Using an Integrated Humanitarian Supply Chain EPR System to Improve Refugee Flow Management: A Conceptual Framework and Validation

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Abstract

Effective coordination of relief efforts of organizations in the Humanitarian Supply Chain (HSC) is a challenge facing various organizations and stakeholders. Despite the importance of information sharing along the HSC, limited previous studies attempted to develop feasible information systems capable of facilitating the effective resource planning and inter-organisational coordination for better relief actions. This study proposes an integrated HSC Enterprise Resource Planning (ERP) system that utilizes the capabilities of the existing Maritime Transport Security Information Systems so as to improve lean operations of HSCs, and to optimize resources planning and usage during the stochastic assignment of accepting refugees and accommodating them in their journey to safer destinations. This paper introduces the conceptual framework of this integrated ERP system and validates the feasibility of this framework in the context of the Greek refugee crisis, involving perspectives of stakeholders in the Greek refugee crisis.

Key words: humanitarian supply chain; information sharing; lean; responsiveness; collaboration

1. Introduction

A humanitarian emergency (also known as humanitarian disaster) is an event or a series of events that represents a critical threat to the health, safety, security or well-being of a community or other large groups of people, usually over a wide area (Humanitarian Coalition, 2013). Refugee crisis can be a direct result of humanitarian emergency that is experienced by many countries around the world due to armed conflicts, epidemics, famine, and natural disasters or other disastrous events. Refugee crisis typically involves large movement of people to another country or other countries, which creates significant risks to the health, safety and well-being of refugees and also economic and social pressures on the receiving countries and regions.

Refugee crisis is very difficult to predict, very difficult to organize the activities and very demanding in terms of specific resources that are required to relieve the suffering of the people involved. It is believed that the success of any humanitarian operation is directly attributable to the efficiency and effectiveness of the humanitarian supply chain management (HSCM) in getting the necessary people and supplies to the right place quickly (Overstreet *et al*., 2011). Poor HSCM will not only result in continued suffering of refugees but also will have major negative impact on the societal conditions of the receiving countries and regions.

One of the major drivers of humanitarian supply chain (HSC) efficiency is information availability and information sharing among the relevant stakeholders, such as authorities, Non-Governmental Organizations (NGOs) and local communities. However, currently

HSCM is widely criticized for being decades behind the commercial sector (Overstreet *et al.,* 2011). One of the main reasons of such laggard is the under use and the lack of effective information sharing mechanisms and systems available to humanitarian organisations along the HSC.

Humanitarian organizations are atypical (Pedraza-Martinez *et al*., 2011) since they are mandated to respond by initiatives that relieve human suffering and pain. These relief entities are not commercial thus they don't strictly abide to market drivers. Due to the specific contextual characteristics, humanitarian organisations have multiple, often self-conflicting objectives (Moore, 2000) and usually these entities engage in activities with incomplete contracts (Balcik *et al*., 2008) and operate in an environment where the information asymmetry is very intense and thus adding to the expenses and costs of humanitarian organizations (Tirole, 1999).

There has been some intense scrutiny on the activities and the process employed by humanitarian organisations in terms of capacity planning (Samii and Van Wassenhove, 2002). The humanitarian organisations have been criticised for ineffective relief programme execution at a micro-economic level, indicating that the information unavailability could play an important role in improving both effectiveness and efficiency (Singh *et al*., 2018). Based on the extensive review of literature and existing systems, we find that although there is a plethora of systems available, the usage is actually limited. Moreover, essential information is not made available until very late in that process of providing relief.

Among various reasons behind such ineffectiveness of humanitarian organizations, coordination in HSCs is a well-known weak point (Altay and Labonte, 2014; Holguín-Veras *et al.*, 2012; Kovács and Spens, 2007). For instance, the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) (Adinolfi *et al.*, 2005) asks for improved coordination among humanitarian response agencies and highlights a number of supply chain related problems, such as the inefficient movement of personnel, material and food, delays in materials dispatching, and the lack of local processes and procedures (e.g., custom clearance procedures). The UNOCHA report identifies that United Nations' efforts will be significantly improved, if the gaps in the logistical operations can be removed by implementing a "system-wide coordination mechanism and a cluster based system". The recent humanitarian emergencies, such as the Syrian refugee crisis, sadden floods in a number of EU Member States (2015-2018), sadden fires in the Mediterranean countries (2017-2018), and the illegal sea crossings in a number of countries around the world, are calling for better coordination and collaboration to improve the effectiveness of humanitarian efforts.

Drawing on the research based on the private sector – which shows that ERP integration has a positive impact on companies' performance (e.g. Gattiker and Goodhue, 2005; Matolcsy *et al.*, 2005; Karim *et al.*, 2007; Madapusi and D'Souza, 2012) – this paper proposes an integrated humanitarian supply chain ERP system that facilitates the collection and dissemination of relevant and accurate information to related stakeholders in a timely manner to improve HSC operations. The system development was based on

context of a single critical case of Greek refugee crisis. This system intends to improve the lean process of HSC and the managerial efficiency of humanitarian organisations. In particular, such a system is based on an existing Maritime Transport Security Information System that has been proved in the operational field with increased security requirements as well as increased resilience prerequisites. This paper validates the system conceptual framework on the basis of a case through semi-structured interviews with representatives of Greek HSC stakeholders.

Given the limited previous studies which combine ERP and lean approaches in the context HSC, this study attempts to develop and verify the integrated ERP system for HSCs, which will pave the way for more sophisticated system development to facilitate effective HSCM in the future.

The next section reviews the literature in HSCM and the potential integration of ERP and lean approaches in HSC, which is followed by the discussion of methodology and approaches adopted by the study. We then discuss the Greek refugee crisis which sets the context of the system development. An integrated HSC ERP system is proposed, which provides major advantages to facilitate data gathering and information sharing among stakeholders along the HSC. This paper concludes by reviewing the advantages and limitations of the system as well as future development opportunities and implications to policy makers.

2. Literature Review

2.1 The Role of Humanitarian Supply Chain (HSC) in Disaster Management

A disaster management cycle is normally composed of four different phases: mitigation, preparedness, response and recovery (Van Wassenhove, 2006). The first two phases happen before a disaster. For example, mitigation includes all the actions that can avoid a disaster, reduce the probability of its occurrence, or diminish its destructive consequences. Preparedness includes the activities and plans so as to build capacities to respond to anticipated disasters (Kovács and Spens, 2007). The latter two phases represent either short-term relief or long-term reconstruction after a disaster. For instance, response includes all the actions taken in the primary consequences of a disaster, like the activities to save lives. Recovery includes all the actions taken after the primary consequences of a disaster to return to stability (Beamon and Balcik, 2008). In such a disaster management cycle, Humanitarian Supply Chain (HSC) is the backbone in amending disruptions physically affecting a system for three main reasons. First, HSC serves as a bridge between disaster preparedness and response, and between procurement and distribution (Kovács and Spens, 2007; Day *et al*., 2012). Second, HSC is crucial to the effectiveness and speed of response for major humanitarian programs, such as health, food, shelter, water and sanitation (Tatham, 2009; Day, 2014). Third, HSC can be one of the most expensive parts of relief efforts and operations, and thus deserves special attention (Van Wassenhove, 2006).

Comparing with traditional supply chains, HSC is a much more complex system (Besiou and Van Wassenhove; 2011) in that it involves not only business suppliers, but also multiple inter-related stakeholders, such as government, donors, NGOs, and even military

forces (Altay and Labonte, 2014). Drawing on previous studies (Balcik, *et al*., 2010; Singh, *et al*., 2018), we depict a generic HSC structure in disaster management for the purpose of the study (see Figure 1). The key stakeholders involved include established suppliers, operators of pre-positioning centres, operators of local distribution points, ad hoc suppliers, governments and governmental agencies, aid/relief organization, and donors who are either local, regional or international entities (Balcik, *et al*., 2010; Singh, *et al*., 2018). Along the physical flow line, Governments and Aid/Relief organizations have established prepositioning centres, following the distribution centre logic of a traditional supply chain. The network layout depends on the specific needs as well as on the collaborative approach such organizations follow when they make operational decisions. These prepositioning centres send materials and equipment to the local distribution points which then send these off to victims (last mile logistics). The local distribution points are also replenished by ad hoc suppliers who may also work in parallel to the pre-positioning centres. In this vein, the effective management of a HSC mainly depends on the close collaboration among these stakeholders.

