

# **A Study of Decision and Information Synergy (DIS) Focused Inter-modal Freight Transportation (IFT) in the Indian context**

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## **Abstract**

The global and local business environment is varying at a different pace. Due to this variation, complexity in the transportation system is becoming a vital issue to be addressed. Literature in the domain of intermodal freight transportation suggests several drivers including globalization, variability in demand patterns and recent advancement in facilitation technologies i.e. Information and Communication Technologies (ICT). To address these issues with an aim to improve freight transportation system performance, it is critical to incorporate synergized IT system and decision system with a pragmatic approach. In developing country like India, where expansion of inland waterways along with inland and global regulations requires research intervention. This paper will attempt to propose and analyze DIS-IFT framework in the Indian context. This novel framework will incorporate decision and information flexibility scenarios. The DIS-IFT framework will facilitate transport operators, planners, designers, policymakers etc to strategize synergy in the intermodal freight transportation system.

## **Keywords**

Intermodal Transportation, Decision and Information Synergy (DIS), Uncertainty, Information and Communication Technologies.

## **1. Introduction**

The business environment is being uncertain, competitive, dynamic, unpredictable which results in more complexities. Quick response time with lower costs can only support the organization to sustain in such a complex business environment. The first trend which is forcing the business to be more flexible is globalization. Business firms are now trading with partners worldwide with ensuring the communication opportunities (Manders, Caniëls, & Ghijsen, 2017). The globalization influenced competition across worldwide and led the organization to focus on its core competencies while outsourcing non-core activities (Christopher & Mangan, 2005). Due to such aspects, flexibility becomes a pivotal element to pacify the business' operational performance. The second most important societal change is the introduction of emerging Information and Communication Technologies (ICT). The emerging technologies such as Radio Frequency Identification (RFID), Blockchain, Internet of Things (IoT), etc. are facilitating the business firms in exchanging the information within the system quickly. This rapid exchange of information leads to reacting quickly to gain its advantages, in other words, the technological advancements influence the organizations to desire flexibility. The disruptions such as earthquakes, floods, strikes, highway accidents, etc. can damage the whole transportation network. Such disruptions occur very frequently, and its impact is much significant. The logistics managers face difficulties to take actions to mitigate or avoid the negative impact of such disruptions on the operational performance. Thus, it is essential to increase the transport flexibility to make the decision making during and post-disruption easily. Also, the uncertain demand induces the supply chain to increase its flexibility to perform better. Nowadays, customer's

demand is highly uncertain and predicting it is a challenging task. Customers are now smart, and their demands and expectations are more and unpredictable, and that too changes in short period even when the product is in its final stage of production or delivery (Manders et al., 2017). Such rapid changes in demands and expectations lead to react immediacy, and thus flexibility becomes the competitive advantage.

The competency of the firm to increase its flexibility depends on various factors such as environmental, organizational or technical factors (Prater, Biehl, & Smith, 2001; M. M. Naim, Potter, & Mason, 2006). The flexibility needs to be proactive to respond quickly while ensuring the minimization of overall costs. The degree of flexibility depends upon the degree of uncertainties to be faced in customer demand, supplier performance, the carrier's internal processes and the transport infrastructure (M. M. Naim et al., 2006). While, the company's variety and uncertainty is also a vital factor in determining the types of flexibility (Slack, 1987).

Despite relevance, transport flexibility seems to be a missing link in the flexibility literature and is dominated in the focus of manufacturing. The objective of this paper is to fill this gap and highlight the flexibility and its types with an emphasis on transportation. This paper proposed a conceptual framework utilizing the definitions of transport flexibility to improve the competitive performance as well as overall performance of an Intermodal terminal.

## **2. Background of the Proposed DIS-IFT Framework**

Upton (1994) defined flexibility as “the ability to change/adapt/react with little penalty in time/cost/effort or performance. In literature, the term flexibility has also been used interchangeably with the term adaptability. The flexibility is considered as an antecedent of agility (Tachizawa & Thomsen, 2007) while it can also be said as flexibility is a subset of agility (R. R. Lummus, Vokurka, & Duclos, 2005). There is a line between the terms flexibility, agility, and responsiveness and it is advocated by several researchers. Prater, Biehl, & Smith (2001) correlated supply chain agility and flexibility as the agility of the supply chain depends on how its physical components are designed to incorporate speed and flexibility.

