



MODELLING THE DISTRIBUTION PERFORMANCE IN DAIRY INDUSTRY: A PREDICTIVE ANALYSIS

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ABSTRACT. Background: Predictive analysis is a vital element to operations management as it facilitates real-time decision making and advanced planning on both strategy and performance. This paper identifies predictors to measure distribution performance in the dairy industry and to establish their importance.

Methods: A distribution model is developed through exploratory structural equation modelling (SEM) techniques. The key performance predictors are marketing and distribution management, quality management, supply chain coordination, and brand management, which account for 71.5% of the variability in distribution performance.

Results and conclusion: The predictors help improving the distribution performance, specifically in quality, order fill rate, and food safety. The outcomes of this research can help dairy professionals in managing their distribution channels, improving traceability, on-time delivery, and shipment accuracy. Consequently, these factors can improve distribution performance. Four predictors are elicited from the data to estimate the distribution performance and the relative importance of predictors is also established.

Key words: distribution performance; food supply chain, dairy industry, structural equation modelling (SEM), predictive analysis.

INTRODUCTION

The food industry has a vital role in promoting our routine activities and is an essential global industry with significant economic growth and rural development in many countries. The volume of the dairy market alone is projected at 216 metric tonnes in 2017 globally. India has noticed significant growth in the dairy sector over the last three decades, and the Indian dairy sector aims to increase milk production by 9% annually by 2022 [Economic Times Report, New Delhi]. The structure of Indian dairy involves private dairies, cooperative societies, milk unions, etc. The dairy supply chain starts with procuring milk from farmers, transporting it to milk processing plants, where milk is processed, packaged, and further supplied to retailers and

finally to end-consumers. Dairy cooperatives contribute a significant share of processed milk and other value-added milk products through milk unions at the district level, and milk unions safeguard the farmers from unfair trade actions. Although India is the leading producer of milk globally, there are several issues in the dairy supply chain, especially on the distribution side, and need to be unexplored. The food supply chain is more complex and challenging to manage, and it differs from other supply chains because of the importance of food quality, safety, and perishable nature. The food supply chain depicts the activities from procurement, production, distribution, and consumption [Mor et al., 2018]. Generally, the word distribution denotes the place and method of delivering products and services to the end-user incorporating logistical and other accompanying supports.

Unlike other industries, the food industry has an exclusive role in the ever-developing economy as it is a universal means of human life and wellbeing. The food industry is developing faster, and this growth is escorted by many challenges such as globalization, regulation, and competition. Novel and evolving technologies present quicker, safer, and more intellectual means to plan, optimize, and manage the different interfaces of the food supply chain viz. procurement, processing, distribution, etc. The role of an effective distribution system in a supply chain is to make vehicle scheduling and routing decisions in addition to the determination of optimal quantities of a product for delivery to a particular point of sale [Hsiao et al., 2010]. Researchers addressed that a systemic approach leading to sustainable practices and effective logistics, packaging, and marketing strategies can leverage the competitiveness status of the industry. It has been shown that decentralization in distribution systems of the food sector leads to distortion of food quality [Glover et al., 2014; Chen et al., 2014]. Specifically, perishable products necessitate a unique supply chain configuration for proper scheduling and delivery of products, mainly to shorten lead times to reduce work-in-progress, inventory, and finally, food waste. Moreover, the concern related to food safety, traceability, and quality issues in perishable products needs special care for the supply chain planning to help better coordinate supply chain partners [Kumar et al., 2020; Leon-Bravo et al., 2019; Mor et al., 2019a; Thomas & Mahanty, 2021]. Thus, a framework is essential to cope with such challenges and to measure the distribution performance.

The effectiveness of the supply chain in the food processing sector is a major concern, mainly for the short shelf-life and safety aspects of food products. Uncertainties in the food supply chains may occur because of various reasons. Still, the key factors include ineffective procurement, poor information and traceability, logistics and operational inefficiencies, inefficient cold chain infrastructure, poor marketing and distribution practices, etc. These uncertainties directly affect the profitability food industry throughout the supply chain [Mor et al., 2020]. Managing distribution practices in the food

industry is equally vital as the procurement and processing operations and is becoming an essential part of food supply chains. Sustainable distribution in the food industry, particularly dairy products, is possible through optimization methods, implementing agile information and coordination systems, different quantitative management techniques, etc. Researchers advocated that the modelling approaches in the food supply chain specifically consider the short lifecycle of food products and the product's perishability characteristics and the waste. Structural equation modelling (SEM) techniques are used for data analysis since the 1980s, for example, to identify the reliability and validity of manufacturing operations and assess SMEs' performance [Thirupathi and Vinodh, 2016]. SEM is applied to evaluate the structural interfaces and the interaction among measured variables and latent constructs. Researchers modelled a mixed structure through constraint programming to improve sustainable supply chain decisions. Thus, this paper aims to identify predictors of distribution in the dairy industry and establish their importance. A framework is developed using SEM methodology to assess the distribution practices [Sitek and Wikarek, 2015]. This paper's outcomes are envisioned to help dairy professionals manage their distribution practices, such as improving traceability, on-time delivery, shipment accuracy, etc. The paper is structured as follows. Section 2 demonstrates a comprehensive literature review. Section 3 introduces the problem formulation, and Section 4 presents research methods applied in this paper. Section 5 illustrates the data analysis and prediction model for measuring distribution performance. Section 6 offers the conclusions of the study and provides the future scope in this area.

LITERATURE REVIEW

Food supply chain and distribution practices

Effective distribution management is the key performance parameter in competitive markets. Distribution contributes about 20% of logistical costs or even more for commodity products and mainly plans to flow the products

in minimum lead time and minimum cost. Studies present optimizing the vehicle routing to handle the problems of distribution and overall distribution costs of dairy food products [Nabhani and Shokri, 2009]. The challenges of distribution management are more complex, and the prolonged distribution channels lead to high costs and high delivery time. The spatial distribution of logistics activities, location features of distribution centers, and effective logistics management is a real problem facing distribution management in the dairy industry. Another way of managing distribution channels is the periodic analysis of decisions taken for distributing food items [Selim and Ozkarahan, 2008]. Traceability offers safer food supplies. The traceability of product quality & location is another key factor of distribution management where information technology like geographical-information-system helps maintain better traceability. The demand and supply equations over the multi-time period, multi-supplier, and region settings are considered to analyze uncertainties and balance supply chains [Kumar et al., 2011;

Dong et al., 2001]. Singh et al. [2011] studied the role of info technology for perishable food products in unorganized sectors and revealed a considerable loss of fresh food items due to ineffective information systems. The distribution performance also depends on better coordination and quality management initiatives to achieve competitiveness in an organization [Okano et al., 2014]. Thus, distribution management is an inherent part of supply chain decisions incorporating different practices about distributing products to the end-consumer. The assessment of supply chain coordination systems in conjunction with the modernized distribution with innovative labelling, packaging, and automatic milk vending technology also effectively manages dairy products' distribution practices [Mor et al., 2019a]. Georgiadis et al. [2005] focused on associating the single-echelon models to ascertain the effective policies and constraints in different decision-making issues of food supply chains. The literature on different supply chain issues about the distribution practices and distribution networks is presented in Table 1.