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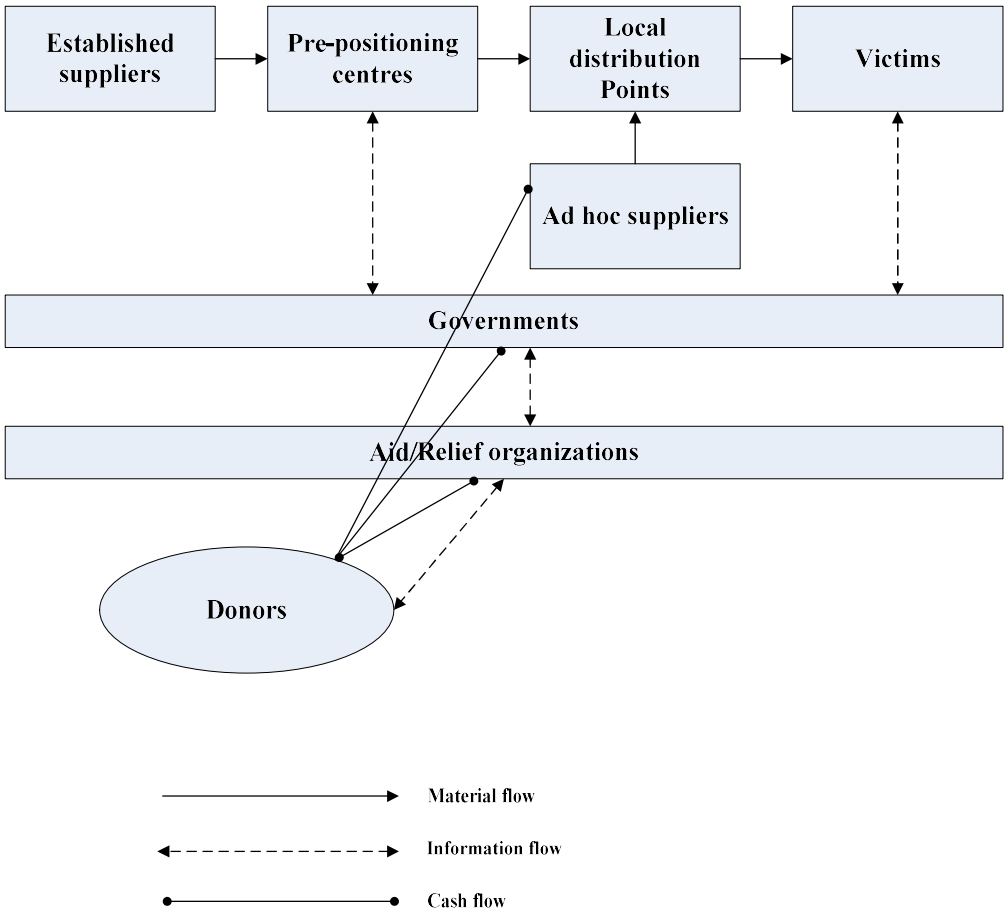

Figure 1 - Humanitarian Supply Chain

Source: adapted from Balcik, et al., (2010) and Singh, et al., (2018)

Modern HSC faces two main challenges. First, the occurrence of both natural and man-made disasters is difficult, if not impossible, to accurately predict with regard to timing, location and scale (Kovács and Spens, 2007; Perry, 2007). As a result, the capacity planning and preparation cannot be easily optimized in terms of material arrangement, warehousing, transport, and human resource allocation (Perry, 2007). Second, in the response and recovery phases of disasters, the multiple stakeholders and organizations involved in a HSC is "a temporary configuration of otherwise disparate resources" (Smith

and Dowell, 2000: 1154). Therefore, poor information sharing and lack of decision synchronization are key risks in HSC operations (Altay and Pal, 2014; Maghsoudi and Pazirandeh, 2016).

2.2 Applying Lean Approaches to Humanitarian Supply Chain Management (HSCM)

Humanitarian supply chain management (HSCM) refers to the management of efficient flow of aid materials and services through a network of supplies, services, finances and information between donors, beneficiaries, suppliers and different units of humanitarian organizations, so as to reduce the impact of either natural or man-made disasters on suffering people and communities (Wassenhove, 2006; Tatham, 2009; Lijo and Ramesh, 2012). Generally, HSCM aims to respond to affected people by using given resources efficiently during and after a disaster, so as to mitigate the sufferings as much as possible (Van Wassenhove, 2006; Naor and Bernardes, 2016).

More recently, there have been several calls for integrating lean approaches into HSCM (e.g., Cozzolino *et al*., 2012; Day *et al*., 2012), so as to overcome the emerging challenges. Originated from Toyota Production System (TPS) in 1990s, lean approaches have developed into an overarching management system towards operational efficiency through both cost and waste reductions (Inman *et al*., 2011; Panizzolo *et al*., 2012; Jasti and Kodali, 2015). In the context of HSCM, lean approaches can be mainly applied to three inter-related areas, namely information sharing and demand forecasting, capabilities mobilization and utilization, and operational processes (Oloruntoba and Gray, 2010; Cozzolino, et al., 2012) (see Figure 2). First, the collaboration and joint decision making

among various stakeholders in a cost-efficient and responsive way is a key success factor in HSCM (Gatignon *et al*., 2010; Papadopoulos *et al*., 2017). To this end, lean approaches can lead to efficient and transparent information flow among various stakeholders (Jasti and Kodali, 2015). Moreover, the resulting centralized information sharing enables more accurate forecasting for relief activities and materials (Cozzolino *et al*., 2012). Second, streamlined information sharing enables key players involved in the humanitarian supply chain to better utilize the existing facilities and recovery resources in response to the emerging relief needs from the victims (Oloruntoba and Gray, 2010). Third, from a lean perspective, HSCM can be divided into a certain number of standardized, sequential operational processes, such as procurement and transportation, warehousing and handling, fleet service, and contingency stock and replenishment (Gatignon *et al*., 2010; Kovács, 2014). Through such a division, a set of lean practices, such as Just-in-Time (JIT) system, Total Quality Management (TQM), and waste reduction, can be applied to these individual processes based on their respective features and needs (Cozzolino *et al*., 2012; Jasti and Kodali, 2015). As a result, the operational efficiency of these modular processes will be gradually increased through continuous improvement (Cozzolino *et al*., 2012).

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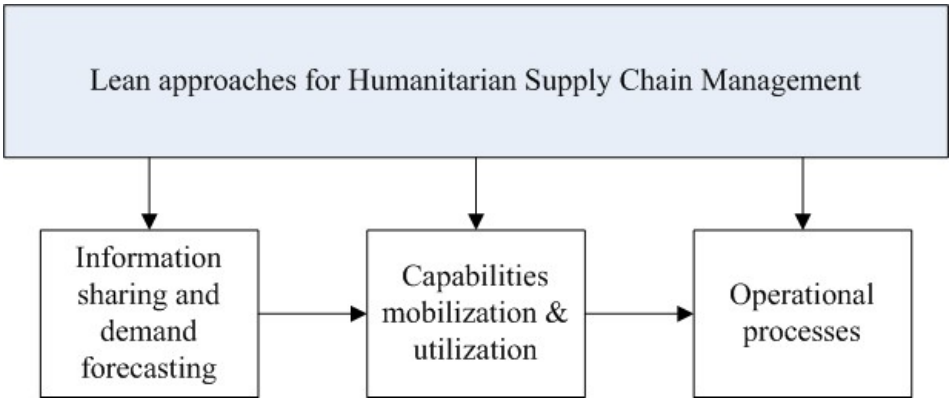

Figure 2 - Lean approaches for humanitarian supply chain management
Source: adapted from Oloruntoba and Gray (2010) and Cozzolino, et al. (2012)

2.3 The Role of ERP in the Lean Process of Humanitarian Supply Chain Management

For modern HSCM, effective information management has been highlighted as a critical success factor (Perry, 2007; Pettit and Beresford, 2009; Atay and Pal, 2014). Atay and Pal (2014) suggest that an information processing and diffusion view provides a suitable disaster relief solution in HSCM. Because humanitarian aid programs face greater uncertainty, greater amount of information should be processed quickly to support onboard decision makings in task execution. Howden (2009) holds that a unified information processing system should be utilized to standardize and streamline the mitigation, preparedness, response and recovery tasks in HSCM. Especially, such a system should be open and scalable, in order to accommodate large volumes of suppliers in preparedness stage of the disaster management cycle (Howden, 2009). In a similar vein, Pettit and Beresford (2009) suggest that, in disaster management, the adoption of advanced Information and Communication Technology (ICT) can assist the integration of various activities for effective functioning of a complex system. Three deep-rooted

factors that impact the effectiveness of HSCM, namely urgent responsiveness, extreme uncertainty, and a short supply chain life-cycle, can thus be mitigated (Day *et al*., 2009).

