An Exploratory Study of Critical Issues and Variables Affecting the Food Supply Chain Risk Iceberg

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Abstract
The food supply chain ecosystem is critical, and a budding sector; this area has several challenges that shall be addressed and requires meticulous attention to detail and environment that are to be considered apart from the general issues that one entity experiences in a broad supply chain environment. It makes the Food Supply Chain Management a complex and precision-driven area towards quality and environmental factors to be dealt with recurrently. The critical aspects of the food supply chain are the cold chain, infrastructure, technology, knowledge, and post-harvest issues. These issues are analysed using statistical methods and interpretation to better understand food supply chain management.

Keywords: Food Supply Chain, Critical Issues, Risks, Food and Vegetable Supply Chain

Introduction
(Bautista et al., 2014) introduces us as food is the bedrock of life and the foundation of our physical, spiritual and emotional wellbeing, which is at the heart of many critical environmental, social and economic challenges we confront. Sustainability issues, climate changes, water scarcity, food security and sustainable nutrition, consumer attitude, demographic change, empowered producers, therapeutic approach, resilient value networks, sustainable market mechanisms, connected consumers are some of the challenges to name. To meet the globalised market demands, value chains are more complex, and this complexity carries with its opportunities for growth into new markets.
Methodology

Problem Statement
Huge losses in the food supply chain due to critical factors/variables. Identification of key issues in the food supply chain to find an innovative solution.

Objectives
• To explore the key issues affecting the iceberg of the food supply chain.
• To analyse the supply chain performance and its relationship with the critical threats.

Literature Review
There is a gap among the existing methods in managing the fruits and vegetables food supply chain. Uncoordinated information from downstream to upstream of the supply chain has created a lot of wastages and losses for most food processors. The recall of expired products justifies it due to excessive supply. The inaccurate information suggests that the processors work on unreliable improved (bullwhip effect) demand data, with profound cost implications (Lee, 2004; Ouyang and Daganzo, 2008). For instance, a facility that processes the fruits and vegetables visited had a recalled product of about 10 tons of tomato sauce; this was a massive loss for the company to recover. (Minegish and Thiel, 2000) the company has to incur labour costs, transportation costs, destruction costs, primary and secondary raw materials etc. One of the respondents from the brewing industry reported incurring inventory costs of about 2 to 3 % of their value, i.e. From rental, interest foregone, obsolescence/damage/expire, insurance, handling, security and stock valuation.
The unfamiliarity of inventory at wholesalers’ and retailers’ stores had the following impacts on the processors.

| Table 1: Key Issues Assimilated by Researchers from Various Journal Articles |
|---------------------------------------------------------------|
| **Issues** | **Variables** | **Source** | **Strategies** |
| Cold Chain Issues: Cold Chain Facilities | Deficiency in Cold storage & warehousing facilities. Infrastructure to assist the needs. | Salin, V., Jr, R. M. N., & Nagya, R. M., (2003); Agarwal, S,(2017) | Development of Cold Chain Infrastructure at the centre area of the central Fruits and Vegetables production belt. Private companies or cooperative societies can set up cold storage services. |
| Fragmentation Issues: Fragmented supply chain | Traders are dominant in the supply chain—many local & commissioning agents. | Burke, G. J, Carrillo, J. E, & Vakharia, A. J,(2007); Samaranayake, P., & Laosirihongthong, T.,(2016); Parwez, S., (2015) | The village farmers may create cooperative market societies. State Government agencies can enter into the higher value-added fruits and vegetable processing activity. |
| Infrastructure Issues: Infrastructure Facilities | Lack of Storage / Warehouse condition on the farm side. Lack of processing & packaging facilities. Poor & inadequate loading & unloading facilities | Caplice, C., Sheffi, Y.; Ganeshan, H, & Sivasamy, N (2018); Hsiao, H, Vorst, J. v, Kemp, R, & S.W.F, O (2010); | Government/agencies/entrepreneur s can set up semi-processing units nearer to the agricultural production zone. |
| Technological Issues: Technological Facilities | Restricted use and lack of appropriate technologies & advanced techniques in food processing. Non-adoption of efficient technology. | Auramo, J., Kauremaa, J. and Tanskanen, K. (2005); Gunasekaran, A., & Ngai, E., (2004); Vickery, S.K., Droge, C., Setia, P. & Sambamurthy, V. (2010); | Developing micro-sized food parks at various centre points of district areas with packaging, semi processing, grading, better equipment for loading and unloading machinery for value addition in F&V. |
| Knowledge and Awareness Issues: Farmer’s Knowledge and Awareness | Lack of knowledge on post-harvest technologies or PHTs. Lack of farmer’s awareness and instruction related to post-harvest management. | Surendra P. Singh, B.K. Sikka, And Ashutosh Singh, (2009); Hemant Saini and Sushma, (2019); Jraisat, L.E. and Sawalha, I.H. (2013); Gebru Hailu, and Belew Derbew, (2015) | Exhibitions and technical fairs can be conducted for recently developed technology initiatives. Support of Research Institutions to provide knowledge on the latest technologies. |
| Quality Issues: Quality and Safety standards | Lack of tracking and traceability facilities. Poor hygiene and safety standards. | Umesha Thilini, Prof. Achini De Silva, and Dr M. A. J. P. Munasinghe, (2020); Woods, E. J. (2003) | Government support provides hygienic packaging material to the farmers at reasonable prices and auto handling of F & V. Use preservation and chilling technologies or cold storage for processing control. |
| Post-Harvest Issues: Supply chain losses and wastage of fresh produce | High wastage in reaching the processing station along the supply chain due to lack of cold chain & infrastructure. | Maryam Rezaei, Bin Liu, (2017); Jenny Gustavsson, Christel Cederberg & Ulf Sonesson, (2011); | Setting up cold chain facilities in various districts and major production belts. Construction of post-harvest facilities. |
Transport Issues:
Transportation Facilities
- Unavailability or inefficient and costly transportation for the movement.
- Lack of Refrigerated vehicles for the transportation of F&V in the hilly and rural areas.
- Setting up state government or public-private partnership refrigerated F&V transportation systems