Table 1. Literature on Distribution Practices

Focus	Source
Flow coordination and information sharing	Sahin and Robinson (2002)
Food safety in global supply chains	Nardi et al. (2020)
Supply chain coordination approaches	Lemma et al. (2015)
Food distribution management	Bumblauskas et al. (2020)
Vertical coordination	Abdul-Rahaman et al. (2020)
Production and distribution of food products	Ahumada and Villalobos (2011)
Agile supply-chain systems	Ngai et al. (2004)
Supply chain coordination systems	Zhang et al. (2020)
Barriers in dairy supply chain	Mor et al. (2018)
Production scheduling and distribution planning	Bilgen and Celebi (2013)
Framework for supply chain	Manzini et al. (2011)
Food supply chain integration	Ling and Wahab (2020)
Production-distribution planning in supply chain	Lee et al. (2002)
Hybrid modelling in supply chain	Safaei et al. (2010)
Logistics efficiency in urban distribution	Cagliano et al. (2017)
Sustainable performance in agri. supply chains	Kamble et al. (2020)
Uncertainty in dairy supply chains	Mishra and Shekhar (2011)
Sustainable food supply chain	Smith (2007)
SC Modelling for delivery of milk products	Huang et al. (2019)
Traceability in food supply chains	Behnke and Janssen (2020)
Supply chain coordination under information asymmetry	Vosooghizajji et al. (2020)

SEM techniques

Vinodh and Joy [2012] explored the usage of interpretive modelling and SEM approaches to establish a structural interface among different enablers of sustainable processes.

Hussey and Eagan [2007] assessed the performance of small and medium enterprises (SMEs) using SEM methodology and found significant results for environmental constraints in the developed model. Hou et al. [2014] studied the associations in sustainable processes and the components affecting

behaviour changes. The research focused on assessing different manufacturing operations also favor the application of SEM methodologies for performance measurement. Eid [2009] studied world-class manufacturing dynamics through SEM to explore the associations among various variables. Kadipas and Pexioto [1999] worked on business strategies by applying the SEM tools and established the interfaces among different variables. The authors analyzed different parameters, such as quality, productivity, and performance. Lau et al. [2010] worked on total quality management and supply chain integration for product modularity and found the SEM approach very useful in assessing the interactions among supply chain enablers. Curkovic [2003] explored the green manufacturing model using SEM. Thus, SEM methodologies have vast applications for evaluating the supply chain performance of manufacturing and service sector organizations worldwide.

Problem Formulation

It is apparent from the literature review that the distribution practices have been explored in different sectors. Still, there exists no such model to quantify the distribution practices in the dairy industry. There is minimal empirical research that measures distribution performance in the dairy industry, particularly in the cooperative system. The literature necessitates an empirical framework to support the policy-makers towards effective distribution management. Hence, this research shields the gap by addressing an empirical analysis of distribution practices in the dairy industry. The following null hypotheses are established to measure the impact of predictors on distribution performance:

H01: 'Supply chain coordination' has no impact on the distribution performance of the dairy supply chain

H02: 'Quality management' has no impact on the distribution performance of the dairy supply chain

H03: 'Marketing and distribution management' has no impact on the distribution performance of the dairy supply chain

H04: 'Brand management' has no impact on the distribution performance of the dairy supply chain.

METHODS

A survey instrument has been developed to study the different distribution practices and further measure the distribution performance in the dairy industry (Figure 1). A survey questionnaire was established after the literature review and focus group discussion with academicians and professionals from the dairy industry. The first part of the questionnaire comprises 22 statements/items of distribution practices followed in the dairy industry and one item measuring overall distribution performance. The second part of the questionnaire encompasses the demographic data of respondents and the industry. The same questionnaire was developed online (Google Forms) to collect data from industries with a difficult approach and at odd locations, making the data collection process very fast and appropriate. The questionnaire is validated through a pilot study before launching [Robson (2002)]. The pilot study involves five specialists from the dairy industry and academic experts in operations management, supply chain modelling, and performance assessment.

The dairy industries from northern India were considered to collect data. Approx. 71% of responses were collected through personal visits to the concerned industry, and the rest of the data were collected through online mode. The questionnaire is distributed to participants to get their views regarding different distribution issues, and through the snowball sampling approach [Nargundkar, 2004], the desired information is obtained from the dairy industry. The responses were acquired on a five-point Likert scale, where 1-strongly disagree, 5-strongly agree (Annexure-I). The participants' privacy was retained secret to facilitate the balanced responses [Saunders et al., 2009]. The responses were received from all ranks, i.e., managing directors, managers, executives, heads of departments, etc. Most responses were received from the executive and assistant/deputy manager rank employees, as shown in Figure 2.