In particular, a growing number of scholars (e.g., Karim *et al*., 2007; Beamon and Balcik, 2008; Koliousis, *et al*., 2015) point out that ICT platforms, such as Enterprise Resource Planning (ERP) system, is the operational foundation for information sharing and lean HSC processes. When applying lean approaches to HSCM, a key focus is the extensive information sharing among various stakeholders. To this end, ERP has been increasingly recognized as a key element for the successful implementation of lean approaches in HSCM (e.g., Ab Talib and Hamid, 2014; Özdamar and Ertem, 2015; Gavidia, 2017).

ERP refers to an integrated information management system with the aim to streamline business processes through real-time information processing and centralization and the elimination of data and operational redundancies (Kanet and Stößlein, 2010). ERP can facilitate the implementation of lean approaches in HSCM in the following ways. First, an ERP system created for HSCM can serve as a centralized database which supports not only effective information sharing across various stages of HSC, but also computer-aided decision makings (Ab Talib and Hamid, 2014; Jasti and Kodali, 2015). Second, the use of ERP systems to track and trace relief logistics activities has the potential to improve the effectiveness of lean-based aid delivery and to minimize wastes (Pettit and Beresford, 2009; Gatignon *et al*., 2010). Third, the distributed design of an ERP system in HSCM can drive process standardization which is required by the lean management approach

(Kovács, 2014). As a result, various lean methods can be implemented to these modular processes to achieve continuous improvement (Cozzolino *et al*., 2012).

Despite the potential role of ERP in the lean process of HSCM, the implementation of such systems and related empirical studies are still rare. Indeed, limited ICT systems (including ERP) haven been developed and tested in previous studies for either international emergency networks or international humanitarian aid programs (Kovács and Spens, 2007; Pettit and Beresford, 2009). This calls for more research on ICT adoption (such as ERP) in the context of HSCM (Pettit and Beresford, 2009; Atay and Pal, 2014). In response, in this study, using a single critical case of Greek refugee crisis (Yin, 2009), we developed and validated a practical information sharing system combining ERP and lean approaches based on the existing Maritime Transport Security Information System.

2.4 Integrating ERP with Lean Humanitarian Supply Chain

Relief operations rely on massive material flows, in a multimodal context. In order to improve the performance, there is a need to achieve effective management of the processes and to implement cross-functional and cross-stakeholder operational models among transport operators, cargo owners, freight managers, security authorities and donors. Flexible interfaces between stakeholders are key enablers of efficient cargo flows and effective information capturing and dissemination along multimodal corridors. Additionally, collaboration with regulatory, customs and security authorities is critical in removing bottlenecks and improving efficiency of HSC.

Powell (2013) proposes a framework that supports lean processes when developing an ERP. In this framework (see Figure 3) six major areas should be considered in applying ERP systems for lean operations. First, the integrated system is based on the premise that combining ERP systems and lean processes can help to improve operational efficiencies and competitive advantages of supply chains. Second, it is recommended that the implementation processes of ERP and lean approaches should be concurrent. Third, the support functionality of ERP and lean approaches should be considered. In this vein, the practicalities of introducing lean practices through responsive ERPs require cross-functional and cross-stakeholder support. Fourth, feeding real time information from various sources will significantly improve the operations for the supply chain end users. To this extent, existing real time information that is currently nested in different (governmental) systems can improve not only the accuracy of the information but also the responsiveness of the supply chain organisations. Supply chain integration can thus be achieved through electronic and dynamic platforms that facilitate seamless data and information sharing. Fifth, ERP systems can be applied as a medium for extending lean practices throughout the supply chain, and thus becoming an enabler of the extended lean practices of supply chain players. Sixth, integrating ERP with lean process can shift the supply chain scope from push practices to pull practices, through the application of e-Kanban.

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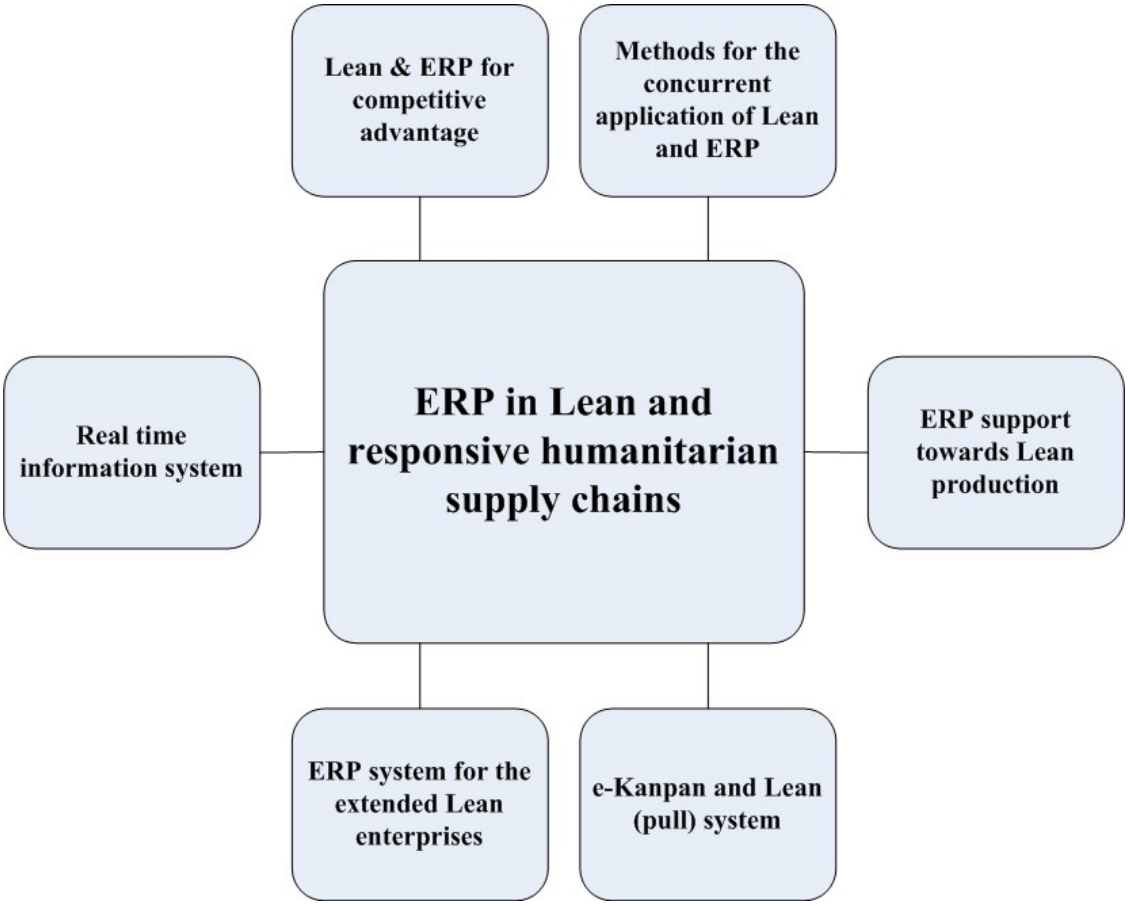

Figure 3 – Integrating lean principles in humanitarian ERP

Source: adapted from Powell (2013)

This framework supports the identification of the potential areas for the successful implementation of an integrated ERP system. In this study, we primarily focus on combining ERP and lean for responsive and agile HSC in providing relief. In the latter sections, the methods for concurrent application of lean and ERP and also how the provision of real time information can help relief operations will be explained. The main premise is that the more information that becomes available to the HSC decision makers, from a universal supply chain viewpoint, the more likely it is to maximise the offering of relief through extending ERP management systems into the lean aspect of the HSC.

