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A Technological Approach to Bridge the Existing Information Gap in the Food Supply Chain

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ABSTRACT

Information flow in supply chain management has always been a concern to improve efficiency. Proper information flow has turned out to be a prerequisite to ensure that there is continuity, visibility, and traceability in the food supply chain. This research paper aims at understanding the risks due to lack of information flow in the food supply chain, particularly concentrating the cluster of Dairy Products, Cold Storage Frozen Products, Perishables: Fruits & Vegetables, Packaged Food Products. Quantitative research has been carried out to identify the key factors that cause an information gap in the supply chain and technological approach has been proposed that can bridge this information gap. The future scope of this research can be on the effective ways of utilizing these technologies to further improve the food supply chain and ensure continuous flow.

Keywords: Information, food supply chain, technology, risk.

INTRODUCTION:

Continuous innovation is a key ingredient in maintaining a competitive advantage in the current dynamic and demanding marketplace (Tyagi, Cai, Yanga, & Chambers, 2015). It is very important that a proper channel of information flow be ensured so that the traceability, problem-solving and decision making becomes easier in the entire supply chain. Innovative ideas have to be brought in to ensure this flow. Interactions among internal and external resources can be leveraged to generate knowledge from existing knowledge unlike other passive resources (Leonard & Sensiper, 1998). However, it so occurs that due to various behavioural, environmental and societal factors, there is no proper information flow which can be a huge cost to the organization. Incorporating a proper information flow into the Supply Chain Management practices, companies can enhance their potential for mounting competitive advantage. Gunasekaran et.al (2004) through his research shows how IT integration has helped supply chains improve their visibility and therefore profitability for the firm (Gunasekaran & Ngai, 2004).

This research paper mainly focuses on the existing gaps in information system in food supply chain especially concentrating on the cluster of Dairy Products, Cold Storage Frozen Products and Perishables: Fruits & Vegetables, Packaged Food Products that acts as a barrier to achieve supply chain efficiency. The variables under consideration are traceability, problem-solving and decision-making skills which would support the research data collection. The data collection would be through questionnaire survey which would help in identifying the gaps involved in the existing information system and proposing a working model that would

eradicate this gap thereby providing social benefits, food security, and better supply chain productivity.
The remainder of this paper is organized as follows: The next section reviews the relevant literature related to the information system that currently exists in the supply chain practices along with identifying the gaps and risks associated with it. Section 3 highlights the research methodology of finding and analyzing the gaps within the existing information systems adopted in the supply chain. Section 4 details the data analysis with the variables obtained through questionnaire survey conducted with the subject matter experts and from the literature review to obtain the root cause of the information gaps in the food supply chain with the help of Ishikawa diagram, Section 5 gives a proposed model to tackle the existing information gap in the system.

LITERATURE REVIEW:

Supply chain information management is a project which involves many subjects, has a complex structure. (Lian & Hu, 2008).In today's world, competition is not among the different organizations in the industry, but among the partners of the supply chain (Kumar & Pugazhendhi, 2012). Kumar and Pugazhendhi (2012) clarify that information in a supply chain is bi-directional wherein the information on point of sales as well as that of demand flows from downstream to upstream while the information about the order flows from upstream to downstream. A firm's competitive advantage is based on how effectively they can translate both their tacit and explicit knowledge into a future useable format. Lack of information sharing between members of the supply chain has been shown to significantly affect total profitability (Shaw, Meixell, & Tuggle, 2008). Effective information management capabilities can help in value creation to its customers by increasing operational efficiency and improved decision making. (Collins, Worthington, Reyes, & Romero, 2010). Simatupang et.al in has identified the importance of information sharing and collective learning for an efficient supply chain management. (Simpatupang, Wright, & Sridharan, 2002).
Information integration has emerged as one of the key dimensions of supply chain integration and plays a significant role in the effectiveness and efficiency of an overall supply chain with agri-food SCs involving a large number of stakeholders that includes logistics partners and regulatory bodies. (Nakandala, Samaranayake, Lau, & Ramanathan, 2017).Four key elements play a major role in determining the knowledge aspect of the supply chain, namely, information sharing, direct and real-time accessibility, planning and decision making. A conceptual framework for supply chain management would help in enhancing the safety, sustainability and logistics efficiency in the food supply chain. (Manzini & Accorsi, 2013).To ensure a throughout sustainability in the food supply chain right from the primary producers to the consumers, through sharing of knowledge is important to ensure sustainability (Gold & Heikkurinen, 2013)
Yong et al. (2012) discussed the need for the integration of the information in the dairy supply chain.to provide producers with timely access to valuable informational resources. The key requirements as identified by the author include: 1) a scientific, firmly-structured agricultural information classification system that can be extended; 2) effective sharing of information. To improve transparency of information flow in the dairy supply chain, necessary infrastructure is required for continuous information exchange between supply chain partners through real-time monitoring systems (Pant, Prakash, & Farooquie, 2015). Parwez (2015) explains how lack of integration of information between the storage warehouses and transportation can lead to food wastage in the cold food supply chain. He also tries to explain that lack of IT infrastructure is one key issue that acts as a barrier for this information sharing. Thus for the information integration, it is necessary to have knowledge of production processes and the informational exchanges between processes and their environments. It is also necessary to identify the useful and redundant information that is available so that unnecessary complications can be avoided. Samaranayake and Laosirihongthong (2016) explain that better information integration can help in on-time delivery of food products and aid in decision making in the dairy supply chain.
Fruits and vegetables supply chain lack in proper information flow and visibility among the various agri-producers. Lack of awareness of the benefits of fruits and vegetables to consumers is another factor that can sometimes reduce the sale of the products (Reddy, Murthy, & Meena, 2010). Zhong et.al (2015) describes the benefits of improved information system in the agricultural domain. Current fruits and vegetable supply chain in India lacks in building necessary market information, necessary cold-storage capacity (Rais & Sheoran, 2015). Lack of demand estimation and product tracking is leading to huge food loss. Wastage in the supply chain is also due to large intermediaries that are unorganised. Thus the key information has to be required on seasonal demand of the products, the shelf life of the products, real-time information about the product from the provenance to end-consumer. Indian perishable food supply chain is quite complex that involves a huge number of stakeholders but there is no strong system in place that helps in these stakeholder collaborations. Lack of accurate information on the demand requirement in the chain. The quality and life of cold chain products

depend on information on temperature and shelf life of products. Göransson et al. (2017) and Olsson (2011) shows that quality information of temperature on the pallets or even closer in the cold supply chain is still a gap. The existence of various formats in the supply chain makes it difficult in gaining information from the data collected in cold food supply chain (Raab, Petersen, & Kreyenschmidt, 2011). Research by the NABARD consultancy service (2015) shows that the infrastructure gap, lack of standardisation of the information received and use integrated computer technology are the main challenges faced by cold food supply chain in India. Real-time monitoring of information is also a critical factor to supply chain.

At the top management level, it is very crucial that the relevant information is obtained so that strategic decisions can be made (Hsiao, Vorst, Kemp, & S.W.F, 2010). It is necessary that information on asset specificity, core closeness and supply chain complexity be understood to have a strong decision making. In the work done by A. Singh et al (2017), an attempt has been made to use social media data in the domain of the food supply chain to transform it into a consumer-centric supply chain. The results from the analysis have been linked with all the segments of the supply chain to improve customer satisfaction. For instance, the issues faced by consumers of beef products, such as discolouration, the presence of foreign bodies, extra fat, and hard texture, have been linked to their root causes in the upstream of the supply chain (Singh, Shukla, & Mishra, 2017). Though the recent attempts to leverage technology has been of key interest, it is generally difficult to ensure full products traceability through industrial food chains, due to the lack of efficient information and communication systems.

All these existing information gaps can be bridged by enabling technology in the supply chain. Leveraging technology such as cloud and internet can boost the supply chain visibility and transparency (Shi, 2017). Increasingly stringent requirements for food safety, as well as a growing demand for food characterized by a certain identity call for the development of increasingly large and efficient traceability systems. Incorporating the recent technologies of RFID can help food supply chain management achieve traceability. (Dabbene, Gay, & Cristina, 2013).