It is evident that the supply chain flexibility has emerged from the manufacturing flexibility (Jafari, 2015). Some of the literature has paid some attention to logistics flexibility (See (Barad & Sapir, 2003; Jafari, 2015; Runhaar, Heijden, & Kuipers, 2002; Zhang, Vonderembse, & Lim, 2005)). Initially, a synthesis of literature in the domain of manufacturing flexibility will be undertaken. Since manufacturing flexibility is particularly mature, and little previous research work has been done in the domain of transport flexibility, thus there is a need to review some literature on manufacturing flexibility.

Slack (1987) presented the flexibility hierarchy for the manufacturing processes of the firm. The hierarchy demonstrated how the structural and infrastructural resources determine the degree of flexibility and how it is associated with competitive performance as well as overall performance. It was also observed that the response flexibility is a short-term concern while range flexibility is a long-term concern. Gerwin (1987) presented process design to link the flexibility with manufacturing processes. The socio-technical aspect was focussed while designing the link. To study further terms of definitions, dimensions, types, etc. of manufacturing flexibility, see (Benjaafar & Ramakrishnan, 1996; De Toni & Tonchia, 1998; Oke, 2005; Parker & Wirth, 1999; Sethi & Sethi, 1990; Upton, 1994; Madaan J., Chan F.T.S. & Niu B., 2016; Wadhwa, Rao, & Chan, 2006).

Wadhwa & Rao (2004) presented a unified framework for manufacturing and supply chain flexibility. The proposed functioning of the manufacturing or supply chain system was viewed between five kinds of flows. The flows were the material flow, the resource flow, the information flow, the decision flow, and the money flow. The view of flexibility in the context of action and decision points was also proposed. The proposed conceptual framework highlighted some unified manufacturing flexibility types with supply chain system. The supply chain flexibility can be broadly classified into four dimensions: sourcing, operating — distribution and information systems flexibility (Moon, Yi, & Ngai, 2012). Rhonda R. Lummus, Duclos, & Vokurka (2003) proposed a model which demonstrate how supply chain flexibility can affect the overall performance. The model also suggested that increased flexibility will result in reduced inventory in terms of value. Sánchez & Pérez (2005) also presented a conceptual model to explore the relationship between supply chain flexibility and overall performance. But the study was limited to the automotive industry and may be related to other industries in some manner. The study results indicated that not all the flexibility dimensions are equally related to the firm performance. R. R. Lummus et al. (2005) defined various characteristics of supply chain flexibility. The Delphi study was carried out in the literature, and the result suggested that the important aspects were the ability to synchronize to customer delivery in terms of time, visibility to customer demand, accurate and timely data, and efficient information flows within the whole supply chain. Tachizawa & Thomsen (2007) conducted an exploratory study to determine the drivers and sources of supply flexibility. The result suggested that the sources of the supply flexibility can be divided into two parts: improved supplier responsiveness

and flexible sourcing. Moon et al. (2012) constructed an instrument to measure the supply chain flexibility for textile and clothing company. An important construct, information system flexibility was added to supply chain flexibility. However, the negative correlation between Information System flexibility and Sourcing flexibility was found in the results. It was also justified that this could indicate that the sharing of information with supply chain actors are the part of the internal operating system. For further studies in definitions, dimensions, types, measures of supply chain flexibility, please refer (Ishfaq, 2012; Manders et al., 2017; More & Babu, 2008; Seebacher & Winkler, 2015; Singh & Acharya, 2013; Slack, 2005; Stevenson & Spring, 2007).

Barad & Sapir (2003) analyzed the effect of the new factor, trans-routing flexibility on the logistics dependability. The study provided a methodology to explore relations between logistics flexibility and its performance. Closs, Swink, & Nair (2005) highlighted the role on information connectivity in making the logistics programs successful. The result suggested the information connectivity mediates the relationship between the logistics programs and asset productivity while partially mediates the relationship between logistics programs and delivery competence. M. M. Naim et al. (2006) highlighted the number of important definitions of transport flexibility to consider the collaborative approach between carriers, suppliers, and customers. Ishfaq (2012) presented the logistics strategy to build supply chain more resilient through flexibility in transportation. Recent improvements in Intermodal transit time performance also allows an opportunity to make transportation more flexible.