3. Research Method

Because there is limited previous research on practical frameworks of information management systems in HSCs, we followed the exploratory research approach as depicted by Edmonson and McManus (2007). To this end, this research followed a two-stage process (Bryman and Bell, 2015). In stage one, a single critical case study sets the context and identifies the operational requirements of the system. Based on the findings in stage one, the development of the system was presented in stage two. A follow-up interview was also conducted in the same case context to validate the conceptual framework of the system.

Specifically, in stage one, we have adopted a field-based case study approach (Meyer, 2001), to explore the Greek refugee crisis, in order to identify the actual interactions and cooperations among different stakeholders in the HSC. The case study also investigated the operational limitations and restrictions, and offered practical references to the operational requirements in ERP system development. Secondary data from public reports, news articles and government statistics were used as the source of information, which was complemented with four qualitative semi-structured interviews (Galletta, 2013) with experienced field experts representing relevant stakeholders in the Greek HSC. The interviews also helped to establish the rapport that enabled more thorough understanding of the HSC processes. This round of interviews was conducted in January 2018 for a baseline understanding of the attributes that enable the creation of the proposed system. Each interview lasted between 1 to 2 hours. Table 1 shows the profile of the three

interviewees, who were identified based on the authors' professional network. Out of the five initially agreed participants, two declined the interview invitation due to commercial or company restrictions.

< Insert Table 1 about here >

Table 1 – Profiles of the interviewees

Interviewee	Entity	Role	Organization Level	Years of Experience	Qualification	Round 1 Interviews	Round 2 Interviews
#1	Port / Terminal Facility	Security Officer	Board Level (Large Company)	25	MSc in cyber security	2	1
#2	Relief materials supplier	Commercial Manager	Management (SME)	25	Degree in Business	1	2
#3	Relief Organization Supply Chain Executive	Regional Project Manager	Management (Regional organization)	5	MSc in Supply Chain Management	1	1

To gain insight into the specific context and the operational requirements of information sharing and lean HSC process, thematic analysis (King, 2004) was conducted to analyse the interview data to examine the underlying patterns of collaboration and information sharing across stakeholders. Thematic categories, for example collaboration, data sharing, capacity allocation, price information, inventory visibility have been established, which helped the identification of areas of improvement in information sharing among HSC stakeholders.

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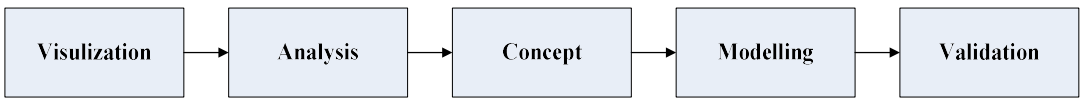

Figure 4 – Modelling process

Source: adapted from (Hernández et al., 2008)

In stage 2 of the study, we followed the conceptual modelling methodology of production planning processes in lean supply chain environments proposed by Hernández *et al*. (2008) to develop the system modelling. As shown in Figure 4, the visualisation stage aims to understand existing processes and activities and define sectorial constraints. In this stage, we defined the main entities and the main components as well as the main business processes of HSC. The analysis stage concerns the review on the processes and procedures. The concept stage involves identification of the static and the dynamic aspects of the proposed model including product/material and information flow processes and related definitions and glossaries. In the modelling stage, we rolled out the system conceptual framework as a pilot to prepare it for the final stage, namely validation, where the field experts' comments on the system's behaviour were collected and evaluated (through the second-round interview as discussed below) and amendments were made to the initial system conceptual framework.

The second-round interview with the same participants from the first round was conducted to verify the feasibility of the conceptual framework developed in the stage 2 of the study. Four semi-structured interviews were conducted in July 2018, providing a thorough review of the intrinsic components of the proposed system to allow amendments to the system conceptual framework.

4. The Greek Refugee Crisis: the Greek-Turkish Border Inflow

The population of refugee inflow into Europe is increasing very quickly. Among all the refugee destinations, the southern part of the European Union is more susceptible to illegal border crossings. In year 2014, 256,150 people requested asylum in EU (including Liechtenstein, Norway and Switzerland), and the number tripled to 735,005 in 2017 (Frontex, 2018). This population comprises refugees, persons internally displaced within their own countries and asylum seekers. Greece has been in the forefront of this refugee crisis since 2015 which involved main refugee flows towards mainland Europe.

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Table 2 – Main routes of entry

Route	**Border location / Modality**
Black Sea	Sea
Central Mediterranean	Sea
Circular Route from Albania to Greece	Land
Eastern Land Borders	Land
Eastern Mediterranean	Sea
Eastern Mediterranean	Land
Western African	Sea
Western Balkans	Land
Western Balkans	Sea
Western Mediterranean	Land
Western Mediterranean	Sea

Source: adapted from Frontex (2018)

The main routes that the immigrants follow involve a number of states and transfer modalities pertinent to the location of the borders. As shown in Table 2, the most heavily

used path of refugee flow is through sea routes and most likely through Greece, making Greece the most important transit destination. Rough figures indicate that on average about 100 people of various ages entering the EU through Greek Sea borders on a daily basis. This is partially because the sea crossing to Greek islands is less than 6 km (4 miles) from the Turkish borders, enabling a quick and "easy" transfer for the major migrant flows from the Middle East. In addition, land crossing of Evros across Turkey is also an easy passage, especially during the low rain periods, offering an alternative easy route for refugees. The huge refugee inflow also accompanies with a high life claim. From 2014 to 2017, the United Nations High Commissioner for Refugees (UNHCR) recorded at least 1,700 people dead or missing along the Eastern Mediterranean route (UNHCR, 2018).

Currently, the Greek government employs a two-stage reception facilities model. The Reception and Identification Centres in the borders act as the first instance reception facility, where the identification and creation of database of personal details take place. Then, based on the operational characteristics, a number of refugees are escorted to the Open Reception Facilities located in the Greek Mainland. Refugees are sent to these refugee camp facilities, where minimum standards need to be met. However, not always are these met in real deployment situations. For example, although UNHCR recommends an average camp size to be 45 square meter per person, this is not always met in practice.

In Greece, at least 17 major NGOs are in operation to support refugees, such as Red Cross/Red Crescent, International Rescue Committee, and Médecins Sans Frontières. Despite providing key support and resources for refugees, not all of these organizations

participate in a centrally organized process. The level of coordination of resources and capabilities between NGOs and Governmental bodies is still very low due to the ad hoc basis of many NGOs and Governmental operations and the lack of information sharing mechanisms between various stakeholders along the HSC. Significant wastes and shortages coexist in various parts of the Greek HSC. Moreover, because there is no clear pattern in the refugee entries, and sudden spikes of refugee inflow can occur at any time without a prior warning, effective coordination of resources and capacities can become very difficult. As indicated by the interviewees, effective HSCM depends on agile and lean processes to serve their mission in a volatile environment. Short lead time, low costs and quick turnaround time of materials, products and supplies may be significantly improved by better information sharing mechanisms.

