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RESEARCH PAPER

Design and Development of Migration Path for Supply Chain Integration for Manufacturing Industries

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ABSTRACT

Increasing competition due to globalization, product diversity and technological breakthroughs stimulate independent firms to collaborate in a supply chain that allows gaining the mutual benefits. This requires a collective coordination framework and migration path to synchronize and to integrate the information systems and also organizational activities of the supply chain partners. However, existing research in supply chain integration has paid little attention in identifying and developing a migration path to know the present level of supply chain among the supply chain partners. Hence, the objective of this paper is to develop a framework for supply chain integration. In the proposed research, the informational, organizational and information technology integration is operationalized for the development of Supply Chain Integration framework for manufacturing industries. Further, this paper includes a comprehensive understanding of supply chain integration in general and specifically organizational, informational and IT integration. The developed framework for supply chain integration is validated by a pilot study and it helps the organizations to know the present level and provides a migration path to move to the next level of supply chain integration. This paper will add onto the contribution of authors who have ventured study in the area of supply chain integration.

KEYWORDS: *Supply Chain Management (SCM); Supply Chain Integration (SCI); Organisational integration; Information Technology (IT); Original Equipment Manufacturers (OEM).*

1. Introduction

The term "supply chain" "supply chain management" (SCM), "supply chain integration (SCI)" is not well-defined constructs [1]. They have different meanings to different people and organizations [1]. Supply chain is described as a chain linking each element from customer and supplier through manufacturing and services so that flow of material, money and information can be effectively managed to meet the business requirements [33]. SCM has evolved as a solution to all scales of industries to improve the productivity of the total supply chain beyond the company's border [2]. The conventional wisdom in most SCM literature is that "the more integration-the better the performance of the supply chains [3]. A key feature of present day business is the idea that it is supply chains (SC) that compete, not the companies [4] [5][6]. In an integrated supply chain, the entire process across the supply chain is designed, managed and coordinated as a unit [7]. Supply chain integration (SCI) is defined as the scope and strength of linkages of supply chain processes across organizations. Supply chain integration is generally complex and it involves management of different flows and poses interesting challenges for effective integration [6]. Supply chain integration (SCI) is facilitated by information, operational and relational integration. SCI can be an effective behavioral response to some types of uncertainty, by facilitating lateral relations that aid collaborating, coordinating and controlling materials and information [34] between members of a supply chain to develop the capability to respond to rapidly changing conditions. In this sense, integration of a supply chain is an operational plan for integration of supply chain members for improving system profit and responsiveness [6]. To achieve seamless and boundaryless flows, supply chain

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members must work towards a unified system [8]. When supply chain members are separate and independent economic entities, this action plan has to include frame-work for migration path for their integration [1] [10]. The study of supply chain management has emerged as a prominent field in providing Organizations with strategies to build long-term competitiveness. Supply chain management has the ability to promote the integration of organizations which was previously independent, for improving in organizational collaboration [28]. Research shows that organization collaboration enhances organizational performance.

1.1. Research background

Supply chain integration (SCI) is recognized as strategic process management that can be instrumental for creating positional advantages associated with improved firm performance [29].Supply chain integration is a complex process and requires consistent involvement and commitment of all the partners of the supply chain. [12], [11], [1]. To date supply chain integration has been studied as a very limited concept and there is a need for more comprehensive frameworks in integration. [11], [6]. Majority of current research on supply chain integration like: [13] [12], [14] [16] focuses on establishing a relationship between integration and performance. Further, few researchers like: [17], [5], [19], [20] have concentrated on IT and supply chain integration. Limited researchers like: [21] have studied barriers for supply chain integration. Within the areas of supply chain management, literatures highlight the need to understand supply chain management practices (SCMPs) which have become an essential requisite to remain competitive in the global race with profitable growth. SCMPs will improve the performance of an individual organization and also performance of the entire supply chain. Supply chain management seeks close integration of internal functions within the firm and external linkages with suppliers, customers and other channel members. Although some organizations have realized the importance of implementing supply chain management, they often do not know exactly what to integrate [28]. In the literature, no research is documented for developing a framework for setting a way to achieve integration in practice. Establishing a guidelines and framework for identifying the level of supply chain integration is however challenging as many of integration variables are interrelated and hence achieving an integration is thus a complex[11][9][3]. Researchers like: [1] have demonstrated a lack of integration in real life supply chains. One reason for the lack of integration is the lack of knowledge and how to achieve integration in practice [11] [1]. Thus, there is a clear need for developing a framework and a migration path for SCI. Therefore, the objective of this paper is to develop a framework for supply chain integration. In the proposed research the informational, organizational and information technology integration is operationalized for the development of supply chain integration framework for manufacturing industries. The remainder of the paper provides a comprehensive understanding of supply chain integration in general and specifically organizational, informational and IT integration. This is followed by the extent of integration, development of the integration framework and at the end a pilot study for conceptual and analytical validity of the framework is presented. This is followed by conclusions and references. Figure 1 explains the mapping of the research methodology followed in this study.