Table 1 Transport Flexibility Types and its classifications (Modified from M. M. Naim et al., 2006)

Flexibility types	Definition
<i>Internal</i>	
Mode	Ability to provide various modes of transport.
Fleet	Ability to provide various types of vehicles to carry multiple goods.
Vehicle	Ability to configure various vehicles to cater for various loading facilities.
Node	Ability to plan and implement new nodes in the network.
Link	Ability to establish new links between the nodes.
Temporal	Ability to sequence infrastructure investment and the degree to which its use requires coordination between users
Capacity	The ability of the transport system to accommodate variations in traffic demand.
Routing	Ability to accommodate different routes.
Communication	Ability to manage a range of different information types.
<i>External</i>	
Product	Ability to accommodate the provision of new transport services.
Mix	Ability to change the transport services currently provided.
Volume	Ability to accommodate the changes in transport demand.
Delivery	Ability to change delivery dates.
Access	The ability of the transport company to provide geographical coverage.

### 3. Proposed DIS-IFT Synergised Framework

“Intermodalism” was penetrated in the late 1960s when the significant challenges in the maritime sector resulted in high turnaround time. This problem reflects towards the containerization, which resulted in the mechanized handling of the goods. After the containerization, the focus was given towards the integration of different modes, as different modes of transportation have its advantages and limitations like for shorter distance road transportation while for average distance rail transportation whereas for long distance maritime transportation is usually preferred (Rodrigue, Comtois, & Slack, 2017). The main actors of an Intermodal Transportation are the shippers, carriers and intermodal

network itself. Intermodal transportation plays a vital role in cost reduction as it includes different modes of transportation as well as enables flexibility in the transportation system.

The Intermodal terminals are smaller than the port infrastructure, but operations carried out are much more or less similar (Monios & Bergqvist, 2015). A three-layered port infrastructure system consists of the physical infrastructure layer, terminal operations layer and terminal services layer (Taneja, Ligteringen, & Walker, 2011). The flexibility-enabled intermodal terminal decision system is depicted in Figure 2. It is challenging to incorporate flexibility into the layers of the decision system so that the system can handle uncertainties. It is evident that the whole decision process is driven by overall performance improvement of the system and so is in the case of Intermodal terminal decision system. The decision system involves the initial three layers of Intermodal Freight Transportation system, i.e. Institutional layer, Intra-organizational layer, and Logistics layer (Sisiopiku, 1997).