5. System Architecture: Integrated Humanitarian Supply Chain ERP

5.1 Reference Framework for Lean and Responsive HSC

Because of the not-for-profit nature of HSC, effective lean HSC is measured by speed, flexibility and responsiveness (Beamon and Balcik, 2008). Therefore, we based our analysis on a Responsive Supply Chain Reference Framework (Gunasekarana *et al*., 2008) (see Figure 5). According to this reference framework, the three enablers of Responsive HSC are the network of partners, Information Technology (IT) and systems, and knowledge management. These enablers enhance speed, flexibility, and responsiveness of HSC. First, by network of partners we define those entities that support and contribute to the objectives of HSCs, either on the voluntary or on the commercial basis. Second, speed and flexibility encompass all those lean attributes that improve the value the end

users (i.e., refugees/victims) get. Third, by IT and Systems we define all those systems that collect and share unambiguous data and information to all relevant players. Fourth, Knowledge Management encompasses both the processes and the systems that collect, store and utilize information and transform it to the knowledge for future reference. In this study, we focus on the IT side of the issues for improving the lean and the responsiveness of HSC. This is achieved by developing and validating an integrated HSC ERP system based on the existing Maritime Transport Security Information Systems that are already operational in either pilot or full-scale mode (Koliousis, *et al*., 2015; Morrall, *et al*., 2016).

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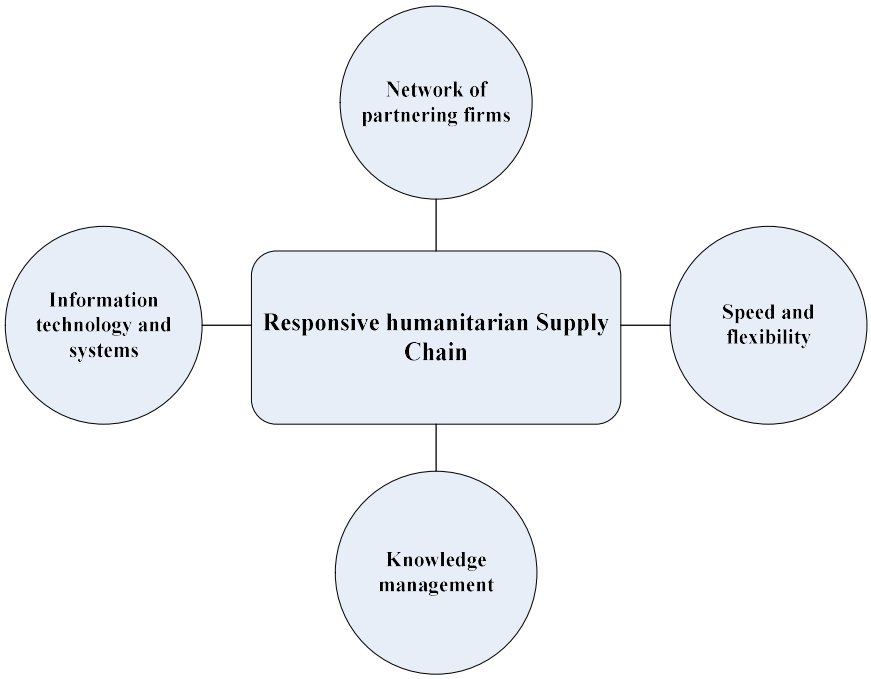

Figure 5 – A reference framework for responsive Humanitarian Supply Chain
Source: adapted from Gunasekarana et al. (2008)

This study obtains data and operational requirements from various sources (including secondary data and the interviews discussed above) in order to propose a system that will be validated by field experts. As evidenced above, information sharing is critical for NGOs, Governmental bodies, and various different aid organisations to effectively serve their relief purposes. Sharing of relevant and pertinent information facilitates improved resource allocation and maximizes relief effectiveness. As with typical ERP systems (Powell, 2013), software platforms should facilitate the seamless integration of both human-computer interaction and optimal decision making. The business, operational and architectural requirements are usually mapped on the functional capabilities of such ERP systems, which will be discussed in more detail later in the paper (see section 5.3-5.5). The key questions need to be addressed to serve this purpose are:

(1) Why is this ERP needed?

(2) What are the operational objectives of such a system?

(3) Which architecture best fulfils these objectives?

(4) Does the state of play fulfil this architecture?

Before these questions are discussed in detail, the Maritime Transport Security Information System will be discussed below, which serves as the base model and the starting point of the integrated HSC ERP system. The concept of such an integrated HSC ERP is based on the premise that key operational processes for logistics management could be integrated within the maritime security management framework, which has been implemented in a centralized manner at the European level by enforcement agencies from a global perspective.

5.2 Maritime Transport Security Information System

Maritime transport is a major economic contributor in the EU as well as a necessary component for the facilitation of international and inter-regional trades on which the European economy is strongly depending upon. The EU Maritime Transport Strategy (European Commission, 2016) actively supports the efforts of the European maritime sector in offering quality shipping services which in turn shape the requirements for upgraded maritime transport information management. The strategic European Maritime Transport framework brings together into a coherent whole the concepts, processes, standards and technologies that enable networking and computer-supported cooperation in (a) improving the safety and security of maritime transport services and assets and environmental protection, (b) increasing the competitiveness of the EU maritime transport industry, (c) integrating sustainable waterborne transport services into efficient and secure door-to-door transport services, and (d) reinforcing the human factor.

The EU Maritime Transport Security Initiative establishes a communication system that connects all member states via a community-maritime information exchange system in order to obtain a complete overview of the movements of ships and of dangerous or polluting cargoes in European waters. The European maritime transport space without barriers builds on a number of capabilities. The core capability is the simplification of customs processes which requires enhanced security activities. This enhancement is achieved among others through the European Border Surveillance System (EUROSUR), which is based on a common European information sharing environment. In addition to

EUROSUR, the customs are also required to upgrade their security perspectives through this system, as to the ports and the supply chain stakeholders through single-window-based information sharing systems like Port Community Systems (Koliousis, *et al*., 2015). The European Maritime Transport Security Information System utilizes a number of complimentary security, surveillance and safety systems at the national or the EU levels, which include maritime safety, search and rescue operated by SafeSeaNet (SSN), Vehicle Tracking Systems, fisheries control through the satellite-transponder-based Fishing Vessel Monitoring Systems (F-VMS) and the marine pollution preparedness and response operated by the European Maritime Safety Agency (EMSA). These systems run on top or on the side of general law enforcement and defence systems. In particular, the SafeSeaNet (SSN) will serve the backbone of the integrated HSC ERP system proposed by this study.

5.3 The SafeSeaNet (SSN) System

SafeSeaNet (SSN) is a European information network encompassing all EU member states (Koliousis *et al*., 2014). This system acts as the European Platform for Maritime Data Exchange between maritime administrations and enforcement agencies. Its role is to ensure the implementation of community legislations by monitoring and enforcing at a number of levels. The system is mainly composed of a network of national SSN systems in European member states, a number of auxiliary systems, and a SSN central system acting as a nodal point. Figure 6 illustrates the SSN system architecture. The core element in the SSN system is the Automatic Identification Systems (AIS) which collects a number of relevant data and transmit them to a centralized database (Central SSN), which in turn,

shares the information to stakeholders in order to support decision making (e.g., the decision to reject entry of a ship in a port or the decision to initiate further controls).