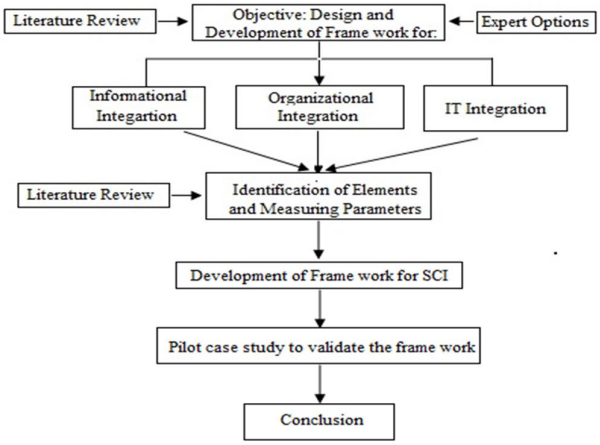

Fig. 1. Mapping of the Research Methodology

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2. Supply Chain Integration

A basic enabler for effective supply chain management is the integration of the supply chain. Reference [22] originally identified four stages of integration: baseline integration, functional integration, internal integration. Since then integration has moved towards a broader channel or network perspective. The focus of integration has shifted from functional integration (Departments) towards integration of various partners in the supply chain [23]. That is from internal integration towards external integration. John T Mintzer [8] views supply chain integration as the synchronization of various flows in a supply chain. Lee [7] outlines three dimensions of supply chain integration: information, coordination and organizational linkage. Information integration refers to the sharing of information and knowledge among the members in the supply chain [8] and coordination refers to the realignment of decisions and responsibility in the supply chain [6]. Organizational linkages include communication channels between the members in the supply chain, performance measurement, and sharing of common visions and objectives [7]. Reference [1] [3] [9] views the integration through informational and organizational.

John T Mintzer [8] proposes three scopes of supply chain integration: dyadic integration, triadic integration or an extended integration. A dyadic integration involves focal companies and their customers or suppliers. A triadic integration involves focal companies and their customers and suppliers. An extended integration refers to integration of more than three parties along the supply chain and can involve focal company, customer, supplier and customers' customer and suppliers' supplier etc. In this study, two dimensions: informational and organization integration is operationalized for triadic scope of integration which involves focal companies, their suppliers and customers for the development of framework. Figure 1 shows the scope of integration in the proposed study.

Fig. 2. Scope of Integration

2.1. Informational integration

Information is a key aspect of the supply chain [14]. One of the reasons for uncertainties in the supply chain is that perfect information about the system cannot be secured. While every single member has perfect information about itself, however, every member in the supply chain lacks perfect information about other members of the supply chain [14]. If the members of the supply chain are willing to share accurate information with the other members of the supply chain, then each member will have more information about others. This cooperation mode or increasing information sharing among supply chain members can be called a supply chain partnership or supply chain informational integration [14], [13], [12]. Information sharing among partners is a basic enabler for the effective management of a supply chain [12]. Looking at the information flow direction, the information sharing in the supply chain is a two way communication between the Down-stream and Up-stream organizations on the supply chain [8]. Flow of information like orders, forecast, and planning from customer to suppliers are typical flows involved in the backward flow that is between manufacturing industries and their suppliers [8]. Whereas, forward flow involves the flow of information related to capacity, availability and delivery schedules between manufacturing industries to customers [13], [12]. In addition, information sharing also includes performance criteria, such as production quality data and early complete date, etc. and production capacities among the partners. Information sharing in supply chain context refers to the extent to which crucial and/or proprietary information is available to members of the supply chain [12]. With relevant information available, for example, when accurate information on demand levels are provided, firms are able to project how much is desired, produce it on time, making it possible to deliver on time and eliminate the bullwhip effect, creating a supply chain with a good performance. Availing accurate information on inventory minimizes costs incurred due to stock outs and over stocking and ensures that deliveries are made on time.