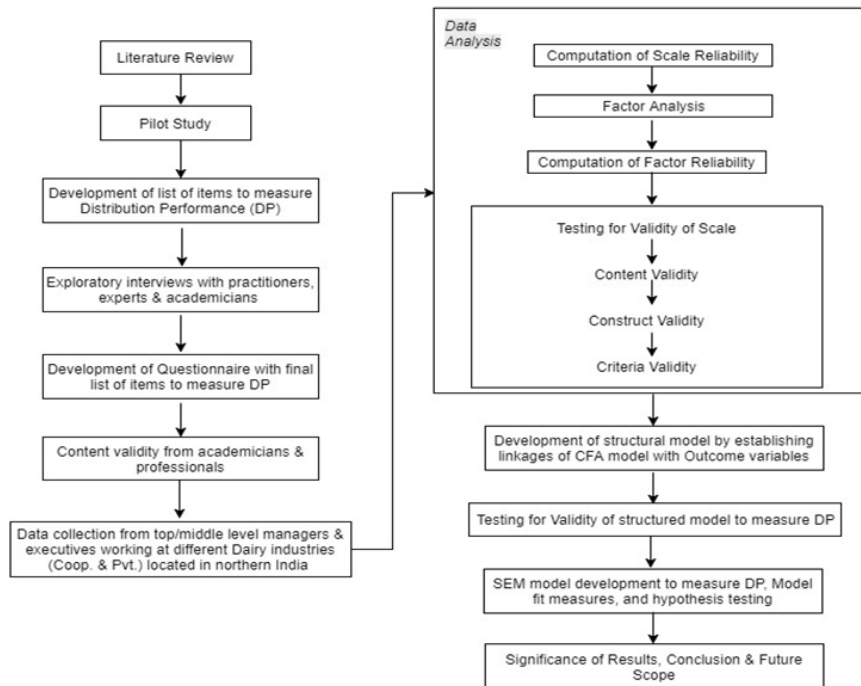


Fig. 1. Methodology

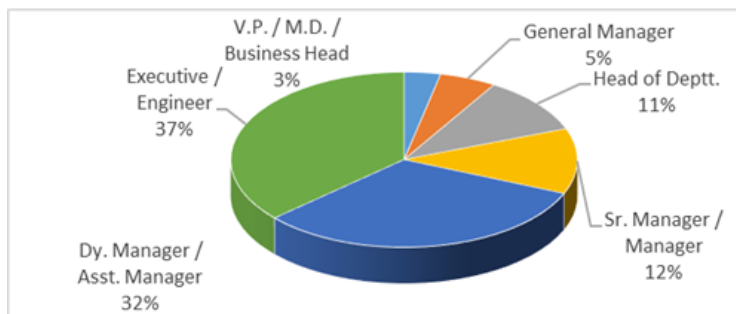


Fig. 2. Demographic distribution of responses

A total of 265 valid responses are carried forward for further examination. Since some of the queries to measure the distribution performance (DP) are selected from available literature and the rest from the pilot study; thus the developed survey instrument needs to be validated. The validation is performed via reliability analysis and exploratory factor analysis (EFA) method, and subsequent confirmatory factor analysis (CFA) process [Mor et al., 2019b], and a final SEM model to assess the distribution performance is developed by connecting the CFA model with outcome variables of the study.

DATA ANALYSIS

Reliability Analysis

The reliability of collected information is evaluated through Cronbach's alpha coefficient, which reveals the equivalence, homogeneity, and correlation of the statements. The reliability analysis is carried out by IBM SPSS v22 software, which indicates the Cronbach alpha coefficient value as 0.911; hence, depicting considerably high reliability of information [Cronin and Taylor,

1992, Mor et al., 2019b]. The reliability of each construct of the questionnaire is also assessed through Cronbach's alpha [Cronbach, 1951].

Exploratory Factor Analysis (EFA)

All 22 statements are selected for the EFA. Initially, the Bartlett test of Sphericity is applied to approve the relevance of factor analysis and measured by evaluating the correlation matrix of collected information. Simultaneously, the evaluation of sampling adequacy (N= 265) is referred by Kaiser-Meyer-Olkin (KMO) statistics, ranging between 0-1. The KMO value of >0.6 is assumed as considerable, and it is 0.897 here, which shows the aptness of factor analysis.

The value of the Bartlett test of Sphericity and the KMO value given by SPSS v22 software is Chi-square 4532.115, df: 231, Sig.: 0.000. The results were significant, thus verifying the factor analysis (Hair et al., 2005). The EFA is performed using the principal component analysis (PCA) method with Kaiser Normalization (four Predictors) and the Varimax rotation procedure through the SPSS software. EFA is applied to shrink the info probed in 22 questions into a reduced set of new elements. This ensued in the extraction of four predictors, explaining about 71.5% of the total variance. The predictors explain 20.85, 18.73, 17.62, and 14.55 percent variance individually. All the predictor loadings are constant with the proposed structure of the EFA model (Table 2).

Table 2. Exploratory Factor Analysis

Predictor No.	Statements (Name & Label)	Commonality	Predictors				Mean	Standard Deviation	Overall Score of Predictor	
			F1	F2	F3	F4	Measurement on 5-point Likert Scale		Mean	Standard Deviation
F1	Supply Chain Coordination (F1)									
	DIS22 You perceive better inter-departmental supply chain coordination in dairy industry	0.82	0.83				4.36	0.86	4.01	0.94
	DIS21 The existing information systems help to strengthen the supply chain coordination in dairy industry	0.77	0.80				3.34	1.17		
	DIS24 You deploy cross-functional teams for better supply chain coordination	0.62	0.70				4.03	1.00		
	DIS20 Supply chain coordination system help in maintaining the shipment accuracy, high order-fill-rate, and on-time delivery of products in dairy industry	0.72	0.73				4.00	0.85		
	DIS25 Supply chain coordination system help for better traceability of vehicles deployed for distribution of products	0.56	0.65				4.24	0.97		
DIS19 Better supply chain coordination leads to effective demand management in dairy industry	0.55	0.61				4.47	0.81			
F2	Quality Management (F2) You perceive wastage in the Distribution of dairy products due to following reasons:								3.41	1.39
	DIS30new Unhygienic practices	0.86		0.92			3.65	1.43		
	DIS28new Improper loading/unloading	0.82		0.90			3.45	1.32		
	DIS27new Poor cold chain infrastructure	0.79		0.85			3.48	1.42		
	DIS31new At retailer level due to unsold products	0.75		0.85			3.40	1.50		
	DIS29new Leakages during transportation	0.71		0.82			3.13	1.23		
DIS26new Inappropriate storage system	0.69		0.79			3.35	1.46			
F3	Marketing & Distribution Management (F3)								3.85	0.97
	DIS1 You perceive an adequate infrastructure to look after the logistics needs and it responds rapidly to demand fluctuations in dairy industry	0.74			0.85		3.82	0.92		
	DIS16 You have implemented the RFID technology to have automated warehousing	0.84			0.85		3.90	0.98		
	DIS9 The logistics systems can accommodate to special or non-routine requests rapidly in dairy industry	0.55			0.69		4.11	0.93		
	DIS12 The level of marketing in rural areas is low as compared to peri-urban & urban in dairy industry	0.62			0.59		4.06	0.81		
	DIS35 You have installed the automatic milk vending machines in the region	0.64			0.69		3.15	1.29		
DIS7 The distribution-planning schedule is highly effective in dairy industry	0.67			0.64		4.08	0.91			
F4	Brand Management (F4) Customers prefer to buy your products due to the following reasons:								4.42	0.82
	DIS38 Long shelf-life of products	0.53			0.68		4.34	0.89		
	DIS37 Close contact with Customers	0.84			0.84		4.42	0.78		
	DIS36 Better order-fill-rate	0.87			0.88		4.41	0.86		
	DIS33 Image for better product quality	0.78			0.83		4.51	0.75		
Reliability (Cronbach Alpha# value) of identified predictors			0.889	0.931	0.892	0.885				