< Insert Figure 6 about here >

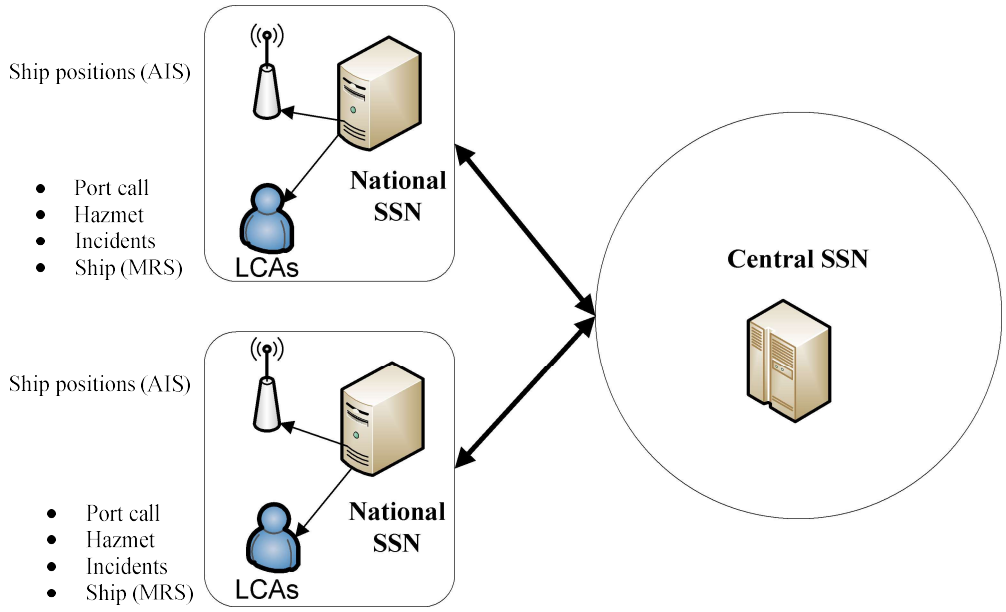

Figure 6 – SSN architecture

Source: European Maritime Safety Agency (2014)

SSN operates as a centralized information sharing system and authorizes users within the SSN Community to retrieve notification-based information. The central SSN system locates and retrieves this information and provides it to the data users. The national competent authorities at the European member states level establish either centralized or decentralized systems where all relevant information is registered, stored and exchanged. The SSN system enables rapid and effective response to users' requests. The central SSN system is flexible to provide message-based, streaming or web browser-based mechanisms.

5.4 Approaches of System Security

To understand the best approach of system security development, previous research on supply chain system security was reviewed. It was found that two main approaches were followed: the system design perspective and the business application perspective. The system design approach focuses primarily on the development of appropriate equipment and/or advanced forecasting algorithms to detect dubious consignments. For example, Arendt *et al.* (2012) describe how the project CHINOS increases the system visibility and security by using innovative IT technology like RFID and automatic damage documentation, as well as how the project INTEGRITY develops and implements an IT system to increase supply chain visibility. Similarly, the project CONTAIN (CONTAIN Consortium, 2011) develops an innovative container device as well the appropriate IT infrastructure to increase system security, whereas the SMART-CM project (SMART-CM Consortium, 2016) is one of the first Research Projects that the European Commission funded to address the improvement of the efficiency of the AEO concept. To this extent, Azaiez and Bier (2007) examine optimal investments in the security of multi-component systems based on the assumption that the defender intends to preserve the overall systematic functionality. In a similar vein, other studies focus on developing advanced algorithms to detect suspicious containers or consignments and warn in advance the relevant authorities. Yang *et al.* (2013) develop an advanced threat-based criticality analysis methodology designed for the identification and prioritization of vulnerable port facilities under uncertainties, combining fuzzy Bayesian reasoning and analytical hierarchy process (AHP) analysis. Based on game theoretic studies, a number

of researchers (e.g. Sandler and Arce, 2003; Basuchoudhary and Razzolini, 2006) have developed advanced game theoretic models to understand the interactions and the reasoning behind attacking vulnerable assets.

On the other hand, business application oriented approach explores the impact of systems regulations at either business operational level or strategic level. For example, Rice and Spayd (2005) claim that security upgrades may bring collateral benefits, such as trade facilitation and asset visibility. Following a previous argument set by Sheffi (2001). Willys and Ortiz (2004) argue that supply chain efficiency and security are interrelated in terms of the reduction of customs delays, the increased transparency of information of goods flows, and the reduction of shipping costs among others. In this context, a number of studies have focused on measuring the adverse effects of security regulations on logistics efficiency. Mazeradi and Ekwall (2009) show how the implementation of the International Ship and Port Facility Security (ISPS) code increases paperwork and slows down processes in ports. Similarly, Stevenson (2005) showed that the ISPS code may have a negative impact on costs and on the efficiency of terminals.

Although automated systems are introduced previously aiming at increasing the efficiency and the effectiveness of supply chain processes, there seems to be a gap in the depth of actual integration of these security systems. More precisely, in most of the cases, the information collected or disseminated is either unidirectional or remains in silos with specific stakeholders. This study argues in favour of data fusion (Hsu and Wallace; 2007; Morris et al., 2014) as a promising alternative to improve the system security level,

capitalize on existing equipment and the security investment, and improve the efficiency of security procedures and the security red tape of the integrated ERP system through a centralized approach.

5.5 The Framework to Improve Humanitarian Supply Chain Communications

In order to exemplify the information flow and the interactions among the different stakeholders, Figure 7 presents a simple scenario of the collaboration and the message exchange. The proposed Data Fusion Framework supports:

(1) Real-time exchange of directly connected data providers;

(2) Near real time exchange of cloud connected external data providers;

(3) Exchange and collaboration of standard agnostic messages, including GPS, Sensor Alerts, ERP Data, Commercial Data, Security Awareness Data, etc.;

(4) Exchange of higher level messages, i.e., messages that have been processed and handled to produce information;

(5) Support different protocols (including HTTP /HTTPS) and methods (including POST, REST, etc).

< Insert Figure 7 about here >

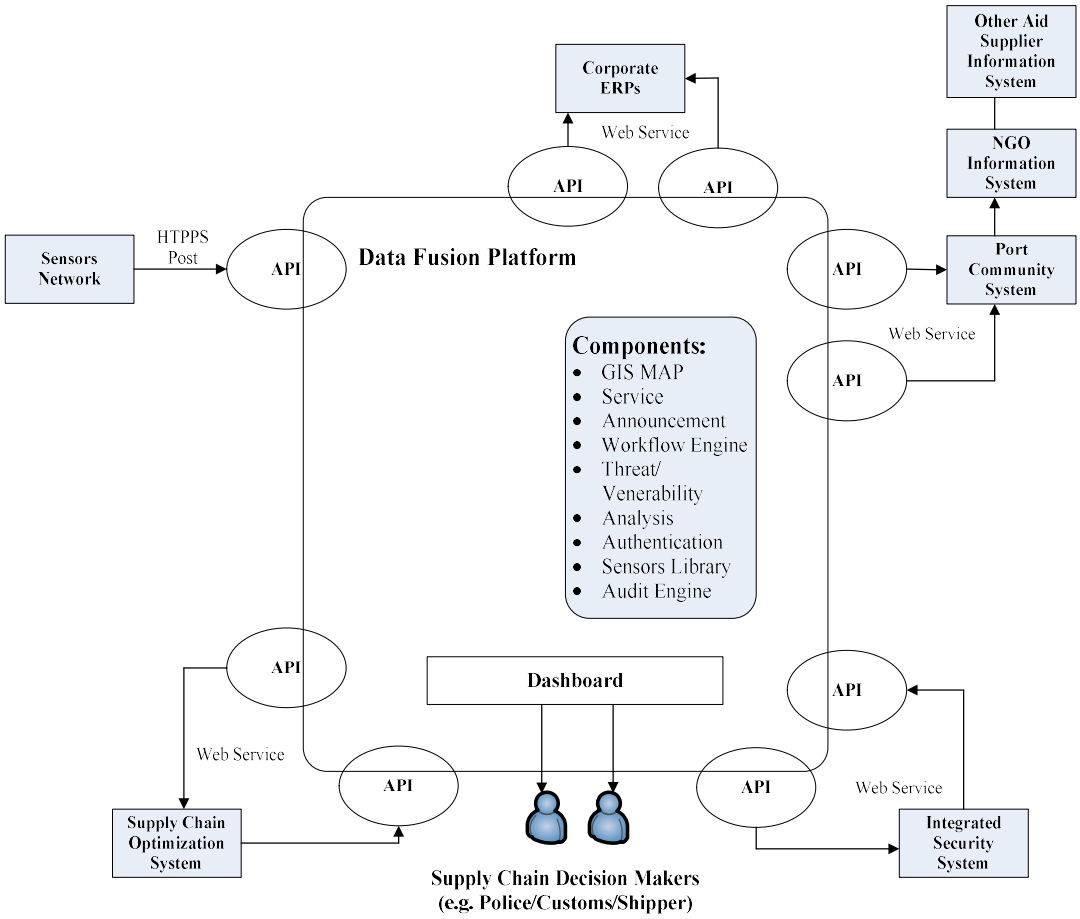

Figure 7 – Information flow architectural design

All sensors in the system (such as GPS Devices, security sensors, capacity sensors) are configured to regularly send real-time data to the Data Fusion Platform. The platform collects security events and related activities for the entire supply chain. Subsequently, the system calculates the risk levels and flags them for the users. The central idea in this architectural design is that the decision maker is provided with a comprehensive dashboard that presents all relevant information that will support decision making. The seamless nature of the data / information exchange is ensured by the different Application Programming Interfaces (APIs) that are developed and shared within the HSC network of

organisations. Components of the dashboard will include relevant information in the form of maps, datasets, information, decisions as well as real time data feed.