Prior research on the importance of formal and informal information sharing between trading partners has shown that effective information sharing enhances transparency and reduces

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uncertainty [5]. It has been reported by several authors like [12], [13], [1] that sharing of right information at right time has close relationship with the supply chain performance, reduces bullwhip effect and reduces wastage and decreases lead time. The ability to access important information across the supply chain can help the supply chain members to modify existing actions or plan future operations.

In the literature, researchers have identified timeliness, accuracy, adequacy, completeness and information credibility are five specific dimensions of information sharing. The various attributes for information sharing are accuracy of information shared, amount of information shared, timeliness, quality and frequency of the information sharing among both Up-stream and Down-stream members of the supply chain. Lee et al [16] argue that for information sharing to be effective, it has to be shared with both down-stream (customers) and up-stream (suppliers).

2.2. Organizational integration

SCI has three dimensions: internal integration, customer integration and supplier integration. Internal integration involves interaction and collaboration that link a plant's internal functions into a cohesive system , sharing of information across functions to enhance collaboration and deepen understanding of customers . SCI is the development of shared meaning that channels the vision, strategies and operations of different supply chain members in the same direction so that they function effectively as an interdependent system[31]. Organizational linkages include communication channels between the members in the supply chain, performance measurement, and sharing of resources, common visions and objectives [1] [3] [12]. Organizational integration between the supply chain members encourages suppliers and customers to become more entrenched members of the network and instills a sense of belonging to the supply chain [1]. It becomes easier to generate trust among partners in an integrated supply chain. Organizational integration promotes collaboration and decision delegation, reduces irrational behavior and "second guessing" among supply chain members thereby reducing the need for safety stocks [1] [6]. The objective of organizational integration is not merely to resolve conflicts should they arise, but rather to recognize and avoid potential conflicts and/or divergence of interest in advance and device governance structure to forestall or avoid it. True organizational integration helps the supply chain members to behave more like a unified entity sharing ideas, skills and culture alike[1][6]. Supply chain integration may fail to blossom without organizational integration among supply chain partners [1] [6]. Supply chain management requires various members at all levels of hierarchy in multiple organizations to work together for achieving a common goal. Managing coordination among the supply chain partners therefore assumes significant importance. Reference [1] showed through empirical study that a positive correlation exists between performance and collaboration among the supply chain members in areas such as supply chain design, inventory management and Customer Relation Management.

2.3. Information technology integration

SCI in general and specifically information sharing is facilitated by recent advances in information technology (IT) like the Internet and other communication devices [24] [25] [26]. Much of the literature suggests that IT tolls are the main drivers for integration [5] [4]. The emergence of the computers, the explosion of the internet and World Wide Web helped the industries to integrate their supply chains in real time for coordinating the various flows in a supply chain[20][25]. A reliable information and communication technology paves the way for timely and efficient information exchange among partners. For example, using Electronic Data Interchange (EDI) technology/Internet and Extranet supply chain members can share up-to-the-minute information about their production needs by giving vendors access to the production planning and control system and vendors can arrange deliveries without the need of any paper transactions. Similarly, timely payments can be arranged using internet banking. Reduction of information sharing lead time and payment delays lowers the cost of doing business significantly, makes supply chains more efficient, and gives the users competitive advantage. The integration of many IT-enabled electronic commerce tools – bar coding, electronic messaging, electronic data interchange, global network management and Internet – is allowing supply chain partners to attain significant productivity gains. The fruits of information technology integration such as reduced cycle time from order to delivery, increased visibility of transactions, better tracing and tracking, reduced transaction costs, and enhanced customer service offer greater competitive advantage for all participants in the supply chain. Yet, despite all

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the classical virtues of information technology (IT), many firms continue to face problems in achieving seamless supply chain management.