Extraction Method: Principal Component Analysis.
 Rotation Method: Varimax with Kaiser Normalization.
 Rotation converged in 5 iterations.
 *Cutoff point for loadings is 99% significant and is calculated by 2.58/√n (Pitt et al., 1995), where n (=22) is the number of items in the scale. F1-F4 represents individual predictor.
 # α values ≥ 0.70 are adequate (Nunnally, 1978).

The extracted predictors are named as: ‘Supply chain coordination, Quality management, Marketing and distribution management, and Brand management’ in discussion with a group of professionals. The communalities depict the amount of variance of 22 items extracted by four predictors. All 22 items have the communalities of above 0.5 value representing as significant. The predictor-item loadings signify the correlations among each item with the underlying predictors. All the items depict the loadings of above 0.55 value specifying as significant [Gandhi et al., 2018; Pitt et al., 1995]. Internal reliability is measured by Cronbach’s alpha coefficients (Bagozzi and Yi, 1988). Reliability scores range from 88.5% to 93.1%; hence, acceptable [Nunnally, 1978].

Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis is performed to further approve the EFA outcomes through testing the CFA model fit. The CFA model, having four individual predictors with their respective statements, has been run using SPSS AMOS v21 software, and the model fit is observed for each predictor [Bienstock et al., 1997]. Table 3 illustrates the key model fit indices of the individual predictor.

The results show that the goodness-of-fit indices (GFI) values are higher than 0.9, which approves the validation of individual predictors of the CFA model [Hair et al., 2005]. The CFA model with the four predictors and their respective statements is presented in Figure 3.

Table 3. Key Fit Indices for CFA model of Distribution practices

Predictors	$(\chi^2)/df = CMIN/df$	RMR	GFI	NFI	CFI	RMSEA
F1: Supply chain coordination	2.738	.036	.950	.955	.964	.056
F2: Quality management	1.399	.065	.907	.930	.936	.068
F3: Marketing & distribution management	2.790	.026	.955	.963	.972	.070
F4: Brand management	2.237	.047	.937	.949	.951	.059

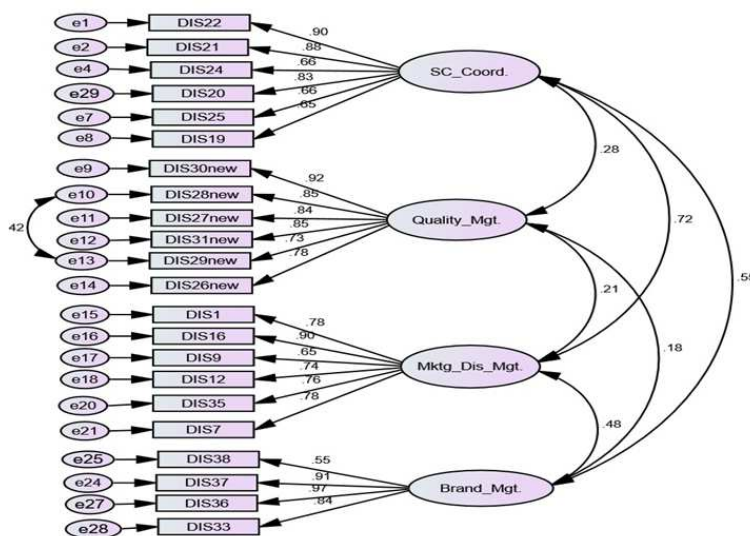


Fig. 3. CFA model of distribution practices

Model Fit

Various goodness-of-fit indices are attained by running the CFA model using AMOS v21 software. The Normed Chi-square value of the developed CFA model is 2.908, which

signifies a good fit. Moreover, the values of Goodness-of-Fit Index (GFI), Normed-Fit-Index (NFI), and Comparative-Fit-Index (CFI) are 0.930, 0.974, and 0.913, respectively, and the root-mean-square error of approximation (RMSEA) value of 0.06 specifies a good fit,

such that the model signifies an adequate fit [Tanaka, 1987].

Interpretation of Predictor Structure

The four predictors specify the leading distribution issues in the dairy industry. The total variance explained by the four predictors is 71.5%. The results propose that four predictors can significantly explain the distribution performance. The mean scores and standard deviations (SDs) of survey instrument items with their underlying predictors are also calculated (Table 2). The first predictor, labelled as 'Supply chain coordination', accounts for 20.85% of the total variance. Six items of this predictor with loadings from 0.61 to 0.83 and the second predictor is labelled as 'Quality management' and accounts for 18.73% of the total variance. Six items of this predictor with loadings from 0.79 to 0.92. The third predictor is labelled as 'Marketing and distribution management' and accounts for 17.62% of the total variance. The six items of this predictor with loadings from 0.505 to 0.782, and the fourth predictor is labelled as 'Brand management' and accounts for 14.55% of the total variance. The four items describing this predictor with loadings ranging from 0.59 to 0.85 are shown in Table 2.

Validity of Construct

The face validity evaluates by perceiving 'on-its-face' to confirm whether it seems like a good translation of the construct. The face validity assessment quality can be improved by making the construct more organized [Trochim, 2007]. The developed model provides a good reflection of distribution practices in the current analysis.

Content Validity

The items' content validity is measured after discussions with scholars and academicians and the literature review and the researchers' knowledge [Trochim, 2007]. Subsequent modifications of the survey instrument are confirmed by focus group discussion with dairy industry representatives. The developed model thus depicts good content validity.