RESEARCH METHODOLOGY:

Problem Statement:

The current food supply chain faces a lot of hiccups in operating efficiently mainly due to information gaps existing within the system (2004). It is quite necessary that we identify the critical elements that contribute to these information gaps which on resolving can aid in improving the operational efficiency of the supply chain.

Research Objective:

The main objective of this research is to identify the critical variables that cause an information gap in the food supply chain and to propose a feasible solution to resolve this pertaining issue.

Methodology:

The research focuses on variable identification creating an information gap with regard to the 5 clusters of the food supply chain. This involves both primary and secondary data collection. The primary data collection has been done through a questionnaire survey with the survey demographics including academicians, supply chain managers, and subject matter experts. The secondary data has been collected by reviewing journals (Elsevier, IEEE explore, Procedia), articles and reports by consulting firms such as Deloitte, BCG, NCCD etc. Reviewing journals have given the surface level causes, which are then drilled down using the Ishikawa diagram to obtain the root causes.

FINDINGS AND DISCUSSIONS:

Data Analysis:

This stage focuses on analyzing the data obtained through primary research from the academicians, supply chain managers, and subject matter experts. The academicians constitute 23% of the total respondents while the supply chain managers and the subject matter expert constitutes the remaining 87%.

Figure 1: Research Framework

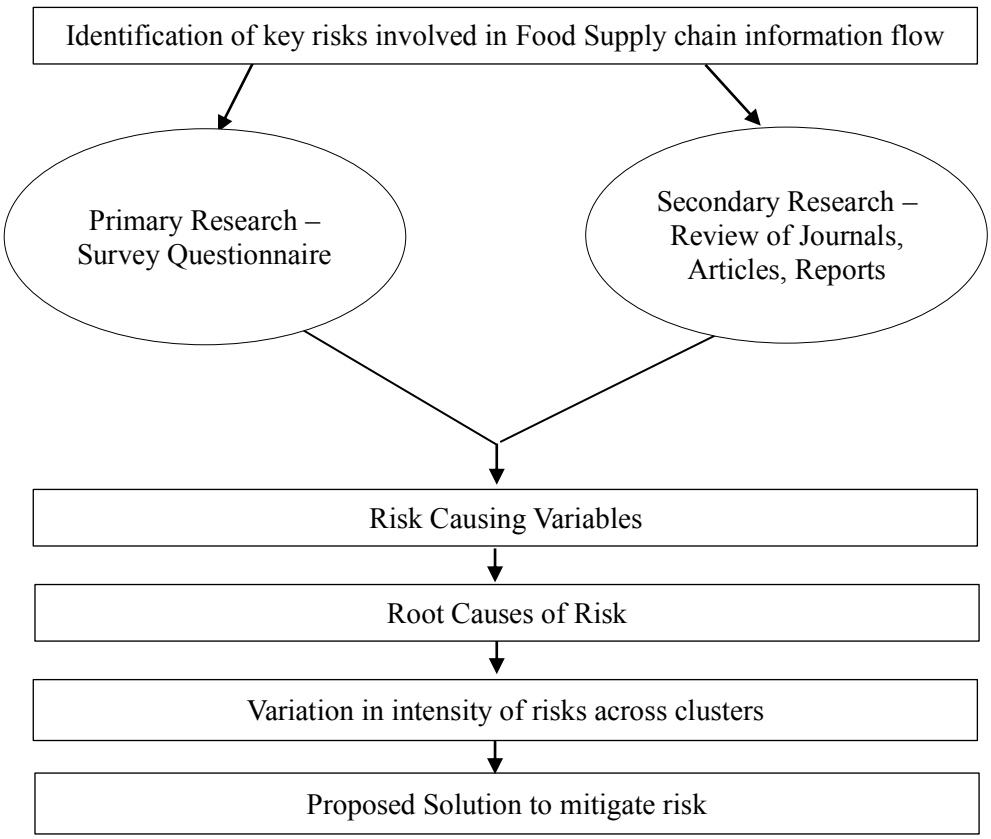
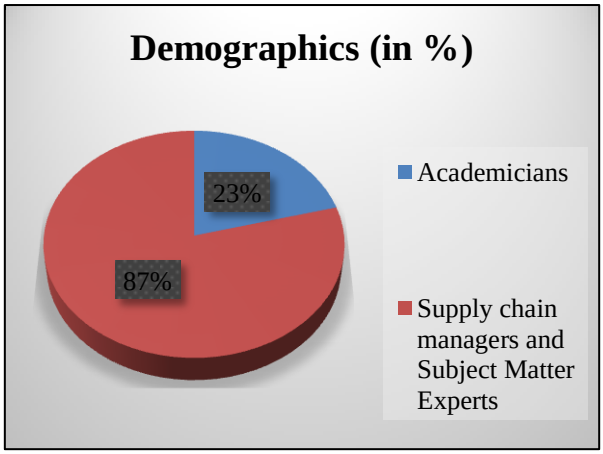
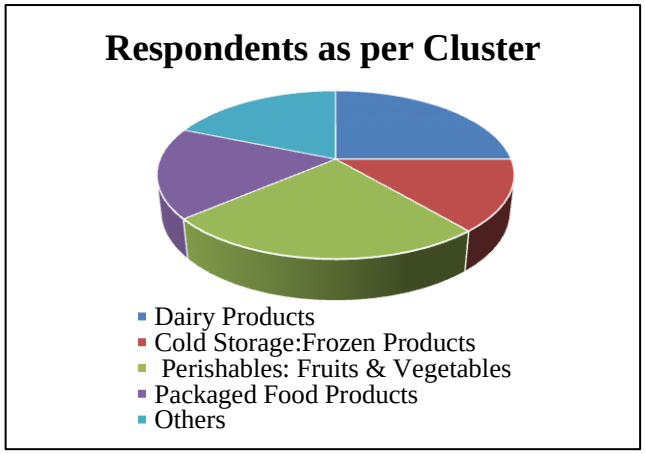


