

ICT adoption in multimodal transport sites: investigating institutional-related influences in international seaports terminals

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Abstract

Seaports represent a major component of multimodal transport networks and they are key in the operation of supply chains and global logistics. In multimodal transport networks it is well acknowledged the use of information and communication technology (ICT) can deliver benefits that include real time track and trace, visibility and reduced lead-time, among others. Given the importance of the benefits associated to the adoption of ICT in the operation of multimodal transport networks, this work uses institutional-related theories in a multiple-case study comprising seven seaports terminals located in two continents. The purpose of the study is to identify key elements that affect and influence the adoption of ICT to support interoperability and connectivity in multi-modal seaport terminal operations. The analysis is used to identify groupings of influence linked to elements comprising institutional-related theories like coercion and mimesis, part of institutional isomorphism, among others. The study shows that both government legislation and dominant organizations running ports in various geographical locations exert great influence regarding ICT adoption policies in seaport terminals. The adoption of ICT has become important given the proliferation of technologies, the increasing need for track and trace capabilities and the economic impact of seaports terminals.

Keywords: ICT adoption; seaport logistics; multi-modality; institutional isomorphism; port research

1. Introduction

Information and communication technology (ICT) plays a fundamental role in the support of supply chains and global logistics. Recent development in the field of ICT have further revolutionized the ways information is shared and supply chains are structured (Harris et al., 2015). In transport logistics the application of information and communication technology (ICT) is to facilitate activities such as cargo tracking, warehousing, and shipment notice forwarding, in support of product movement in the supply chain (Wong et al., 2009a). Another important characteristic of logistics operations found in ports is multi-modality or co-modality, which is about the efficient use of different modes on their own and in combination, resulting in a sustainable and optimal utilization of resources (Zomer and Anten, 2008). Complex logistics arrangements can result from the combination of different modes of transportation like road, sea and air.

International ports, though invisible to many, constitute a fundamental element of global supply chains and logistics. Seaports play an important role as they are responsible for handling a significant number of goods in and out of economic regions/trade blocs. A seaport has been defined as an interface between a sea transportation system on one side, and, on the other side, a land transport network (Rodon et al., 2008). Cullinane and Talley (2006) acknowledge ports as economic units providing a service or nodes between various transportation modes, or as facilities through which cargoes pass, or as part of logistics and supply chains. International port terminals have become fundamental elements of global supply chains which have to support economic growth with the corresponding trade and transport volumes, hence ports and terminals have been pushed to increase further their capacities and speed of handling (European Commission, 2010). In the European Union about 90% of the international trade is performed by sea (Gonzalez and Trujillo, 2008) and just before the negative effects of the economic crisis of 2008 started to have an impact, maritime ports in the EU-27 handled 3,919 million tonnes of seaborne goods (Eurostat, 2009). In the last decades, ports have witnessed a substantial increase in competition, due to technological and organizational innovations and the emergence of powerful international players, such as ocean carriers and terminal operators (Parola et al., 2013). The rapid increase in port competition has put pressures on ports to improve the quality of the traditional port services, implementing differentiation strategies by providing more specialized, value-added services and delivering door-to-door transport solutions (Cetin and Cerit, 2010). Seaport operations these days comprise complex arrangements in where road transportation is highly involved.

The multi-modality and diversity of logistics activities found in ports and the various types of technologies available represent a formidable challenge in terms of identifying trends dictating the adoption of ICT. For example, Toh et al. (2009) highlight that early globalization and internationalization of supply chains placed significant emphasis on electronic data interchange (EDI) through systems that include CargoWise EDI, TradeGate, TradeXchange, and TradeNet to facilitate trade administration (e.g. processing of trade and customs declarations) and enabling seamless trade transactions with the critical involvement of customs services. In recent years transport logistics operations have witnessed the adoption of various technologies based on radio signals, for example radio frequency identification (RFID) tags are widely used to track and trace different types of cargoes within the confinement of a port area. The RFID tag may be attached directly to the cargo or carried by the driver/operator of a haulage vehicle serving in the port premises. Technologies broadly used to link haulage vehicles include cellular networks and satellite systems and in a lesser scale Wi-Fi, UMTS, 4G/LTE and WiMax. Nonetheless, significant challenges still persist in terms of reliability and connectivity, problems due to difficulties associated with limited range, scalability and security (Coronado et al., 2009).

Alongside the proliferation of various types of technologies in logistics and supply chain management, representative studies in the field of ICT adoption have covered the development of models to examine the relationships among perceived benefits, perceived barriers and organizational context related to the adoption of information systems in logistics companies in a specific location (Ngai et al., 2008). This is important as in a port, there can be numerous ICT applications being used simultaneously. Stahlbock and Voß (2008) acknowledge that powerful ICT and logistics control software systems including optimization methods can be deployed so existing infrastructure and equipment can be used more efficiently.