Construct Validity

Construct validity is calculated in four steps, (i) Unit-dimensionality, (ii) Convergent Validity, (iii) Discriminant Validity, and (iv) Predictive Validity.

- i. Uni-dimensionality: The developed CFA model illustrates the CFI value of 0.913, which suggests a strong uni-dimensionality, where CFI relates the model with a null model supposing that there is no relationship between different measures [Bollen and Ting, 1993].
- ii. Convergent Validity: Convergent Validity evaluates the degree to which different methods of assessing a construct produce the same results, where a value of ≥ 0.55 of loadings in the CFA model proves strong convergent validity [Ahire et al., 1996]. The predictor loadings lie between 0.55 and 0.92 and depict a robust convergent validity in the current analysis.
- iii. Discriminant Validity: Discriminant Validity evaluates the amount to which a construct and its indicators are dissimilar from another [Bagozzi et al., 1988]. The square root of average variance explained (AVE) for individual predictor is diagonal cells and the Correlation Coefficient of a predictor with the others in non-diagonal cells (Table 4). The discriminant validity has been judged using the 'StatToolPackage' proposed by Prof. James Gaskin. The value of the square root of AVE for individual predictors is higher than that predictor's correlation coefficient with others, proving the discriminant validity of the CFA model.
- iv. Predictive Validity: Predictive validity is recognized if a standard external to the dimension is interrelated with the structure [Nunnally, 1978]. The predictive validity of four predictors is calculated by ascertaining the correlation of individual predictors with mean scores of items (being an external criterion) through Pearson correlation. All the correlation coefficients are substantial at the significance level of 0.05; hence, predictive validity is proved here (Table 5).

Table 4. Discriminant Validity for CFA model of Distribution practices

	SC_Coord.	Quality_Mgt.	Mktg_Dis_Mgt.	Brand_Mgt.
SC_Coord.	0.77			
Quality_Mgt.	0.276***	0.832		
Mktg_Dis_Mgt.	0.723***	0.207**	0.772	
Brand_Mgt.	0.545***	0.176**	0.481***	0.833

The $\sqrt{\text{AVE}}$ is represented in the diagonal cells and the correlation in other cells

Table 5. Correlation for CFA model of Distribution practices

Sr. No.	Predictors	Correlation with Distribution practices
1	Supply chain coordination	0.771*
2	Quality management	0.816*
3	Marketing & distribution management	0.648*
4	Brand management	0.723*

*Correlation is significant at the 0.05 level (2-tailed).

- DIS_out1: Order-fill-rate against daily demand fluctuations
- DIS_out2: On-time-delivery of products
- DIS_out3: Customer satisfaction

DISTRIBUTION MODEL

A distribution model is developed to measure the overall distribution performance by associating the CFA model with the three outcome variables. The outcome variables were nominated in consultation with professionals from the academics and dairy industry, as follows.

The final distribution model comprising the four predictors (with 22 statements) and three outcome variables define distribution performance in the dairy industry (Figure 4).

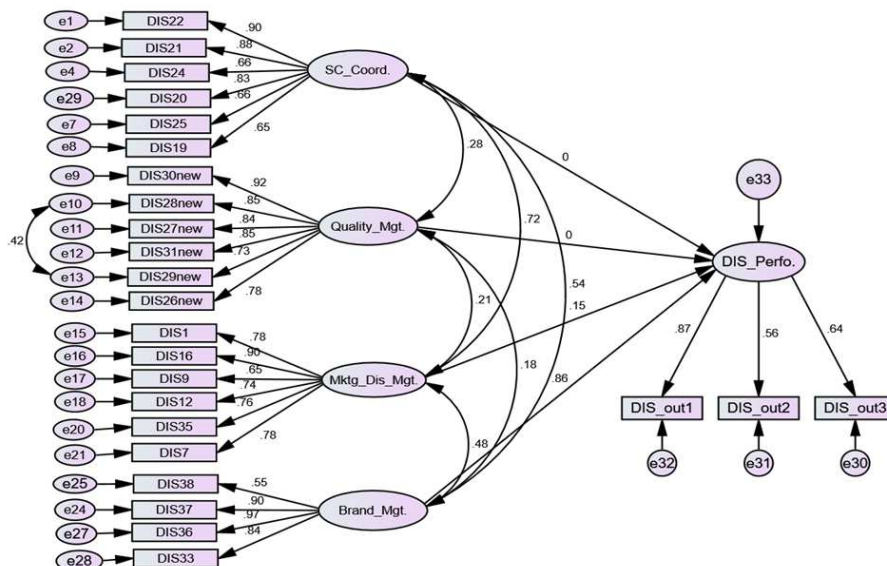


Fig. 4. Distribution model

Validity of Model

The validity of the SEM model is assessed in different steps as follows.

Discriminant Validity of Model: The discriminant validity is measured using 'AMOS Plugin,' and 'StatToolPackage', which depicts that all MSV values are lesser than AVE, values of AVE are >0.5, and critical ratio (CR) is greater than AVE. AVE's square

root for individual predictor is better than the correlation coefficient of that predictor with others, which supports the discriminant validity of the model (Table 6). In reference to

Hu et al. [1999], all values supported the model well, and hence, there are no validity problems in the distribution model.

Table 6. Discriminant Validity of Distribution model

	CR	AVE	MSV	MaxR(H)	SC_Coord.	Quality_Mgt.	Mktg_Dis_Mgt.	Brand_Mgt.
SC_Coord.	0.85	0.54	0.524	0.923	0.715			
Quality_Mgt.	0.89	0.59	0.076	0.942	0.276***	0.771		
Mktg_Dis_Mgt.	0.87	0.58	0.524	0.915	0.724***	0.207**	0.717	
Brand_Mgt.	0.92	0.7	0.294	0.966	0.542***	0.176**	0.479***	0.838

Source: Hu et al. (1999); Gaskin et al. (2016).

Model Fit Measures

The model fit measures were assessed using ‘StatToolPackage’, and obtained values are CMIN/DF: 2.631, CFI: 0.912, SRMR: 0.068, RMSEA: 0.079, and PClose: 0.061, and all

values support the distribution model well (Hu et al., 1999) (Table 7).

Hence, the established SEM model is suitable for assessing the distribution performance in the dairy industry.