Information and Communication Technology (ICT) tools consist of both hardware and software which can be used for integrating the supply chains. IT tools help to gather, store, share and analyze the information and makes the information available to the right person at the right time. In the literature, researchers have defined three levels of IT integration [11]. Level 1: refers to low level IT integration where a small amount of information is shared electronically. Level 2: Moderate integration in which a moderate amount of information is shared electronically among the supply chain members but ability to change the shared data and documents is limited to few members in a supply chain. Level 3: is defined as a high level of IT integration which involves complete sharing of information electronically and all members in the supply chain can change and manipulate the shared information.

3. Design of Migration path for Supply Chain Integration

The details of design and development of supply chain integration framework is discussed in this section

3.1. Development of migration path for informational integration

Information sharing involves sharing any type of data or information that could influence the performance of the supply chain members. Consequently in this study we would like to know the extent of sharing of the information related to sales forecast, inventory levels, product design development, market trends, companies future plans, knowledge sharing, resource sharing and sharing of the decisions among the supply chain members in the both Up-stream and Down-stream of the supply chain. In the literature informational flow has been extensively described and explored, but it is still difficult to find measures for informational integration. The question of what metrics should be used to evaluate the level of integration in the supply chain still needs further consideration [11]. Different aspects to information integration exist in the literature. These aspects in this study are referred to as "elements" of information integration: each element is being an integral constituent of the notion of information sharing in a supply chain.

The literature distinguishes two aspects of information sharing: level of information sharing and quality of information sharing. Level of information sharing implies the extent to which the critical and important information is shared among the supply chain members. In this study the different types of information shared among the supply chain members is considered as the first element.

The characteristics of information shared in supply chains include: type of information, quality of information and availability of information at the right time to the right person. Especially, the suppliers depend on the type, quality and accuracy of information passed on them by their focal company (Customer). The available information can be shared through paper, fax or, electronically. Further, in the literature four common factors are considered to describe information quality and they are: Accuracy, usefulness, reliability and completeness of information shared. Accuracy indicates the degree of conformity of the received information compared to its actual content or in other words whether the information is free from the error or not. Inaccurate information may result in misleading or harmful to its users. Usefulness of information describes the usefulness of the information for a certain or specific purpose. Reliability of the information refers to the probability that information is correct. Reliability can be two types: Content reliability and source reliability. Completeness of the information refers to how complete the information about the subject. Incomplete information may be completely useless or have reduced value to its users. Availability of information refers to how often the information is available when it should be. Information availability supports better decision making at strategic, tactical and operational level. An integrated supply chain helps its members to share accurate and quality information more frequently. Frequent communication and interaction has been considered an important mechanism for efficient management of information flow. In the literature different ways to define and describe the extent of shared information exists. The extent of information shared can be none, partial and full information sharing. Some describe the extent of information shared as low to high. Few have described the extent of information sharing through the concept of transparency. They categorize the varying degrees of transparency moving from opaque (no information sharing) through translucent to transparent. In this study we consider the extent of information sharing as low to high.

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In the literature three concepts have been widely used to describe supply chain integration and its extent: Direction, Scope and Level. The direction of integration describes whether the integration is directed down-stream or up-stream or both in a supply chain. Scope describes the dimension of integration. Level refers to what extent the activities are integrated within the direction and dimension. Table1 presents the migration path and framework for Informational Supply Chain Integration and it has following characteristics:

1. Scope of Integration: Both Up-stream and Down-stream of supply chain
2. Dimension of Integration: Informational integration
3. Extent of Integrations: Low, Medium and High level
4. Elements of Informational Integration: Types of Information shared, Frequency of information sharing, quality of information shared and timeliness of information sharing

3.2. Organizational integration frame work

The collaboration among the various organizations in the supply chain members is needed for increasing the performance. Because of the impact of technological progress over the supply chain operations, in the literature it can be documented that there is a large and growing number of studies exploring collaboration in the SCI. These relate to either the joint efforts in implementing such Technologies or the impact of various technology systems on performance.