Figure 2: Demographics (in %) and the number of respondents per cluster of the primary survey





The data obtained from the survey was initially tested for significance using Chi-square test which showed that improving traceability, timeliness of information, lack of IT infrastructure, technological disruption, data security, cost, inventory, reduced productivity, reduced traceability, complete information, and bullwhip effect were significant. The cleaned data is then put to IBM SPSS 21 to identify the clusters that significantly have an impact on the information gaps.

Table 1: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.769
Bartlett's Test of Sphericity	Approx. Chi-Square	208.767
	Df	55
	Sig.	.000

In table 1, KMO measure > 0.5
Hence it is possible to extract reliable factors from the given set of variables.
Bartlett's test of sphericity:
Null hypothesis H0: correlation is not significant
Alternate hypothesis H1: correlation is significant.
Here p-value < 0.05, Hence the correlation is significant which means that we can perform factor analysis

Table 2: Component Score Coefficient Matrix

	Component	
	1	**2**
Improving_traceability	-.143	-.242
Timeliness_of_information	-.032	-.195
Lack_of_IT_Infrastructure	.228	.036
Technological_Disruption	-.198	.021
Data_Security	.255	.192
Cost_effectiveness	-.087	-.024
Inventory	.030	.245
Reduced_Productivity	.218	.010
Reduced_traceability	.171	-.054
Complete_Information	-.021	.187
Reduced_Bull_whip_effect	-.010	.223

Extraction Method: Principle Component Analysis
Rotation Method: Varimax with Kaiser Normalization
Component Score coefficient matrix (Factor score coefficient matrix)
Factor score for factor 1 = -0.143 (standardized score of X1) - 0.032(standardized score of X2)

Table 3: Total Variance Explained

Component	Extraction Sums of Squared Loadings	Rotation Sums of Squared Loadings		
	Cumulative %	**Total**	**% of Variance**	**Cumulative %**
1	49.697	4.260	38.726	38.726
2	74.646	3.951	35.919	74.646

Extraction Method: Principal Component Analysis.
Percentage of total variation explained by factor 1 is 38.726%; by factor 2 is 35.919%. Total variation explained by both the factors put together = 74.646%

Scree Plot:

Figure 3: Scree Plot

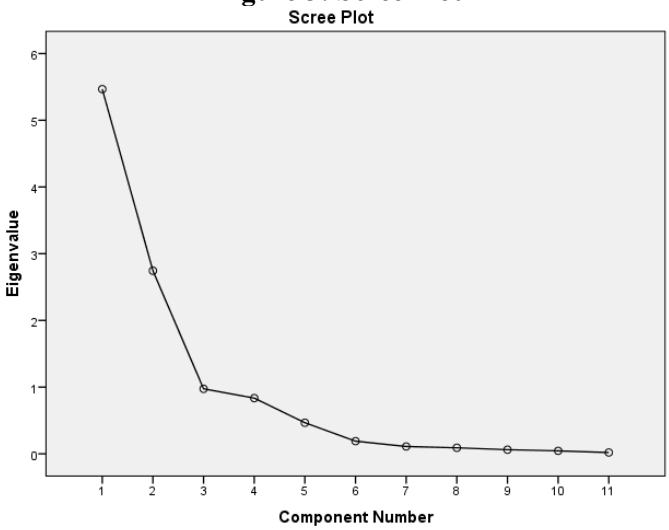


Table 4: Rotated Component Matrix

	Component	
	1	2
Improving_traceability	-.281	-.764
Timeliness_of_information	.127	-.727
Lack_of_IT_Infrastructure	.923	-.165
Technological_Disruption	-.873	.350
Data_Security	.825	.415
Cost_effectiveness	-.340	.025
Inventory	-.206	.930
Reduced_Productivity	.915	-.256
Reduced_traceability	.800	-.443
Complete_Information	-.342	.768
Reduced_Bull_whip_effect	-.344	.894

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.
We assume that the cut-off point is 0.7, i.e. the values greater than 0.7 are significant. Thus the two factors are:

Table 5: Analysed Factors

Factor 1	Factor 2
Lack of IT Infrastructure	Timeliness of Information
Reduced Traceability	Complete Information
Reduce Productivity	Inventory
Technology Disruption	Reduced Bullwhip Effect
Data Security	

Thus factor 1 can be defined as technological factors and factor 2 can be defined as information requisite factors. The secondary research from the review of the literature shows that the key variables that cause the information gap in the food supply chain are:

- Poor Traceability
- Lack of supply chain Integration
- Poor Decision Making
- Lack of Information Accuracy
- Shelf life
- Lack of Visibility
- Lack of Technology
- Poor Partner Collaboration

The root causes of each of these perceived risks can be obtained by using the Ishikawa diagram, with the supporting data obtained from the research papers that have been reviewed.

Table 6: Identification of Root causes from the perceived risks of an information gap in the food supply chain

S no	Variables Identified (Y's)	Factors of Y - X's	Source	Type of Industry	Impacts in FSC	Remarks
1	Poor Traceability	Producers alter information for personal gain, Enterprise concerned with individual profits rather than entire chain, Variation of rules across borders	Research on the risk factors affecting food traceability in the food supply chain	Dairy Industry	Food contamination , unhygienic food processing, hazards in storage and transportation	Lack of traceability leads to information opacity that can cause food contamination and hazards in storage and transportation.

S no	Variables Identified (Y's)	Factors of Y - X's	Source	Type of Industry	Impacts in FSC	Remarks
2	Lack of supply chain Integration	Technology, Culture of organisation, employee training, trust, risk and reward sharing	A Study of the Different Factors That Affecting the Supply Chain Responsiveness	General	Integration can help in better visibility across the supply chain. Lack of collaborative decision making can have an effect on coordination.	Effective system of communication can improve the chain performance and enable supply chain integration
3	Poor Decision Making	Information for Top level management, financial decision, reduce asymmetry information, better customer service			Lack of collaborative decision making can have an effect on coordination.	Information supports better decision making, as visibility helps in better demand forecasting and also helps in developing trust between partners.
4	Lack of Information Accuracy	No real time information, Technology	Scope of Supply Chain Management in Fruits and Vegetables in India	Fruits and Vegetables	Decision making, quality and safety of food, collaboration between chain partners can be affected	Lack of information accuracy can lead to poor decision making, customer satisfaction in the products, food wastage
5	Shelf life	Information on safety, quality, validity of products, packaging and nutritional value	Techniques in shelf life evaluation of food products - Yuthana phimolsiripol; Panuwat Suppakul	Package food industry	Controlled production and supply of food products as per the market demand	Shelf life impacts the continuity of the products in the supply chain. It is crucial to the entire supply chain partners to ensure high quality of the product during its storage.
6	Low Transparency	Geographical constraints, Frequency of transaction, explicitness of information, quality of communication	Transparency in food supply chains: empirical results from German pig and dairy production Mark Deimel, Mechthild Frentrup and Ludwig Theuvsen	Pig and Dairy Industry	Lack of trust and safety can lead to high cost in the chain	Transparency helps in gaining consumer trust by ensuring the quality and safety of food.
7	Lack of Visibility	Technology, Investment, Synchronisation difficulty of end to end process, response from chain partners, no data integration	https://3pllinks.com/supply-chain-visibility-important/ ; Improving SC Efficiency through convergence, collaboration and visibility -Kewill	General	Efficiency is reduced	Visibility ensures end to end synchronisation of process, which helps in improving the chain efficiency and reducing cost
8	Lack of Technology	lack of skilled person, investment decision,	The role of Information	Food supply	lack of technology can	The information about the need for