In the specific context of seaports the adoption of ICT can be associated to various academic theories. Diffusion is a theory that addresses ICT adoption (Hu et al., 1997) and which can be linked to the adoption of ICT in ports. Lai et al. (2006) indicate that diffusion is based on the assumption that rational adopters make decisions and choices based on the information that is received via communication and social networks. Others researchers have focused on identifying the factors that affect the adoption of ICT, more specifically Internet-based inter-organizational systems and how their adoption affects various measures of performance (Sila, 2010).

Ports and logistics are fundamental factors in today's business landscape where global supply chains are seen as integrative systems that mirror a traditional focus on improving connections at the intra-organizational level through tightly coupled information systems (Park et al., 2005). It is indeed the proliferation of ICT in ports that gives the opportunity to build-up theory that relates to managing ICT adoption in ports. This is relevant as according to Woo et al. (2011) the low proportion of papers with discernible theories and models and the lack of theories and models specific to port operations and management may have made port research seen as a body of knowledge without firm theoretical bases or without original theories. In the view of Cepolina and Ghiara (2013) the port sector has progressively endorsed ICT based items (intranet, extranet, RFID, communication platforms) since the mid-1980s and opportunities exist to explore aspects such as governance concepts with specific operational, technological implementation strategies and use options which aim towards the facilitation of port actors. The researchers highlight that the port field scientific literature is not so abundant, hence giving the opportunity to expand the current knowledge in the area.

The management of ICT has become a major challenge in various sectors and given the importance of ICT in global supply chains and its conspicuous presence in global logistics and international seaport terminals, this paper aims to build-up the body of knowledge on port research linked to the adoption of

ICT solutions for the support of logistics operations involving terminal operations and road haulage. Academic theories such as technology acceptance model (TAM) shifted to an organizational focus – supply chain technology acceptance-, institutional isomorphism and institutional theory among others are reviewed and applied to a multiple-case study of seven seaport terminals in two continents. The multiple cases investigated make possible to identify similarities but also the differences that institutional-related theories exert on the adoption of ICT in seaports terminals to support interoperability and connectivity and from there build-up the elements of a concept model that addresses ICT adoption in ports.

2. Literature Review: seaport terminals research and ICT

World seaports have gained their efficiency on primary sources that include improved management and optimized operation of container terminals, adjustment of production scales and technological progress (Cheon et al., 2010). For some years it has been recognized that container terminals typically have well developed computer and communication networks (Das and Spasovic, 2003). Focusing on the technological side, one area that offers the opportunity to contribute to the development of port research is the study of the management of the adoption of ICT solutions. Indeed, seaports can benefit from ICT developments because many of them still suffer from congestion and are in urgent need of procedures and technologies to increase the through-put speed of goods (Nyquist, 2009), not to mention that the growing complexity in ports is also due to the various types of cargoes handled such as containers, bulks (solids and liquids), ro-ro, lo-lo, heavy-lift and out-of-gauge cargoes.

Seaports have become a key element of global logistics. For this reason, logistics require the use of ICT for effective coordination to deal with the processes of planning, implementing, and controlling the efficient flow and storage of raw materials, in-process inventory, finished goods, services, and related information from points of origin to consumption while conforming to customer requirements (Lai et al., 2006). Harris et al. (2015) identify terminal and seaport ICT and applications benefits that include: *a)* reduced loading-and unloading time at inter-modal terminal due to advanced terminal operation systems; *b)* Improved utilization of intermodal terminal infrastructure; *c)* Improved, efficient interfaces between different modes at transshipment points for achieving seamless transfer of cargo; *d)* Reduced operation costs and *e)* Improved customer service and satisfaction. ICT has become important as technological adoptions in transport logistics enable partner firms to share information between them (Wong et al., 2009a) and also because collaborative investment in information technologies among supply chain stakeholders has become a strategic thrust to achieve more transparent and efficient supply chains (Lee et al., 2011).

Research on ICT in seaports/terminals is limited and research undertaken in recent years has addressed the field in different ways. The work by Keceli (2011) explores the generation of a number of guidelines for the development of a port community system as the efficiency of communications among all the parties connected to a seaport has a crucial effect on port administration. The researcher used in-depth interviews with industrial organizations in Turkey to generate a list of expected benefits. Wickert et al. (2012) highlight the importance of ICT in seaport container terminals, as the software packages used by them are always especially tailored for huge amounts of cargo handlings and the optimisation of transshipment device usages and storage slots. The researchers acknowledge that ICT in intermodal hinterland transport can benefit the haulage transport chain by providing routing results based on ecological and technical issues and economic use of equipment.

Cetin and Cerit (2010) argue that ICT is a process that along with other processes including port operations, human resources, marketing and the relationship between the port and its environment should be analysed to assess effectiveness in a port organization. Using a delphi study the authors focus on ICT as a port subsystem comprising Electronic Data Interchange (EDI), cargo tracking and tracing and IT programmes. The delphi study included experts from both port and terminal operators. The study encapsulates the views of experts by claiming ICT infrastructure of a port is a must for the safe and efficient port operations and the integration of and collaboration on virtual networks provides time and cost utilization in the port processes. The study concludes the use of ICT together with the customer orientation is a requirement for port competitiveness.