Information Issues:
Demand and market information
- The farmers lack market information, such as prices, demand, product flow, food processing unit, etc.
- Information on demand forecasting ITC initiative of e-choupal can be replicated in the state F&V sector.
- A government portal can be established showing daily prices of F&V.

Table 2: The Research Journey for Studying the Several Key Papers Across Years on the Topic of Factors/Variables Affecting the Food Supply Chain

| Year | Authors |
|------|---------|
| 2000 | Bowersox DJ, Closs DJ, Keller SB., Lokunarangodage, C. V. K, Wickramasinghe, I, & KKDS, R., Christopher, M. |
| 2001 | Gunasekaran, A., Patel, C. and Tirtiroglu, E., Sheffi, Y., Tan, K. C., Lummus, R.R., |
| 2002 | Simatupang, T.M. & Sridharan, R., |
| 2003 | Salin, V., Jr, R. M. N., &Nagya, R. M., Basnet, C., Corner, J., Wisner, J. and Tan, K Brian, B. |
| 2004 | Christopher, M, & Lee, H.,Gunasekaran, A., & Ngai, E., Gunasekaran, A., Patel, C., McGaughhey, R.E., Chopra, S. & Sodhi, M. S., |
| 2005 | Samaranayake P., |
| 2006 | Wu, T., Blackhurst, J., Chidambaram., V.; Ulbrich, F., |
| 2007 | Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J., & Handfield, R. B., Matopoulos, A., Vlachopoulos, M., Manthou, V., & Manos, B., Ruben, R., Boselie, D., & Lu, H., |
| 2008 | Wu, D., Olson, D.L.,Lummus, R.R., Vokurka, R.J. & Krumwiede, D.,Bhardwaj S, & Palaparthy, I., |
| 2009 | Tang, C.S., Zimmerman, J.D., & Nelson, J. J.; Trkman, P.; Goknur A., Akyuz & Turan E; |
| 2010 | Hsiao, H., Vorst, J.V. & Kemp, R., Reddy, G., Murthy, M., & Meena, P., Green, D.P. |
| 2011 | Tummala, V.M.R. and Schoenherr, T; Ahsan, D.A; Brandenburg M, Seuring S.; Halder, P, & Pati, S |
| 2012 | Helena C, Susana G, Azevedo & V. Cruz-Machado., Diabat, A., Govindan, K., and Panicker, V. V. |
| Year | Key Authors | Key Papers | Important FSCM Risks/Issues Identified |
|------|-------------|------------|--------------------------------------|
| 2010 | Reddy, G., Murthy, M., & Meena, P | Value Chains and Retailing of Fresh Vegetables and Traditional and Modern Retailing, Food Value Chain | |
| 2011 | Ahsan, D.A. | Farmer’s motivations, risk perceptions and risk management strategies in a developing economy: Bangladesh experience Risk perception, and risk strategies are discussed. | |
| 2012 | Diabat, A., Govindan, K., and Panicker, V. V. | Supply chain risk management and its mitigation in a food industry Classification and mitigation of risk in the food supply chain. | |
| 2013 | Bosona, T., & Gebresenbet, G. | Food traceability is an integral part of logistics management in the food and agricultural supply chain. Food traceability issues. | |
| 2014 | Ouabouch, L.& Paché, G. | Risk management in the supply chain: Characterization and empirical analysis Evaluating the impact of the risks concerning the functioning of a supply chain on its logistical performance. | |
| 2015 | Chang, W., Ellinger, A. E., & Blackhurst, J. | A contextual approach to supply chain risk mitigation. Focussed more on identifying, evaluation and management of sources of supply chain Risk. | |
| 2016 | Samaranayake, P., & Laosirihongthong, T. | Configuration of supply chain integration and delivery. A Conceptual framework of an integrated supply chain model can measure, evaluate and monitor operational performance under dynamic and uncertain conditions. | |
| Year | Authors | Title | Abstract |
|------|---------|-------|----------|
| 2017 | Agarwal, S | Issues in supply chain planning of Fruits and Vegetables in Agri-food supply chain: A review of certain aspects. | Inventory management, Agri-supply chain management, Strategy to respond to upstream-side demand and to absorb downstream-side risks. |
| 2018 | Göransson, M, Nilsson, F & Jevinger | Temperature performance and food shelf-life accuracy in cold food supply chains - insights from multiple field studies. | Food quality that evaluates the temperature performance of cold food supply chains in relation to dynamically predicted shelf life and printed shelf life. |
| 2019 | Zhao G., Shaofeng Liu, Carmen Lopez, Huilan Chen, Haiyan Lu, Sachin K.M., & Sebastian Elgueta | Risk analysis of the agri-food supply chain: A multi-method approach | Thematic analysis, Risk Identification for AFSC (Agri-food supply chain) practitioners. |