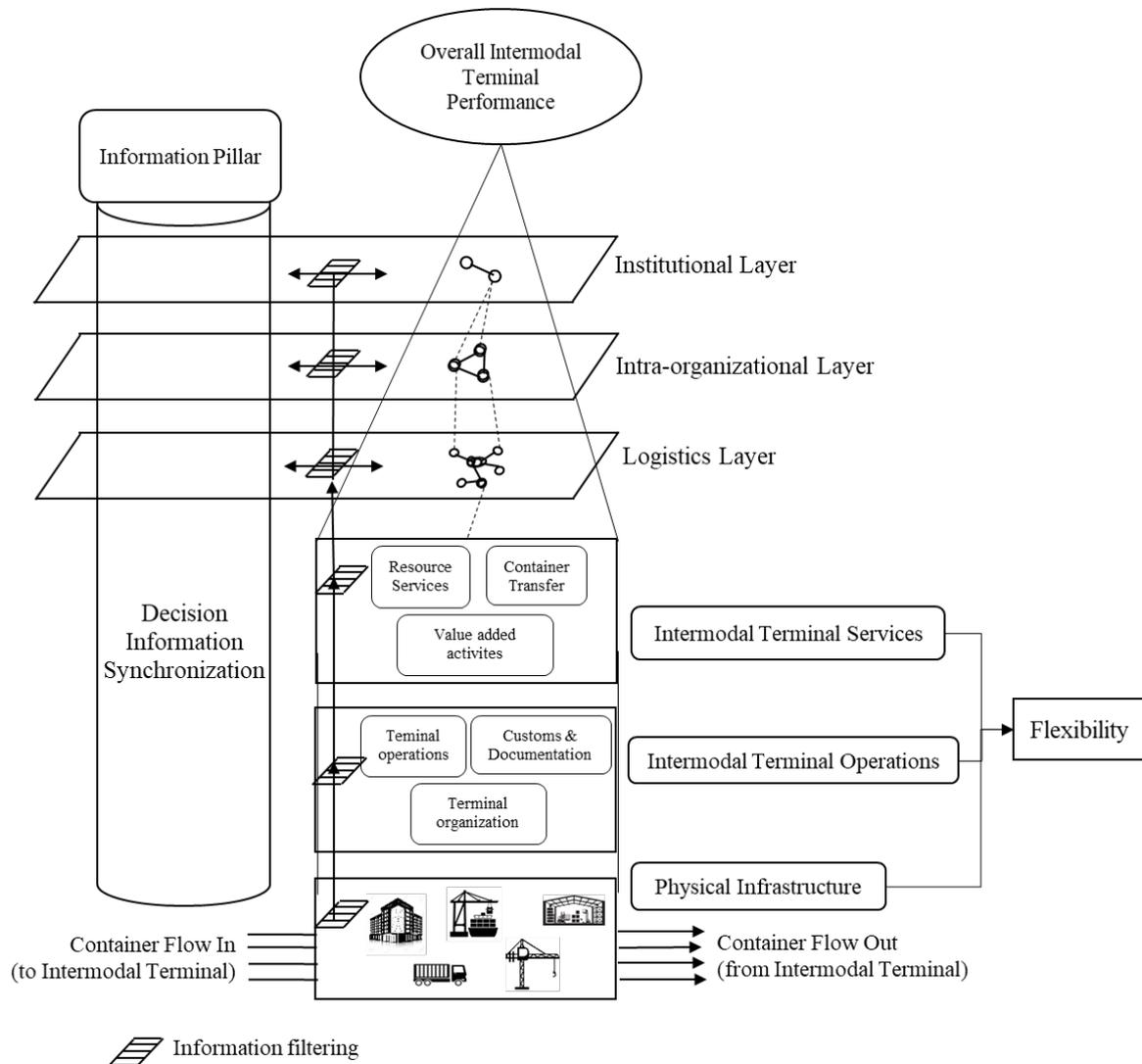


Figure 1. Proposed DIS-IFT Framework for Intermodal Transportation

In Intermodal Terminal infrastructure system, the bottom layer is the physical infrastructure layer which includes the infrastructures such as Berths, Quay Cranes, Warehouses, etc. Investment in physical infrastructure can provide physical flexibility to the whole system to react in sudden uncertainties. The second layer, Intermodal terminal operations layer includes regulations, contracts, Customs and documentation, terminal operations, etc. In this layer, flexibility can be incorporated by formulating contracts, regulations or planning which can allow the system to react better in case of uncertainties. The third layer is the Intermodal terminal services layer, which includes Intermodal

terminal services like the volume of containers handled, container transfer, resource services etc. Additional services can provide flexibility to the system to respond during uncertainties.

Information sharing within the transportation system is an important part to enhance the system's flexibility. It could be possible that the information sharing with supply chain actors are the part of the internal operating system (Moon et al., 2012). But, the information connectivity mediates the relationship between logistics programs, productivity and delivery competence (Closs, Swink, & Nair, 2005). Thus, it is believed that information system flexibility is an important construct and can be considered for both internal and external types of transport flexibility.

#### 4. Flexibility Focused Performance Mapping for Intermodal Transportation

The hierarchy is developed in figure 2 using different types of transport flexibility listed by M. M. Naim et al. (2006). The developed hierarchy in the context of Intermodal transportation highlights different levels involved in improving overall performance. Structural and infrastructural resources of Intermodal terminal facilitates to determine the degree of flexibility which can be measured in terms of both range and response (Slack, 1987). Especially the external types of transport flexibility at Intermodal terminal operations level — product flexibility, mix flexibility, volume flexibility, delivery flexibility, and access flexibility. Enhancement in external flexibility of transport flexibility gives a better operational performance in terms of availability, dependability and productivity. This enhancement in flexibility will result in improving business competitiveness. The hierarchy depicted in figure 2 is to help to define the development of resources through different levels. Desired levels of availability, dependability, and productivity which was chosen by the logistics company to be in a competitive position can be defined using the above hierarchy. This will facilitate to indicate the necessary flexibility elements such as range or response for external types of flexibility. The organization can set goals and in improve the internal flexibility types to improve its overall performance.