Involvement of customers and suppliers in research and development, product design, production planning activities, marketing and sales promotion, supply chain design and implementation, quality improvement, cost reduction, long term and short planning of the organization are considered in this study for the development of migration path. Mutual trust among the organizations involved in the supply chain is a necessity for supply chain integration. Sharing of resources and technical expertise among the organizations helps the weak members of the supply chain to improve their resources and technical expertise. Table 2 presents the various elements considered in this study for Organizational Integration and it has following characteristics:

1. Scope of Integration: Both Up-stream and Down-stream of supply chain
2. Dimension of Integration: Organizational Integration
3. Extent of Integrations: Low, Medium and High level
4. Elements of Organizational integration: Involvement of customers and suppliers, Communication channels, Joint training programs to train manpower and sharing of technical knowledge, Joint cultural programs to achieve bonding, Trust among the organizations, Vendor managed inventory

3.3. Informational technology integration

Developments in the Information and Communication Technology (ICT) tools are the enablers for information sharing. In the literature, communication methods are divided into traditional communication methods like: telephone, fax, email, written communication and face to face communication. Advanced communication methods include: computer to computer links, Electronic Data Interchange (EDI), Enterprise Resource Planning (ERP). Advanced communication tools broaden and deepen the accessibility of information among the supply chain members. IT tools increase the frequency and reduce the lead time for information sharing. Table 3 presents the framework for Informational Technology Integration and has following characteristics:

Scope of Integration: Both Up-stream and Down-stream of supply chain the supply chain to improve their resources and technical expertise. Table 2 presents the various elements considered in this study for Organizational Integration and it has following characteristics:

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3.4. Informational technology integration

Developments in the Information and Communication Technology (ICT) tools are the enablers for information sharing. In the literature, communication methods are divided in to traditional communication methods like: telephone, fax, email, written communication and face to face communication. Advanced

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1. Scope of Integration: Both Up-stream and Down-stream of supply chain
2. Dimension of Integration: Informational Technology integration
3. Extent of Integrations: Low, Medium and High level
4. Elements of Informational Integration: IT and communication tools, automation and IT coverage

3.5. Calculation of level of supply chain integration

The following steps are proposed to calculate level of supply chain integration.

Tab. 1. Migration path for informational supply chain integration
Note: 1 for low integration and 5 for high integration

Dimensions of Supply Chain integration	Elements of Integration	Variables of Integration	Level of Integration(Up- stream) with suppliers			Level of Integration(Down- stream) with OEMs		
			Low	Medium	High	Low	Medium	High
Informational Integration	Types of Information sharing among the supply chain members	Sales forecast	Five point Likert scales (1extremely low–5 extremely high)			Five point Likert scales (extremely low–extremely high)		
		Inventory levels						
		Product Design development						
		Market trends						
		Companies future plans						
		Knowledge sharing						
		Resource sharing						
		Sharing of the decisions						
	Frequency of information sharing among supply chain members	Low , medium and high frequency	Five point Likert scales (1extremely low frequency –5 extremely high frequency)			Five point Likert scales (1extremely low frequency –5 extremely high frequency)		
	Time related information	Information availability	Information is provided when demanded	Part of the information is put in real time	All information is available in real time	Information is provided when demanded	Part of the information is put in real time	All information is available in real time
		Information lead time	Slow information sharing	Moderate lead time	Lead time close to zero. Real time information sharing	Slow information sharing	Moderate lead time	Lead time close to zero. Real time information sharing
	Quality of information		There are deficits in accuracy, usefulness, reliability and completeness of the information	Accuracy, usefulness, reliability and completeness of the shared information is at the acceptable level	Accuracy, usefulness, reliability and completeness of the shared information is at the acceptable level	There are deficits in accuracy, usefulness, reliability and completeness of the information	Accuracy, usefulness, reliability and completeness of the shared information is at the acceptable level	Accuracy, usefulness, reliability and completeness of the shared information is at the acceptable level

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Tab. 2. Migration path for organizational supply chain integration
Note: 1 for low integration and 5 for high integration