Table 7. Model Fit Measure for measuring Distribution performance

Measure	Estimate	Threshold	Interpretation
CMIN	694.486	--	--
DF	264	--	--
CMIN/DF	2.631	Between 1 and 3	Excellent
CFI	0.912	>0.95	Acceptable
SRMR	0.068	<0.08	Excellent
RMSEA	0.079	<0.06	Acceptable
PClose	0.061	>0.05	Acceptable

Source: Hu et al. (1999); Gaskin et al. (2016).

Hypotheses testing and relative importance of predictors

The key aim of SEM methods is to examine the validity of theoretical models by recognizing, estimating, and assessing the linear relationships among perceived and ignored variables. The models established in SEM are generally more optimistic and

definitive than other approaches [Collis and Rosenbloom, 1985; Cudeck and O’Dell, 1994]. Table 8 depicts the values of C.R. >1.96 (95% confidence) and p-values <0.05, thus, indicating as significant. The null hypotheses are rejected, and all predictors positively impact the dairy industry's distribution practices.

Table 8. SEM Model for measuring Distribution performance

Sr. No.	Outcome	Predictor	Estimate	S.E.	C.R.	p Value	Status	Order of importance
1	Distribution Performance	Supply chain coordination	0.293	0.061	3.110	***	Significant	3
2		Quality management	0.300	0.052	4.321	***	Significant	2
3		Marketing & distribution management	0.321	0.068	4.760	***	Significant	1
4		Brand management	0.208	0.070	3.127	***	Significant	4

Statistical significance is shown by *** p < 0.05

The standardized coefficient beta results signify the importance of each item incorporated in this study, Table 8 [Parasuraman et al., 1988]. These results depict the inference of the inclusive regression model ($p < 0.00$), with 71.5% of the variance in distribution practices described by the different items. The predictors of distribution practices are shown in order of their significance based on the β coefficient. It shows that the greater the standardized β coefficient, the more the predictor supports explaining the dependent variable. The predictor 'Marketing and distribution management' emerges to be the most imperative, followed by others, i.e., quality management, supply chain coordination, brand management. Therefore, all four predictors describe the distribution performance considerably here.

CONCLUSIONS

This research investigates the sustainable distribution practices of the dairy industry both theoretically and the empirical validation of the outcomes. A total of 22 items of distribution practices are selected for factor analysis based on a comprehensive literature review and pilot study, summarized the items into four predictors viz. supply chain coordination, quality management, marketing and distribution management, and brand management. The mean score of quality management, and marketing and distribution management indicates the key improvement areas. The relative importance of predictors is indicated through standardized beta value, and marketing and distribution management are vital ($\beta = 0.321$), followed by quality management, supply chain coordination, and brand management. The final distribution model is developed after confirming the reliability (Cronbach's alpha) and the validity of the CFA model (loadings ≥ 0.6), discriminant validity (AVE > 0.5), and predictive validity (correlation constant positive at 0.05 level) of the model. The hypothesis testing outcome advocates that all four predictors positively impact distribution performance in the dairy industry. The SEM model is verified for discriminant validity and model fit indices and found acceptable for measuring the distribution performance.

It is concluded that an effective information system results in improved coordination and traceability. The cold chain and automated milk handling management help improve the sustainable distribution performance of the dairy industry. Effective product marketing into rural areas and agile logistics systems also play an important role in achieving marketing goals. The predictors explored in this study can help dairy professionals towards effective distribution management. Further, predictive analysis is a vital element to ensure compliance with risk & safety factors, and in the food industry, it is mission-critical to achieve optimal distribution performance. Future studies in this context may be conducted to validate the survey instrument and empirically assess the proposed model in alternate settings. The dairy supply chain interfaces, i.e., procurement, processing, etc., can also be revealed using applied SEM methodology. However, some case studies and other methods may also be used to collect more intuitive results, and the procedure may be tested in other perishable food processing industries.

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REFERENCES

- Ahire S.L., Golhar D.Y., Waller M.A., 1996. Development and validation of TQM implementation constructs. *Decision Sciences* 27(1): 23-56. <http://doi.org/10.1111/j.1540-5915.1996.tb00842.x>
- Ahumada O., Villalobos J.R., 2011. A tactical model for planning the production and distribution of fresh produce. *Annals of*

- Operations Research 190(1): 339-358. <http://doi.org/10.1007/s10479-009-0614-4>
- Bagozzi R., Yi Y., 1988. On the evaluation of structural equation models. *Journal of Academy and Marketing Science* 16(1): 74-94. <http://doi.org/10.1007/BF02723327>
- Behnke K., Janssen M.F., 2020. Boundary conditions for traceability in food supply chains using blockchain technology. *International Journal of Information Management*, 52, 101969. <http://doi.org/10.1016/j.ijinfomgt.2019.05.025>
- Bilgen B., Aelebi Y., 2013. Integrated production scheduling and distribution planning in dairy supply chain by hybrid modelling. *Annals of Operations Research*, 211(1), 55-82. <http://doi.org/10.1007/s10479-013-1415-3>
- Bollen K., Ting K., 1993. Confirmatory tetrad analysis. *Sociological Methodology*, 147-175. <http://doi.org/10.2307/271009>
- Bumblauskas D., Mann A., Dugan B., Rittmer J., 2020. A blockchain use case in food distribution: Do you know where your food has been? *Int. Journal of Information Management*, 52, 102008. <http://doi.org/10.1016/j.ijinfomgt.2019.09.04>
- Cagliano A.C., De Marco A., Mangano G., Zenezini G., 2017. Levers of logistics service providers efficiency in urban distribution. *Operations Management Research*, 10(3-4): 104-117. <http://doi.org/10.1007/s12063-017-0125-4>
- Collis B.A., Rosenblood L.K., 1985. The problem of inflated significance when testing individual correlations from a correlation matrix. *Journal for Research in Mathematics Education* 16, 52-55. <http://doi.org/10.5951/jresematheduc.16.1.0052>
- Cronin J.J., Taylor S.A., 1992. Measuring service quality: a re-examination and extension. *Journal of Marketing* 6, 55-68. <http://doi.org/10.1177/002224299205600304>
- Cronbach L.J., 1951. Coefficient alpha and internal structure of tests. *Psychometrika* 16(2): 297-334. <http://doi.org/10.1007/BF02310555>
- Cudeck R., Odell L.L., 1994. Applications of standard error estimates in unrestricted factor analysis: Significance tests for factor loadings and correlations. *Psychological Bulletin*, 115(3): 475-487. <http://doi.org/10.1037/0033-2909.115.3.475>
- Curkovic S., 2003. Environmentally responsible manufacturing: The development and validation of a measurement model. *Journal of Operations Research*, 146(2), 130-155. [http://doi.org/10.1016/S0377-2217\(02\)00182-0](http://doi.org/10.1016/S0377-2217(02)00182-0)
- Dong K., Xu Y., 2001. Towards better coordination of the supply chain. *Transportation Research Part E: Logistics and Transportation Review* 37(1): 35-54. [http://doi.org/10.1016/S1366-5545\(00\)00010-7](http://doi.org/10.1016/S1366-5545(00)00010-7)
- Economic Times Report, New Delhi, 2018. Milk production to grow at 9 per cent annually by 2022 from 6 per cent now: Radha Mohan Singh. Retrieved from: <https://economictimes.indiatimes.com/news/economy/agriculture/milk-production-to-grow-at-9-per-cent-annually-by-2022-from-6-per-cent-now-radha-mohan-singh/articleshow/64418219.cms?from=mdr>
- Eid R., 2009. Factors affecting the success of world class manufacturing implementation in less developed countries: the case of Egypt. *Journal of Manufacturing Technology Management*, 20(7): 989-1008. <http://doi.org/10.1108/17410380910984249>
- Fornell C., Larcker D.F., 1981. Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research* 18(1): 39-50. <http://doi.org/10.1177/002224378101800104>
- Gandhi S., Sachdeva A., Gupta A., 2018. Developing a scale to measure employee service quality in Indian SMEs. *Management Science Letters*, 8(5): 455-474. <http://doi.org/10.5267/j.msl.2018.3.005>