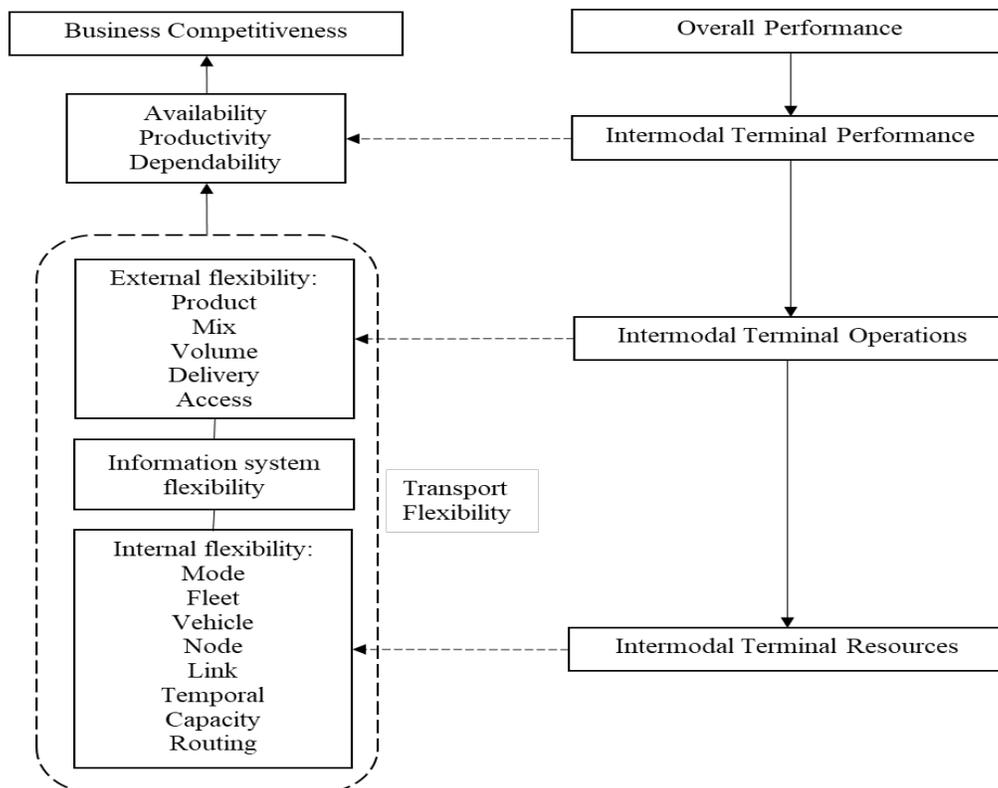


Figure 2. Transport flexibility hierarchy in Intermodal Transportation context.

## 5. Conclusion & Managerial Implications

The term flexibility is an equivocal term which is required to be redefined in an intermodal transportation context. Some authors used “flexibility” interchangeably with versatility and adaptability, while some asserted that flexibility is an antecedent of agility. Paper has enriched domain by proposing framework flexibility-enabled Intermodal Terminal decision framework. This model can simplify decision making and improve performance under uncertain conditions prone intermodal transportation system with further real-time data supplemented by the shipping industry in India. This study is in infancy and being supported by the Ministry of Shipping Govt of India. The potential success of flexible intermodal transportation will depend on competing actors, but also on the decision of competing modes, the shipping transport sector in particular. It is striking that with the emergence of cost-effective inland ports facilitated by Indian Government initiatives like Sagarmala and Bharatmala Projects. The decision makers still require improving their productivity by achieving a competitive position towards flexible intermodal transport in emerging scenario. Performance improvements can only be accomplished with more intelligent (flexible) planning systems and agreements. The proposed DIS-IFT will framework will surely benefit transport operators, planners, designers, policymakers by upbrining more clarity in understanding the flexibility of shipping transportation. Furthermore, the proposed model will assist to redefine coordinated flexibility capabilities. Finally, this framework can benefit managers to set their goals and develop strategies related to internal and external flexibilities to gain its competitive advantages.

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