Dimensions of Supply Chain integration	Elements of Integration	Variables of Integration	Level of Integration(Up- stream) with suppliers			Level of Integration(Down- stream) with OEMs		
			Low	Medium	High	Low	Medium	High
Organizational integration	Involvement of customers and suppliers	Research and Development Product Design Production Planning activities	Five point Likert scales (1extremely low frequency –5 extremely high frequency)			Five point Likert scales (1extremely low frequency –5 extremely high frequency)		
		Marketing and sales promotion						
		Supply chain design and implementation						
		Quality improvement Cost reduction						
		Long term and short planning of the organization						
	Communication channels		Only at top management	Top management and Managerial levels	At all levels	Only at top management	Top management and Managerial levels	At all levels
	Joint training programs to train manpower and sharing of technical knowledge	Low , medium and high frequency	Five point Likert scales (1extremely low frequency –5 extremely high frequency)			Five point Likert scales (1extremely low frequency –5 extremely high frequency)		
	Joint cultural programs to achieve bonding	Low , medium and high frequency	Five point Likert scales (1extremely low frequency –5 extremely high frequency)			Five point Likert scales (1extremely low frequency –5 extremely high frequency)		
	Trust among the organizations		All Material from suppliers are inspected and then sent to production	Majority of materials from suppliers are inspected and then sent to production	Few of materials from suppliers are inspected and then sent to production	All Material are inspected and then sent to production	Majority of materials are inspected and then sent to production	Few of materials are inspected and then sent to production
	Vendor managed inventory		Not used	Experimental stage with few suppliers	With majority of suppliers	Not considered		

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Tab. 3. Migration path for information technology integration
Note: 1 for low integration and 5 for high integration

Dimensions of Supply Chain integration	Elements of Integration	Level of Integration(Up- stream) with suppliers			Level of Integration(Down- stream) with OEMs		
		Low	Medium	High	Low	Medium	High
Informational Technology Integration	Use of IT tools for sharing the information	Majority of information sharing is paper based/Fax or informally	Partly is shared electronically and partly by informally and paper based	Fully shared electronically	Majority of information sharing is paper based/Fax or informally	Partly is shared electronically and partly by informally and paper based	Fully shared electronically
	IT coverage	Some data and information is in the files/folders and much data is in the hard copies	Most data and information needed is in the systems and not accessible to all.	All data and information needed is in the systems and can be accessed by all.	Some data and information is in the files/folders and much data is in the hard copies	Most data and information needed is in the systems and not accessible to all.	All data and information needed is in the systems and can be accessed by all.
	Communication tools	Phone/Fax/email	LAN/Electronic links with selected suppliers	Dedicated server and extensive use of EDI/Internet/XML links with supply chain members	Phone/Fax/email	LAN/Electronic links with selected customers	Dedicated server and extensive use of EDI/Internet/XML links with supply chain members
	Automation	Software are used on functional basis related suppliers and SRM activities	Software are used for connecting key suppliers	Software are used for connecting all suppliers	Software are used on functional basis for marketing and CRM	Software are used for connecting key customers	Software are used for connecting all customers

1. The data for identifying the level of supply chain integration can be collected from the survey or through the case study and collected data are converted in terms of five point Likert scale. (1extremely low and 5 extremely high)
2. Up-stream and Down-stream integration for all the tree dimensions of supply chain integration is calculated as: Up-stream Integration or Down-stream Integration= [∑ measured numbers] ÷ Number of Up-stream or Down-stream elements
3. Three dimensions of supply chain integration is calculated by using formula: Level Informational integration= [∑ Up-stream integration and Down-stream integration] ÷ 2. Similarly, the level of organizational and IT integration are calculated
4. Last step is to calculate a Supply chain integration index = [∑ (Level of Informational Integration + Level of Organizational Integration + Level of IT Integration)] ÷ 3

The calculated supply chain integration index is between 1 to 2 then organization is a low level, if it is between 2 to 4 then medium and if it is between4 to 5 then it is a high level of supply chain integration. The different levels of integration can be calculated by using this framework and these levels help the organizations to know the current status of integration and provide them a migration path to improve the integration level.

4. Pilot Study to Illustrate Supply Chain Index

The proposed framework for identifying the level of supply chain is validated by collecting the data from the two pilot industries. The objective of the pilot study is to check the migration path for conceptual and analytical validation. The data is collected by conducting a case study. The structured questionnaire is prepared and data is collected for all the variables discussed in the study. The collected information is converted and measured in five point Likert scale. (1 extremely low and 5 extremely high). The details of the data collected and their level of integration are shown in Table 4, 5 and 6. From these data the level of supply chain integrations/indexes are calculated.