< Insert Figure 8 about here >

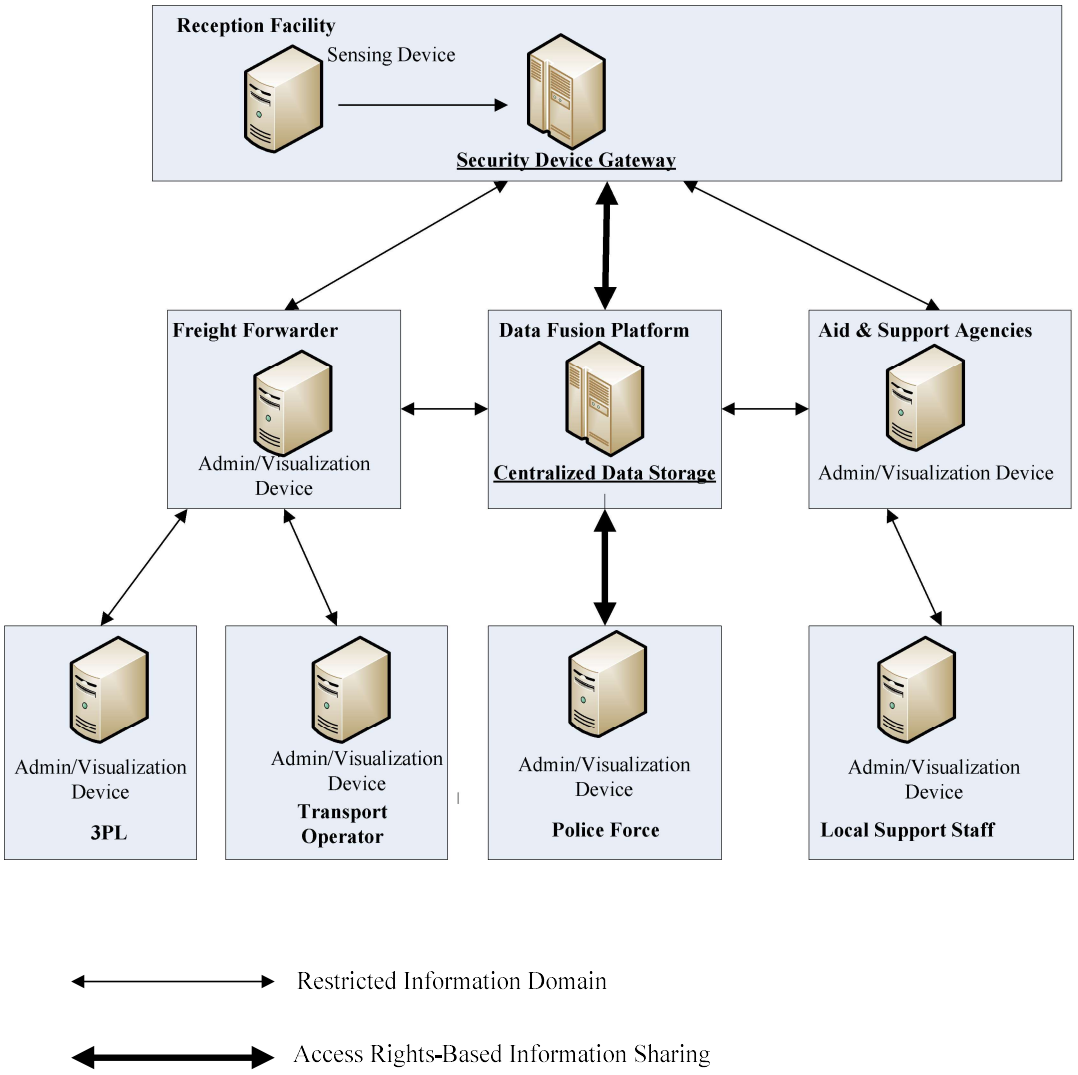

Figure 8 – Collaboration among humanitarian supply chain stakeholders: exchange of operational information

The collaborative relationships among the participants are shown in Figure 8. In this sub-scenario, a number of relevant HSC organizations participate. In particular, six main groups of organizations exchange messages and information with the Data Fusion System:

(1) Reception facility providers: these entities own and operate reception facilities and nest operational messages (including alerts). Internet of Things enabled devices are installed onto various means (e.g., vehicles and containers) to monitor the supply chain services.

(2) Aid and support organizations and local support staff: they are either global or local organizations offering aid. They may own or rent infrastructure and assets and offer aid (e.g., food and medicine). These entities require supply chain alerts, thus heavily relying on incoming information from various sources, such as reception centres.

(3) Police forces: they are law enforcement agencies with the responsibility of securing borders / perimeters, carrying out immigration and customs controls, checking illegal activities etc. These authorities have been assigned to operate screening processes, checking documentation, and collecting (often sensitive) intelligence.

(4) Freight forwarders: these entities manage the transfer of cargo thus they need access to increased security awareness.

(5) Transport operators and third-party logistics providers: these entities undertake the movement of cargo and also need advanced security awareness.

(6) Suppliers: they are tier 1 and tier 2 suppliers, providing materials and resources to the relief centres.

As discussed earlier, the proposed framework adopts a centralized approach for the information security. The Data Fusion Platform collects the information from all related stakeholders and disseminates the information to the respective entities. This approach facilitates rule-based or access-based sharing and pushing of information. For example, the data producer's security domain may determine whether a given data consumer has access to unprotected representation of a particular set of monitoring events. Data consumers may only have access to the unprotected monitoring events if both sub-domains allow them to do so.

5.6 Use Case and System Validation: Relief Operation in the Greek Reception Facilities

In order to validate the system conceptual framework, we consider a contemporary scenario of providing relief services to refugees in a first instance reception facility based on a second round interview with representatives from key stakeholders of the Greek refugee crisis. As depicted by Jasti and Kodali's (2015) Lean Supply Chain Management (LSCM) Pillars, the primary decisions of lean supply chain include capacity planning, allocation of resources, manufacturing of products, supplier management, and JIT practices. In a similar vein, the success of the relief organisations in HSC is based on how quickly they respond to the crisis, how quickly they receive and transfer the refuges, and how well they cater the refuges' needs. As the inflow of the refugees is essentially stochastic (Van Wassenhove, 2006), the success of the HSC depends on the adequate sharing of time information among the key stakeholders during sudden crisis outbursts. For example, the capacity planning may start as early as when the Hellenic Coastal Guard

identifies the dispatch of a small unidentified boat. Based on the information collected from the Maritime Transport Security Information Systems, the enforcement authorities recognize a potential need for providing relief to 40 to 50 people. This is when the resource allocation process begins. Room/bed availability in the first instance reception facilities needs to be explored. Once the availability is requested, a number of messages are sent to the relevant stakeholders (relief agencies, medical authorities, enforcement agencies and local suppliers). This procedure requires significant relief offering, as the crossing trip of arrivals takes only about 24 hours before reaching the final destination.