- Gaskin J, Lim J., 2016. Master Validity Tool. AMOS Plugin, Gaskination's StatWiki. <http://doi.org/10.1080/10705519909540118>
- Glover J.L., Daniels D.C., Dainty A.J., 2014. An institutional theory perspective on sustainable practices across dairy supply chain. *International Journal of Production Economics*, 152: 102-111. <http://doi.org/10.1016/j.ijpe.2013.12.027>
- Georgiadis P., Vlachos D., Iakovou E., 2005. A system dynamics modeling framework for the strategic supply chain management of food chains. *Journal of Food Engineering*, 70(3), 351-364. <http://doi.org/10.1016/j.jfoodeng.2004.06.030>
- Hair J.F., Anderson R.E., Tatham R.L., Black W.C., 2005. *Multivariate Data Analysis*, 5th Ed. Pearson Education, New Delhi, India.
- Huang K., Wu, K.F., Ardiansyah, M.N., 2019. A stochastic dairy transportation problem considering collection and delivery phases. *Transportation Research Part E: Logistics and Transportation Review*, 129, 325-338. <http://doi.org/10.1016/j.tre.2018.01.018>
- Manzini R., Accorsi R., 2013. The new conceptual framework for food supply chain assessment. *Journal of food engineering*, 115(2), 251-263. <http://doi.org/10.1016/j.jfoodeng.2012.10.026>
- Hou D., Al-Tabbaa A., Chen H., Mamic I., 2014. Factor analysis and structural equation modelling of sustainable behaviour in contaminated land remediation. *J. Cleaner Production* 84: 439-449. <http://doi.org/10.1016/j.jclepro.2014.01.054>
- Hsiao H.I., Van der Vorst J.G.A., Kemp R.G.M., Omta O., 2010. Developing a decision-making framework for levels of logistics outsourcing in food supply chain networks. *International Journal of Physical Distribution and Logistics Management*, 40(5), 395-414. <http://doi.org/10.1108/09600031011052840>
- Hu L., Bentler P.M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives, *SEM* 6(1): 1-55. <http://doi.org/10.1080/10705519909540118>
- Hussey D.M., Eagan P.D., 2007. Using structural equation modelling to test environmental performance in small and medium-sized manufacturers: can SEM help SMEs? *Journal of Cleaner Production* 15(4): 303-312. <http://doi.org/10.1016/j.jclepro.2005.12.002>
- Kadipas N., Pexioto M.B., 1999. Global manufacturing practices: An empirical evaluation. *Industrial Management & Data Systems*, 99(3): 101-108.
- Kamble S.S., Gunasekaran A., Gawankar S.A., 2020. Achieving sustainable performance in a data-driven agriculture supply chain: A review for research and applications. *International Journal of Production Economics*, 219, 179-194. <http://doi.org/10.1016/j.ijpe.2019.05.022>
- Kumar A., Mishra A.K., Saroj S., Sonkar V.K., Thapa G., Joshi P.K., 2020. Food safety measures and food security of smallholder dairy farmers: Empirical evidence from Bihar, India. *Agribusiness*. <http://doi.org/10.1002/agr.21643>.
- Kumar A., Staal S.J., Singh D.K., 2011. Smallholder dairy farmers' access to modern milk marketing chain in India. *Agricultural Economics Research Review*, 24: 243-253. <http://doi.org/10.22004/ag.econ.118232>
- Lau K.W., Yam C.M., Tang P.Y., 2010. Supply chain design and product modularity. *International Journal of Operations & Production Management*, 30(1): 20-56.
- Lee Y.H., Kim S.H., Moon C., 2002. Production-distribution planning in supply chain by using a hybrid approach. *Production Planning and Control* 13(1): 35-46. <http://doi.org/10.1080/09537280110061566>
- Lemma H., Singh R., Kaur N., 2015. Determinants of supply chain coordination of milk and dairy industries in Ethiopia: a case of Addis Ababa and its surroundings. *SpringerPlus* 4: 1-12. <http://doi.org/10.1186/s40064-015-1287-x>
- Ling E.K., Wahab S.N., 2020. Integrity of food supply chain: going beyond food safety and

