagram in Figure 4 and in form of a diagraph in Figure 5.

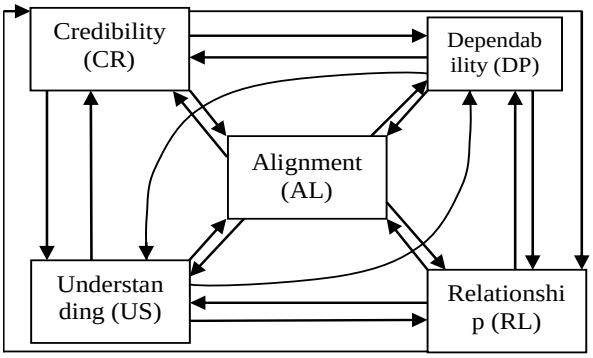

Figure 4. Schematic diagram of factors of SSQ

The diagraphs for five individual factors of SSQ viz. Credibility (CR), Relationship (RL), Alignment (AL), Understanding (US), and Dependability (DP) are shown in Figures 6-10 respectively.

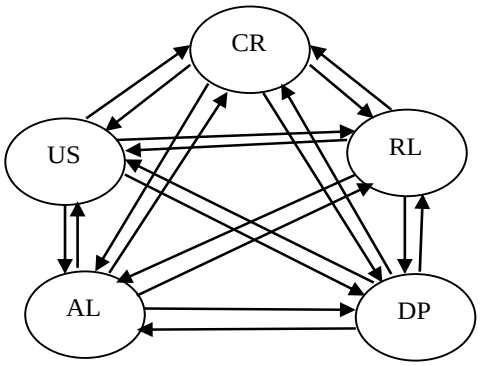

Figure 5. Diagraph of factors of SSQ

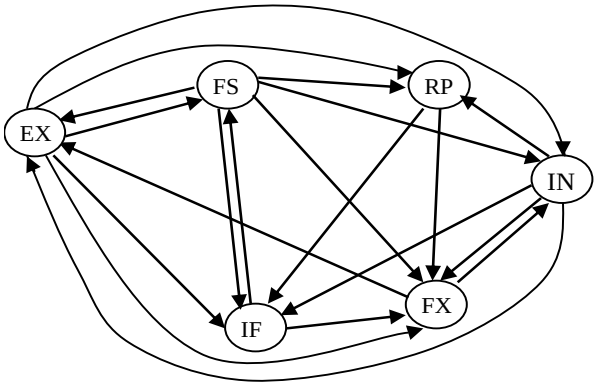

Figure 6. Diagraph of factors of CR

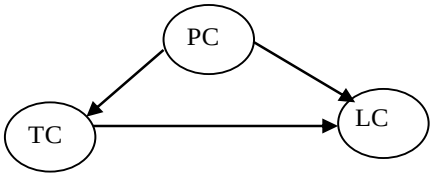

Figure 7. Diagraph of indicators of RL

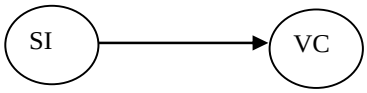

Figure 8. Diagraph of indicators of US

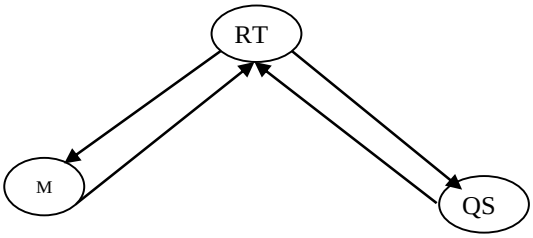

Figure 9. Diagraph of indicators of AL

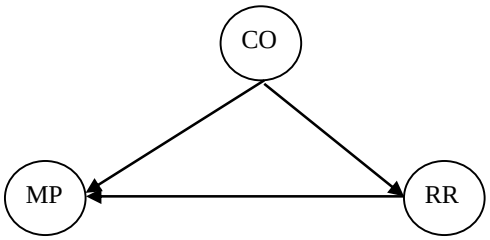

Figure 10. Diagraph of indicators of DP

The actual value, of VPM of SSQ is computed in the following matrix:

VPM_{SSQ} (Actual) =

	G1	G2	G3	G4	G5
*G*1	122687	12	12	4	6
*G*2	6	225.42	16	6	8
*G*3	4	8	31.64	9	6
*G*4	6	6	12	228.31	16
*G*5	9	6	6	6	122.81

$= 2.5 * 10^{13}$

The actual value of service quality seems strange and does not convey any information till it is gauged in comparison to the minimum and maximum values. To find the minimum value, interaction values of attributes are considered minimum maximum whereas to find the minimum value, interaction values of attributes are considered maximum.

VPM_{SSQ} (Minimum) =

	G1	G2	G3	G4	G5
*G*1	122687	3	3	2	2
*G*2	3	225.42	4	3	2
*G*3	2	4	31.64	3	2
*G*4	2	3	4	228.31	4
*G*5	3	3	3	3	122.81

$= 0.514 * 10^{13}$

VPM_{SSQ} (Maximum) =

	G1	G2	G3	G4	G5
*G*1	122687	15	15	10	10
*G*2	15	225.42	20	15	10
*G*3	10	20	31.64	15	10
*G*4	10	15	20	228.31	20
*G*5	15	15	15	15	122.81

$= 4.63 * 10^{13}$

Conversion of Service Quality Value into Index Value

SQ Value on standard linear scale = (2.5-0.514)/ (4.63-0.514) = 0.4825 or it can be stated that supplier service quality in this case has an index value of 48.25%.

Relative Importance of Factors of Supplier Service Quality

To bring out the order of importance of five dimensions, regression analysis was conducted by taking the overall supplier service quality ratings as the dependent variable and the mean scores on the five factors as independent variables. The standardized coefficient beta *(β)* of the individual dimension represented their importance (Seth *et al.* [26]) as presented in Table 8.

The results clearly show the significance of overall regression model ($F = 121.800$, $p < 0.00$), with 81% of the variance in supplier service quality is explained by independent variables. The significant factors that remained in the equation in the overall service quality and are shown in order of their importance based on ß coefficient. Higher the standardized ß coefficient, the more the factor contributes to explaining dependable variable (de Carvalho and Chima [62]).

The factor 'Dependability' emerges to be the most important dimension, with β coefficient = 0.452 followed by 'Alignment' ($\beta = 0.392$), 'Understanding' ($\beta = 0.295$), 'Credibility' ($\beta = 0.241$) and 'Relationship' to have the lowest impact ($\beta = 0.099$).

Conclusion

This study has shown how the scale was built and expressed its usefulness for the managers of small-medium manufacturing units. An attempt was made to calculate the index value of SSQ in numerical terms. The insights provided by this study can help managers and researchers in further understanding the service quality delivered by suppliers in small-medium manufacturing units. The scale can be utilized by managers of manufacturing units in following ways:

The scale yields five useful determinants to measure supplier service quality offered to the manufacturing unit viz. Credibility, Relationship, Understanding, Alignment, and Dependability. The total scale can be obtained by adding the scores on individual dimensions.

Table 8. Regression results for relative importance of SSQ dimensions

Independent variables	R^2/Sig.	Beta *(β)*	Sig.	Order of importance
Dependability	0.809/	0.452	0.000	1
Alignment	0.000	0.392	0.004	2
Understanding		0.295	0.000	3
Credibility		0.241	0.000	4
Relationship		0.099	0.003	5

Constant: 0.047, t = 0.271 (Sig. = 0.787); Dependent variable: Overall Supplier Service Quality.