Total Informational integration index for Organization O1= (Average Up-stream integration + Average Down-stream integration) ÷2. That is (2+1.90) ÷2=1.95 similarly for O2= 1.63

Total Organizational integration index for Organization O1= (Average Up-stream integration + Average Down-stream integration) ÷2 that is (2.4+2.33) ÷2=2.365 similarly for O2= 3.015

Total IT integration index for Organization O1= (Average Up-stream integration + Average

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Down-stream integration) ÷2 that is (2.75+2.75) ÷2=2.75 similarly for O2= 2.375

Supply chain integration index for O1= [∑1.95+2.365+2.75] ÷3=2.355

Similarly for O2=2.34

5. Conclusion

In this paper, an effort has been made for developing a migration path as Tabled in 1, 2 and 3 and to define a new term supply chain integration index for identifying the level of supply chain integration in the manufacturing industries as Tabled in 4,5 and 6. Surely many researchers will question its generalization and elements considered here in this study. With marginal changes in the elements and variables detailed in the Table 1, 2 and 3, developed migration paths can be used to know the state of integration of a supply chain. Future research should focus on implementing this migration path in the manufacturing industries. So, the developed migration path should be operationalized for different types of industries like: Original Equipment Manufacturers (OEMs), Auto Component Manufacturers etc. We believe a larger study should be carried out and compared with our work to obtain better understanding of Supply Chain Integration index and migration path for SCI.

Tab. 4. Calculation of level (Index) of informational supply chain integration
Note: 1 for low and 5 for high integration

	Up-stream integration												Down-stream integration											
Informational Integration	Information sharing								Frequency of Information sharing	**Lead time in information sharing	Quality of information shared	Average Up-stream integration	Information sharing								Frequency of Information sharing	Lead time in information sharing	Quality of information shared	Average Down-stream integration
	Sales forecast	Inventory levels	Product Design development	Market trends	Companies future plans	Knowledge sharing	Resource sharing	Sharing of the decisions					Sales forecast	Inventory levels	Product Design development	Market trends	Companies future plans	Knowledge sharing	Resource sharing	Sharing of the decisions				
O1	2	3	1	2	2	2	2	1	3	2	2	2	2	3	2	2	2	1	1	2	2	2	2	1.90
O2	1	2	3	1	1	2	1	1	3	2	2	1.72	1	2	3	1	1	2	2	2	1	1	1	1.54

** Low number means more lead time

Tab. 5. Calculation of level (Index) of organizational supply chain integration
Note: 1 for low and 5 for high integration

	Up-stream integration												Down-stream integration											
	Involvement of Suppliers in decision making												Involvement of Customers in decision making											
Organizational Integration	Research and Development	Product Design	Production Planning activities	Marketing and sales promotion	Supply chain design and implementation	Quality improvement	Cost reduction	Long term and short planning organization	Joint training programs to train manpower and sharing of technical knowledge	Joint cultural programs to achieve bonding	Trust among the organizations	Vendor managed inventory	Average Up-stream integration	Research and Development	Product Design	Production Planning activities	Marketing and sales promotion	Supply chain design and implementation	Quality improvement	Cost reduction	Long term and short planning of the organization	Joint training programs to train manpower and sharing of technical knowledge	Joint cultural programs to achieve bonding	Trust among the organizations	Vendor managed inventory	Average Down-stream integration
O1	2	3	2	3	2	3	3	2	2	2	3	2	2.4	2	2	2	3	2	4	3	2	2	2	2	2	2.33
O2	3	3	4	4	3	4	3	3	3	2	3	3	3.2	3	3	3	2	3	4	3	2	2	3	3	3	2.83

Tab. 6. Calculation of level (Index) of information technology integration
Note: 1 for low and 5 for high integration

	Up-stream integration					Down-stream integration				
IT integration	Use of IT tools for sharing the information	IT coverage	Communication tools	Automation	Average Up-stream integration	Use of IT tools for sharing the information	IT coverage	Communication tools	Automation	Average Down-stream integration
O1	3	2	3	3	2.75	3	3	3	2	2.75
O2	2	3	2	2	2.25	2	3	3	2	2.5

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