**Research Hypothesis**

- **H1:** There is a significant direct negative relationship between Performance-related risks and supply chain performance
- **H2:** There is a significant direct negative relationship between information and knowledge asymmetry related risks and supply chain performance
- **H3:** There is a significant direct negative relationship between market-related risks and supply chain performance

**Micro-level Hypothesis for subfactors**

| Micro-level Hypothesis | Description |
|------------------------|-------------|
| H1.1                   | There is a direct positive relationship of in-transit storage conditions with overall supply chain performance |
| H1.2                   | There is a direct negative relationship of in-transit delays with overall supply chain performance |
| H1.3                   | There is a direct positive relationship of supplier reliability with overall supply chain performance |
| H1.4                   | There is a direct negative relationship of poor quality with overall supply chain performance |
| H1.5                   | There is a direct negative relationship between inventory fluctuations with overall supply chain performance |
| H1.6                   | There is a direct negative relationship of operations downtime due to process variability with overall supply chain performance |
| H2.1                   | There is a direct negative relationship between IT failures with overall supply chain performance |
| H2.2                   | There is a direct negative relationship of Data errors with overall supply chain performance |
| H3.1                   | There is a direct negative relationship of Credit risk with overall supply chain performance |
| H3.2                   | There is a direct negative relationship of Trade inflation with overall supply chain performance |

**Analysis**

Industry Professional Survey: Survey done of key stakeholders (distributors, retailers, end customers, supply chain experts, industry operations managers)

A qualitative thematic study was done with inputs on risks practically faced in the food supply chain from experienced 50 industry experts. The product of the two coded parameters is expressed to design a prioritising factor herein. During a focus group discussion in a panel, the industry...
experts debated the challenges and conflicts in prioritising and identifying these in the supply chain and tabled the issues.

| No. | Sub Factor | Importance Rating | Frequency of Occurrence in the Factor in the Survey | Degree of Intensity of Expression in the Survey - Mean Calculation | Prioritizing Code |
|-----|------------|-------------------|---------------------------------------------------|-----------------------------------------------------------------|-------------------|
| A   |            |                   |                                                   |                                                                 |                   |
| B   |            |                   |                                                   |                                                                 |                   |
| C   |            |                   |                                                   |                                                                 |                   |

### Table: Importance Rating

- **A**: This is the number of times this parameter or rather sub-factor was mentioned by the expert or stakeholder during the discussion. This tells about the number of times in the discussions by all 20 people.