Table 9. Latent variables and their operational definitions

Service quality delivered by supplier (SSQ)		
Factor	Operational definition	Relevance from literature
Credibility	The supplier's aspect of providing honest and expected service to manufacturer	Kamakoty and Sohani [35]; Santouridis *et al.* [63]; Lepmets *et al.* [50]
Relationship	The aspect of giving importance to human and behavioural factors	Sharabi [64]; Tseng and Wu [65]; Rauyruen and Miller [66]
Understanding	The ability of knowing the way of working of manufacturing unit	Miran and Rasha [67]; Wilkins and Balakrishnan [68]; Mittal *et al.* [69]
Alignment	The ability to forge business interests and supply schedule with manufacturer.	Prakash [70]; Seth *et al.* [9]; Grace *et al.* [71]
Dependability	The aspect of accuracy in service provided by supplier as per commitment	Bakti and Sumaedi [72]; Prakash [31]; Nenadal [73]

The scores on individual sub-dimensions indicate suggestions for improvements to suppliers' unit along those areas. The scale can also be used as a diagnostic tool for identifying poor and/or excellent performance to benchmark across multiple departments within a single manufacturing unit. Furthermore, any of these situations can also be compared across time.

Based on performance assessment using these scales, an incentive or reward system can be proposed by a supplier to reward timely delivery, quickness in resolving complaints, innovation, and agility exhibited by particular employees.

The operational definitions of various dimensions identified at different junctions with relevance from the recent literature of supply chain are used for are summarized in Table 9.

Actionable Framework

Summarizing the analysis and the findings of the research data, an actionable framework is proposed for improving the efficiency and effectiveness of supply chain. The framework is shown in figure 10. This framework is in line with that proposed by Prakash [31], Srai and Gregory, [74], and Sahay *et al.* [75] for supply chain strategy.

Recommendations

The study makes the following recommendations to supplier units: The honest sharing of operational information, integrating supply strategy with manufacturing strategy, promptness in handling queries or failures, attention to manufacturer's requirements, maintaining confidentiality in dealings, flexibility in terms and conditions as per requirements, and preference for a long-term collaborative relationship.

Implications for Practice

This study also provides several important implycations for practitioners. SME managers are expected to use this scales for continuously measuring and monitoring supplier service quality for improving their purchasing strategy. This may also help for benchmarking as well as supplier selection purposes. The consequences of supplier service quality can be viewed as very important driver for business success. As for example, the strong relationship with firm provides a base to the manufacturing units to move towards effective buyer-supplier partnerships. In short, most of the conceptual developments could be meaningfully used in the organizations, so the study has got a considerable amount of practical value.

Limitations

A small geographical spread, a small sample size and snowball sampling precludes much of the generalizability of the study findings. Further, the unit of analysis has been individual respondent; future researchers may take single organization as a unit of analysis. This research consideres the functional perspective of service quality and uses un-weighted "performance only" measures for analysis of service quality. These two could be other limitations of the study. Adapting this model across different manufacturing industries would be an interesting area of research. The study uses interview schedule technique as the main methodology for data collection. However, case study method in conjunction with other methods may also be used to gather more insightful findings.

Scope for Future Work

This research presents a rich agenda for future researchers. Future researchers can replicate this study with a larger and randomized sample collected from across India. Another area of interest would be the use of 7-point Likert scale rather than 5-point Likert scale for measurement of internal service quality items and infer their suitability. Instead of using un-weighted performance only measure, it would be interesting to use the weighted versions of service quality scale and bring out a comparison. Conceptualization of service quality from the outcome/technical aspect of service quality would be another area of future research. A more interesting study can be made on the effects of service quality towards service loyalty by combining the opinions of suppliers and manufacturer. In future, the same study may be repeated over a period to gain the changes in perceptions of the executives.

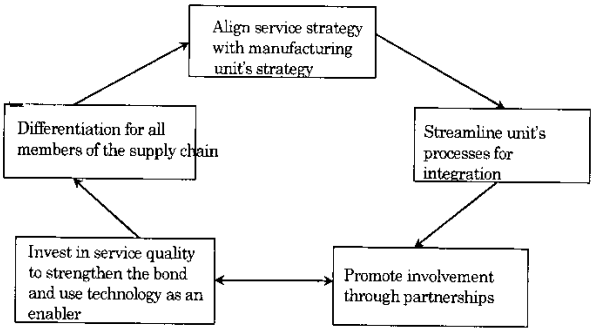

Figure 11. Framework for improving service quality of supply function

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