- food quality. *International Journal of Productivity and Quality Management*, 29(2): 216-232.
<http://doi.org/10.1504/IJPQM.2020.105963>
- Len-Bravo V., Caniato F., Caridi M., 2019. Sustainability in multiple stages of the food supply chain in Italy: practices, performance and reputation. *Operations Management Research*, 12(1-2): 40-61.
<http://doi.org/10.1007/s12063-018-0136-9>
- Abdulai Rahaman A., Abdulai A., 2020. Vertical coordination mechanisms and farm performance amongst smallholder rice farmers in northern Ghana. *Agribusiness*, 36(2), 259-280.
<http://doi.org/10.1002/agr.21628>
- Mishra P.K., Shekhar B.R., 2011. Impact of risks and uncertainties on supply chain: a dairy industry perspective. *Journal of Management Research* 3(2): 1-18.
<http://doi.org/10.5296/jmr.v3i2.651>
- Mor R.S., Bhardwaj A., Singh S., Arora V., 2020. Exploring the factors affecting supply chain performance in Dairy industry using exploratory factor analysis technique. *International Journal of Industrial and Systems Engineering*, 36(2), 248-265.
<http://doi.org/10.1504/IJISE.2020.110277>
- Mor R.S., Jaiswal S., Singh S., Bhardwaj A., 2019a. Demand Forecasting of the Short-Lifecycle Dairy Products, In: Chahal H., Jyoti J., Wirtz J. (eds.), *Understanding the Role of Business Analytics*. Springer, Singapore.
http://doi.org/10.1007/978-981-13-1334-9_6.
- Mor R.S., Bhardwaj A., Singh S., Nema P.K., 2019b. Framework for measuring the performance of production operations in dairy industry, In: *Managing operations throughout global supply chains*. <http://doi.org/10.4018/978-1-5225-8157-4.ch002>, IGI Global.
- Mor R.S., Bhardwaj A., Singh S., 2018. Benchmarking the interactions among barriers of dairy supply chain: An ISM approach. *International Journal for Quality Research*, 12(2): 385-404.
<http://doi.org/10.18421/IJQR12.02-06>
- Nabhani F., Shokri A., 2009. Reducing the delivery lead time in a food distribution SME through the implementation of six sigma methodology. *Journal of Manufacturing Technology Management* 20(7): 957-974.
<http://doi.org/10.1108/17410380910984221>
- Nardi V.A.M., Auler D.P., Teixeira R., 2020. Food safety in global supply chains: A literature review. *Journal of Food Science*, 85(4), 883-891.
<http://doi.org/10.1111/1750-3841.14999>
- Nargundkar R., 2004. *Marketing Research: Test and Cases*, 2nd Ed., Tata McGraw Hills Pvt. Ltd: New Delhi, India.
- Ngai E.W.T., Cheng T.C.E., Ho S.S.M., 2004. Critical success factors of web-based supply-chain management systems: an exploratory study. *Production Planning & Control*, 15(6): 622-630.
<http://doi.org/10.1080/09537280412331283928>
- Nunnally J.C., 1978. *Psychometric Theory*, 2nd Ed. New York: McGraw Hill.
- Okano M.T., Vendrametto O., Santos O.S., 2014. How to improve dairy production in Brazil through indicators for the economic development of milk chain. *Modern Economy* 5: 663-669.
<http://doi.org/10.4236/me.2014.56062>
- Pitt L.F., Watson R.T., Kavan C.B., 1995. Service quality: A measure of information systems effectiveness. *MIS Quarterly*, 19, 173-187.
<http://doi.org/10.2307/249687>
- Robson C., 2002. *Real World Research*, 2nd Ed. Oxford: Blackwell.
- Sahin F., Robinson E.P., 2002. Flow coordination and information sharing in supply chains: review, implications, and directions for future research. *Decision Sciences* 33(4): 505-536.
<http://doi.org/10.1111/j.1540-5915.2002.tb01654.x>
- Saunders M., Lewis P., Thornhill A., 2009. *Research Methods for Business Students*, 5th Ed. Essex: Person Education.
- Safaei A.S., Husseini M., Farahani R.Z., Jolai F., Ghodsypour S.H., 2010. Integrated

- multi-site production distribution planning in supply chain by hybrid modelling. *International Journal of Production Research* 48(14): 4043-4069. <http://doi.org/10.1080/00207540902791777>
- Selim H., Ozkarahan I., 2008. A supply chain distribution network design model: an interactive fuzzy goal programming-based solution approach. *Int. J. Advance Manufacture & Technology* 36, 401-418. <http://doi.org/10.1007/s00170-006-0842-6>
- Singh N., Javadekar P., 2011. Supply chain management of perishable food products: a strategy to achieve competitive advantage through knowledge management. *Indian J. of Marketing* 41(10).
- Sitek P., Wikarek J., 2015. A hybrid framework for the modelling and optimisation of decision problems in sustainable supply chain management. *Int. J. Production Research* 53(21): 6611-6628. <http://doi.org/10.1080/00207543.2015.1005762>
- Smith B.G., 2007. Developing sustainable food supply chains. *Philosophical Transactions of the Royal. Society B: Biological Sciences* 363(1492): 849-861. <http://doi.org/10.1098/rstb.2007.2187>
- Tanaka J.S., 1987. How big is big enough? Sample size and goodness of fit in structural equation models with latent variables. *Child Development*, 58(1): 134-146. <http://doi.org/10.2307/1130296>
- Thirupathi R.M., Vinodh S., 2016. Application of interpretive structural modelling and structural equation modelling for analysis of sustainable manufacturing factors in Indian automotive component sector. *International Journal of Production Research* 54(22): 6661-6682. <http://doi.org/10.1080/00207543.2015.1126372>
- Thomas A.V., Mahanty B., 2018. Dynamic assessment of control system designs of information shared supply chain network experiencing supplier disruption. *Operational Research*, 21, 425-451. <http://doi.org/10.1007/s12351-018-0435-9>.
- Trochim W.M., 2007. *Research Methods*, Biztantra, New Delhi.
- Vinodh S., Joy D., 2012. Structural equation modelling of lean manufacturing practices. *International Journal of Production Research* 50(6): 1598-1607. <http://doi.org/10.1080/00207543.2011.560203>
- Vosooghizaji M., Taghipour A., Canel-Depitre B., 2020. Supply chain coordination under information asymmetry: a review. *International Journal of Production Research*, 58(6): 1805-1834. <http://doi.org/10.1080/00207543.2019.1685702>
- Zhang X., Yousaf H.A.U., 2020. Green supply chain coordination considering government intervention, green investment, and customer green preferences in the petroleum industry. *Journal of Cleaner Production*, 246, 118984. <http://doi.org/10.1016/j.jclepro.2019.118984>

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