As the suppliers play a vital role in the success of any supply chains (Chin *et al*., 2004), so do the suppliers in the HSCs. In many instances, it is realized that a significant number of requests for quotes are urgent and this practice is attributed to "unusual" circumstances. However, according to the interviewees, the urgency materials (e.g., pallets, wood, energy, hygiene) could somehow be foreseen. A proposed improvement would be the use of the information stored in the enforcement agencies, so as to nurture and maintain long-term relationships with the suppliers. In this respect, the intention would be to not only achieve cost savings, but also achieve improved supplier performance in terms of lead time and commitment. This is also in line with Jasti and Kodali's (2015) finding that 70% of the LSCM frameworks propose supplier relationship management initiatives.

Furthermore, strategic supplier development should include a thorough evaluation and certification process, which is currently overlooked due to the urgency of the request. Building long-term supplier partnerships should be at the regional level. Additionally,

this activity should also entail careful selection of suppliers and, as advised by interviewees, include only a small number of reliable pre-selected suppliers. Managing the suppliers from commodity / function-based teams is also expected to include cost-based negotiations with suppliers, so as to further improve the cost performance. In this way, the successful integrated HSC ERP system can support seamless information flows across the stakeholders.

The suggestions of interviewees also include moving from the individual organization to the extended eco-system based organization. For this point to be materialized, the information technology should be utilized so as to improve supply chain effectiveness. The proposed integrated HSC ERP system enables information sharing which goes beyond legacy EDI communications, by using a centralised database for documentation, information sharing, and ultimately interconnection of ERPs, so as to improve and expedite decision making. The system can support multi-echelon decision making, from the local level up to an international level. The information technologies used employ effective and transparent information flow throughout the HSC. Furthermore, the proposed system is scalable, thus is able to incorporate electronic commerce outlets (e.g., local food and personal items deliveries). More importantly, the proposed system has a number of elements enabling lean processes to eliminate wastes. This is achieved by standardizing products and processes and by constantly analysing the supply chain for improvements. For the proposed system, the continuous improvement is also allowed by constant improving the content of the messages and the recipient lists.

6. Discussion

The key finding of the use case is that the relief organisations are requested to provide immediate responses when the refugees have arrived at the first instance reception facilities in the crisis. The present setup significantly hinders the effectiveness of the relief provisioning due to lack of information sharing and cross-functional and cross-organizational coordination. In fact, required information is already accessible by a number of enforcement authorities, who could share it in advance to improve the resource allocation of relief organisations. To this end, this study develops an integrated HSC ERP system that allows the real time information sharing in all relevant HSC stakeholders. This system is based on lean principles so as to improve HSC efficiency and effectiveness.

Based on the feedback from the interviewees, the proposed system is expected to improve the overall performance of the HSC. First, the system has the potential to facilitate the HSC planning at both upstream and downstream by reducing administrative and bureaucratic data sharing inefficiencies and by including lean principles. Second, the system improves supply chain integration and coordination through the enhanced monitoring of the refugee flows. In this respect, the HSC can be more flexible and responsive, and thus be able to cope with uncertain refugee volumes. Third, the HSC stakeholders are connected at a trust-based information sharing platform through the utilization of the existing Maritime Transport Security Information System and the SSN. Fourth, the proposed system can significantly improve the collaboration and the interoperability among border agencies and enforcement organizations. Fifth, the system

is expected to increase the transparency between reception facilities, ports, terminals and inland terminals, so as to reduce the transaction and turnaround time of relief operations as well as reducing resource requirements.

It is important to point out that this study is exploratory in nature and bears certain restrictions. The first restriction regards the content of information that the enforcement agencies are willing to share. For security or personal data protection reasons, many enforcement agencies consider that a significant amount of information they hold as sensitive. Secondly, the relief organizations consider many requests for resources as urgent and thus are not able to properly prioritize a lean acquisition process. Thirdly, our analysis reveals that the HSC is not easily replicable from one context to another, for example from refugee relief to earthquake relief, despite the core components and the main management principles being transferable. To this end, our study recommends that the development of future systems and frameworks should consider these constraints in addressing lean approaches for the HSC.

The system developed in this study is a starting point deploying the lean HSC ERP system that can cope with the internal and external limitations. One of the key advantages of the system is that it is practitioner driven rather than academic driven considering real life requirements from suppliers, operators and enforcement agencies. This system reflects the industrial environment, and the intention is to offer a practicable, realistic and replicable framework (Soni and Kodali, 2013). In this respect, we found that the main

objective of reduced turnaround times and improved effectiveness may be achieved through a lean perspective.

Moreover, the proposed system had initial proof through a validation process with practitioners. In this respect, we tried to bridge the gap between theory and practice. As indicated above, although there are a number of constraints that need to be further studied, the proposed system has the practical value to better facilitate the operations of relief organizations and will encourage more practitioners to adopt similar systems.

7. Conclusion

This research attempts to address the challenge of improving HSC efficiency and lean process by focusing on the information sharing among different HSC stakeholders. We highlight that real time information sharing will support effective and lean HSC processes. To this end, this research proposes a simple system that facilitates improved data sharing among HSC stakeholders. Providing rule-based access to HSC information in real time enables not only optimization of the supply chain but more importantly the improvement of the relief level.

The study contributes to the field of HSCM by developing and validating a practical information sharing system combining ERP and lean approaches based on the existing Maritime Transport Security Information System. According to Jasti and Kodali (2015), very few existing lean supply chain frameworks are practitioner based. We fill this gap by incorporating field experts' experience into the development of this system. The

system discussed in our study is novel in two ways. First, we develop an information sharing system that combines lean and responsive practices with HSCs. Second, by building on existing IT frameworks, we propose and validate an ERP system that satisfies the main requirement of HSCs of offering relief when and where needed in a coordinated manner.

We concur that the relief operations and more broadly the HSCs are a complex topic and more research is needed to improve the lean aspects of the HSC operations. However, our research is a good starting point to bridge the gap between information sharing, lean and responsive HSC. Based on the use case analysis, we identified not only the system requirement of the integrated ERP system, but also the key managerial requirements which need to be considered by HSC organizations and stakeholders. For example, creating the culture and effective mechanism of information sharing is an important element, as we have found that many HSC organizations are reluctant to share pertinent information. Therefore, the strategic alignment of the different organizations in the HSC is needed. This should be built upon the shared understanding of various performance metrics and data sensitivity between HSC organizations as well as stakeholders.

Moreover, further exploitation of this integrated HSC EPR system requires a top-down approach by authorities and policy makers. The security domain (e.g., Maritime Transport Security Information System) is heavily regulated and as such, centrally imposed decisions will enable better usage of such innovative information sharing frameworks.

Furthermore, one of the main trade-offs that has to be considered is the sharing of security related sensitive information and the increasing requirement for the effectiveness and responsiveness of HSCs. Decisions, therefore, have to be made on the categorization of information sharing and the establishment of rules and shared understandings between authorities and HSC stakeholders to retain the information sensitivity while ensuring effective HSC coordination.

There are limitations of this study which deserve future research. First, the validation of the system conceptual framework was performed by field experts representing 3 different stakeholders in the Greek HSC. Although this serves as an initial proof of the system and the framework, a more inclusive validation and extended verification process would also be required. Future research should provide more empirical verification to assess the value of the different information sharing mechanisms along the HSC. Such effort could also improve the Technology Readiness Level of this system. Second, we did not differentiate the quantity and the quality of the data shared through the system. Both quantity and quality of the shared data are important for any successful HSC systems. In this respect, relevant HSC organizations should be committed in understanding the data to be shared and also setting up common rules and principles which could be reflected in the further development of the system. Third, we haven't touched upon any reengineering of processes, but it is expected that this will be a necessary step in implementing this system with the HSC stakeholders in the future. Nevertheless, the flexible architecture we proposed supports either centralized or decentralized or even hybrid systems, as well as

fostering collaborative processes, visibility and transparency of HSCs and cooperation between different stakeholders. Fourth, this paper proposes but a simple system to a complex reality. More advanced data fusion frameworks may be further explored. Future research could increase the responsiveness of the HSC information system by integrating Port Community systems, ERP, EDI as well as any other similar systems through the internet, which can be an important step in improving communication and ensuring a smooth flow of relief resources along the HSC.

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