### Table: Degree of Intensity of Expression (in the Survey) - Mean Calculation

- **B**: Each time a respondent talks about or emphasises or writes about any of these parameters or sub-factors, there are degrees of intensity based on which the respondent does give that input, in the sense that on a Scale of 1 to 10 the intensity of that input is rated by the researcher as to whether the respondent was very impactful, effective and assertive about this sub-factor or not. The degree of this impact is gauged a psychometric analytic and a Score is given for each respondent’s response on these parameters. The Mean is the average of all these Response Intensities.
## Risk or Threat factors identified

The table collates data through thematic study, industry experts, and literature review.

### Table 4: Food Supply Chain Prioritization of Risks with Secondary and Primary Data

| Risks or Threats affecting the Food supply chain | Main Risk variables for better understanding towards mitigation measures | Percentage of Secondary Data in Literature prioritising these | Rate of Industry Experts Prioritising these issues | Mean Response on Variables (from Field Survey - Likert Scale) | Response on Standard Deviation for Affirmation (from Field Survey - Likert Scale) |
|-----------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------------------|-----------------------------------------------|-------------------------------------------------------------|------------------------------------------------------------------|
| Performance Threats                          | Logistic Threats- In-Transit Storage Conditions                         | 75                                                          | 81                                            | 4.3                                                         | 1.8                                                              |
|                                               | Logistic Threats- In-Transit Delay & Inefficiencies                     | 64                                                          | 76                                            | 3.9                                                         | 1.5                                                              |
|                                               | Supply Threats- Supplier Reliability                                   | 42                                                          | 62                                            | 4.1                                                         | 2.2                                                              |
|                                               | Supply Threats- Order Discrepancy                                     | 15                                                          | 23                                            | 2.4                                                         | 2.2                                                              |
|                                               | Supply Threats- Poor Quality                                           | 62                                                          | 56                                            | 4.2                                                         | 1.9                                                              |
|                                               | Demand Threats- Forecasting errors                                    | 38                                                          | 28                                            | 2.3                                                         | 1.9                                                              |
|                                               | Demand Threats- Price Fluctuations                                    | 10                                                          | 19                                            | 1.4                                                         | 0.9                                                              |
|                                               | Demand Threats- Inventory Fluctuations                                 | 82                                                          | 78                                            | 4.65                                                        | 2.8                                                              |
|                                               | Process Threats- Operations Downtime (Process Variability)             | 72                                                          | 76                                            | 3.99                                                        | 2.2                                                              |
Table 5: Food Supply Chain Risks Faced by Firms

| Key factors                      | Strongly agree (%) | Agree (%) | Not sure (%) | Disagree (%) | Strongly disagree (%) | Mean  | SD   |
|----------------------------------|--------------------|-----------|--------------|--------------|-----------------------|-------|------|
| Performance-related Risks        | 24                 | 68        | 8            | 0.0          | 0.0                   | 3.56  | 0.58 |
| Information and Knowledge Risks  | 14                 | 84        | 2            | 0.0          | 0.0                   | 4.02  | 0.38 |
| Market Risks                     | 12                 | 62        | 26           | 0.0          | 0.0                   | 2.96  | 0.46 |

Source: Compiled from Primary Data from Pilot Survey

The Table highlights the critical issues based on the occurrences in the literature and information in the secondary sources, industry experts and field inputs. The majority of the respondents agreed that the organisation faces the following supply chain management risks: Information and Knowledge Risks are more prominent in the organisation 98%; Performance related Risks are common in the organisation 92%. Market Risks are more prevalent in the organisation 74%. There
seems to be a need to further analyse with primary data to precipitate and prioritise all conflicting issues in the present context of the disruption-prone food supply chain.

**Cronbach Alpha**

The Cronbach’s Alpha Test assesses the reliability or the internal consistency of all the test items. An alpha value greater than 0.70 indicates higher acceptable internal consistency. From the tests, it is understood that Performance Risks (alpha value – 0.905), Information and Knowledge Risks (alpha value – 0.801), and Market risks (alpha value – 0.886) imply that all their independent variables are closely related, respectively.

**Factor Analysis**

The tested sampling adequacy shows that the value of KMO to 0.775 (EFA-1) and 0.763(EFA-2), which is greater than 0.5. All the variables are accepted and can be taken forward for Confirmatory Analysis.

**Confirmatory Factor Analysis (with field data) for Finalised Variables Path Diagram**

The path diagram is considered for the initial input for the confirmatory factor analysis. The information is obtained from the data set prepared post data collection from the field study. Initial regression weights are allocated to non-observed variables. The variables considered for the confirmatory factor analysis have been considered for further research. The primary independent variables are network management, operational indicators and legal aspects which affect the performance of the non-fragmented food supply chain.