S no	Variables Identified (Y's)	Factors of Y - X's	Source	Type of Industry	Impacts in FSC	Remarks
		less perceived technological benefits	Technology in Supply Chain Integration Injazz J. Chen,Antony Paulraj	chain	reduce transparency and coordination in the supply chain	new technology is often unknown to the employees and top management. The resistance to change from legacy system also plays an important role.
9	Poor Partner Collaboration	Commitment - willingness of trading partners to exert effort on behalf of the relationship; Trust - one party's expectation that other party will perform satisfactorily; Cooperation-work towards mutual goals	Factors affecting collaboration in supply chain: A literature Review Manoj Hudnurkar , Suresh Jakhar , Urvashi Rathod	General	Information sharing is imporatant in exchange of critical and proprietary information between supply chain members through media such as face to face meetings, telephone, fax, mail, and the Internet so that timely and accurate information is obtained.	Information sharing acts and adhesive in binding the supply chain partners as well as the chain. This enables supply chain to be agile in responding to challenges.

Findings:

Thus the data analysis shows that information gap in today's food supply chain is mainly caused due to the poor traceability, lack of accurate information that can lead to wrong decision making from the operational level to the strategic level.

Only the right information of the right quality to the right person at the right time can help such a dynamic supply chain work efficiently. These critical issues can be solved by involving a technological perspective to the system.

Technological approach to bridge the information gap:

The recent advancements in the technology have opened up new and innovative ideas to bring down the cost and improve the efficiency of the supply chain. The horse meat scandal of 2013 in Britain opened up the need for tracing back to the suppliers to its provenance. (Linch, 2014). Companies that are a part of the supply chain have already adopted technologies such as RFID for improving the visibility, as mentioned by Dabbene et.al. (2013) and Manzini et.al (2013).

But increasing complexity of the food supply chain due to changing demands and needs from the customer end can only be met by implementing an advanced technology such as blockchain. As per a report from World Watch Institute (2015), the three critical information nodes in the agriculture food supply chain are farmers, chain transparency and low-cost technology. This efficiency can be achieved by blockchain implementation.

Another important technology is the IoT (Internet of Things) that can help in bridging this gap. Companies such as DiscoveryIoT, STELLAPPS, and TagBox (2018) have enabled this technology in the various food supply chain. STELLAPPS is the first Indian IoT company in the dairy industry. The aim of this technology is to reduce the food spoilage and improve transparency in the food chain.

CONCLUSION AND SCOPE FOR FUTURE RESEARCH:

With the research, the critical variables that caused the information gap in the food supply chain's five clusters under study were identified. The critical factors identified from the primary research are technological factors

and information requisite factors while the factors identified from the secondary research are Poor Traceability, Lack of supply chain Integration, Poor Decision Making, Lack of Information Accuracy, Shelf life, Lack of Visibility, Lack of Technology and Poor Partner Collaboration. Out of the available alternatives, one best method to bridge the existing gaps in the food supply chain is by leveraging technologies such as RFID, IoT and blockchain. The future research can be on the effective ways of utilizing these technologies to further improve the food supply chain and ensure continuous flow.

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