![Figure 1: Figure Path Diagram](http://www.shanlaxjournals.com)
Analysis of Variance (One Way ANOVA)

Table 6: Analysis of Variance (One Way ANOVA)

| Dependent Variable | Independent Variable                                      | p-value | Status of p |
|--------------------|-----------------------------------------------------------|---------|-------------|
| Logistics Threats (X1) | In Transit Storage Condition (X.1.1)                      | 0.004   | p<0.05      |
| Supply Threats (X2)   | In Transit Delay Inefficiency (X1.2)                      | 0.002   | p<0.05      |
|                      | Supplier Reliability (X2.1)                              | 0.000   | p<0.05      |
|                      | Order Discrepancy (X2.2)                                 | 0.125   | p<0.05      |
|                      | Poor Quality (X2.3)                                      | 0.002   | p<0.05      |
| Demand Threats (X3)   | Forecasting errors (X3.1)                               | 0.179   | p>0.05      |
|                      | Price Fluctuations (X3.2)                               | 0.180   | p>0.05      |
|                      | Inventory Fluctuations (X3.3)                            | 0.200   | p<0.05      |
| Process Threats (X4)  | Operations Downtime (Process variability) (X4.1)         | 0.045   | p<0.05      |
|                      | Operations Downtime (Distribution breakdown) (X4.2)      | 0.210   | p>0.05      |
| Information and knowledge Risks (Y2) | IT Failure (X5)                         | 0.004   | p<0.05      |
|                      | Data error (X6)                                          | 0.000   | p<0.05      |
|                      | Lack of IT infrastructure(X7)                           | 0.156   | p>0.05      |
|                      | Training (X8)                                            | 0.135   | p>0.05      |
|                      | Credit Risk (X9)                                         | 0.006   | p<0.05      |
| Risks(Y3)            | Trade Inflation(X10)                                     | 0.007   | p<0.05      |
|                      | Receivables Risk (X11)                                   | 0.000   | p<0.05      |

Source: Computed from the data analysed from the Field Survey

Table 6 represents the output of the ANOVA analysis and shows the significant relationship between dependent and independent variables. The factors post the EFA1 EFA2 CFA. The funnelled variables are shown to be substantial since the p-value is less than 0.05.

Table 7: Regression Analysis of the Model

Supply Chain Management Performance related to the various factors of Performance risks, Information and Knowledge risks, Market risks.

| Model     | B   | Std. Error | T-Statistic | Sig.  | R-square | F-Statistics | P-Value |
|-----------|-----|------------|-------------|-------|----------|--------------|---------|
| Constant  | 2.05| .057       | 7.400       | .000  | 0.767    | 50.76        | .000    |
Table 7 reveals the Food Supply Chain Management Performance Regression Analysis with various key impact factors. A regression result is given as R-Square = 0.767, F-Value = 50.76 and significance (P-Value <0.045) showing the positive significance relationship.

**Discussion Solution**

Several models and frameworks can be designed to address these variables and predict the risks. The applicability of the model framework would provide a sound approach to (i) identify the key variable and the related consequences that affect the food supply chain (ii) measure the performance of the supply chain and its relationship with the variables (iii) mitigating the risks by scheduling and strategizing (iv) monitor the different types of risks in the food supply chain system.

A risk iceberg approach is suggested so that seen and unseen variables can be analysed by the stakeholders. It is an essential framework to identify variables and work on the various techniques to look for easily ‘Seen Risks’ (visible and easily visible) versus the hidden ‘Unseen Risks’ (need to be discovered and identified through analysis) that erupt any disruption. Organisations’ managers can create a framework for better understanding operational risks and responding to and recovering from operational disruptions. Safeguard business by knowing the potential hidden risks.

**Figure 2: Iceberg View for Organizations**

*Source:* Diagram created by Researcher (Suggested by the researcher to the Organizations)

Organisations like Big Basket and Nilgiris have started aligning this risk management step model in their strategic plan. The feasibility of handling disruptions is anticipated to increase threefold from the baseline as per their latest reviews.

**Conclusion**

This paper dealt with secondary and primary research contributing to the risk factors affecting the food supply chain system. The critical issues of the food supply chain risks are performance threats: storage conditions, forecasting errors, poor quality, price fluctuations, operations downtime, delay, and inefficiencies. Managers need to look at all the aspects of threats and how well the issues are addressed in their ongoing strategy. The model framework helps managers identify the iceberg risks and handle disruptions.
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