The proliferation of the use of technologies in seaports including RFID, cellular networks, GPS/satellite systems, UMTS, 4G/LTE, WiMax and vehicle wireless networks (VANETS) as well as internet-based inter-organizational systems including enterprise resource planning (ERP) to support transport and logistics services constitute a reminder that the wide assortment of supply chain technologies challenges firms to perpetually evaluate the emerging technologies available in the market and in use by both competing and partnering firms (Ranganathan and Sethi, 2002). Furthermore, in a competitive environment firms are often encouraged by their supply chain partners to employ specific technologies, and the variety of technologies available for consideration is typically characterized by continuous and rapid change (Carr, 2003; Jones, 2003). Verdegem and De Marez (2011) highlight that as more technological innovations are introduced in rapid succession and an increased number of those innovations fail, therefore profound insights in the determinants towards adoption and use become more important.

Addressing ICT adoption at the institutional level, the work by Hernandez et al. (2008) focuses on areas that cover the acceptance of management software (i.e. CRM, financial accounting, budgeting) by evaluating usefulness in the firm's activity and the difficulties that arise to adapt its structures to the new technology. By using the technology acceptance model (TAM), the researchers demonstrate that the firm's decision-maker, not the end-users, can provide an adequate vision of the acceptance of new management software being deployed in an organization. Bayo-Moriones and Lera-Lopez (2007) use a survey of large and small Spanish firms to analyse the role of five groups of factors related to ICT adoption including environment, firm structure, human capital, competitive strategy and internal organization. Their work highlights that the complexity of ICT diffusion and its implications in a firm management need to consider different features such as firm characteristics or workers profiles. The next subsection addresses ICT adoption theory in the context of the particularities of the logistics/ports which is a sector/area that has received little attention in the academic literature.

2.1 ICT adoption theory in the context of logistics/ports operations

Seaports play a fundamental role in today's supply chains, hence, the various technologies and applications used in seaports have an effect on supply chain management and logistics. In their research work Autry et al. (2010) identify the technology acceptance model (TAM) as suitable for the study of supply chain technologies, a term that encompasses "tools and/or techniques that may be implemented in order to effectuate integrated supply chain management within or across organizational boundaries". TAM addresses the perceived usefulness of the technology and its perceived ease of use (Parasuraman, 2000). However Autry et al. (2010) recognize the needed shift to an organizational focus and supply chain technology context, a theoretical application and analysis of the TAM comprising organization-level cognitions and behaviors. Moreover, Autry et al. (2010) add that enlarging TAM enables the examination of the firm as a user of supply chain technology. The recognition of the firm as the user which accepts and adopts supply chain technologies which are inter-organizational in scope, can give the opportunity to coin terms that reflect such condition like supply chain technology acceptance. At the supply chain level, characterized by inter-organizational relationships, the organization is the user of technologies in a process that has included adoption (reflected in the actual implementation of the technology) and which has been preceded by acceptance, a stage commonly associated with a company's aim to operate a specific technology.

Diffusion is perhaps one of the original theories conceived to explain the adoption of ICT. However, in the view of Lai et al. (2006) this theory has a major pitfall as it has failed to address what is called institutional isomorphic processes, which can affect the decisions of organizations regarding the adoption

of innovations. Institutional isomorphism as defined by DiMaggio and Powell (1983) is the constraining process that forces one unit in a population to resemble other units that face the same environment conditions. Moreover, the theory of institutional isomorphism provides a theoretical lens to explain the institutional isomorphic influences among a group of firms that face the same environmental conditions, and to advance the knowledge of IT adoption for SCM (Lai et al., 2006). Modern seaport sites are inherently multi-modal in their logistics operations; that makes them unique scenarios for investigating institutional isomorphism, as it occurs in the structures, interactions, practices and dominion of the firms participating in supply chains, where the parties join forces to manage their logistical activities (Lai et al., 2006).

Organizations compete for political power and institutional legitimacy for social and economic rewards (DiMaggio and Powell, 1983) and seaports are not the exception. Indeed, organizations have to base their decisions on three major types of institutional isomorphism identified by Lai et al. (2006): coercion, mimesis and norms. As an example, the research work by Theo et al. (2003) makes use of institutional theory to understand the factors that enable the adoption of inter-organizational systems. They conducted a survey of 222 Singapore-based organizations to investigate a set of institutional factors that influence the intent to adopt financial EDI. The results from their study show that three institutional pressures – mimetic, coercive and normative- have a significant influence on organizational intention to adopt financial EDI.

Coercion is usually associated to political influence and legitimacy. Coercive pressures are exerted on a dependent firm by other organizations and by cultural expectations in the society within which the dependent firm operates (DiMaggio and Powell, 1983). When talking about coercion related to ICT adoption, the adopting firms may acquire technical assistance from the dominant firm and/or relevant professional associations, especially in the case of integrating their existing systems and processes with newly adopted ICT (Lai et al., 2006). In some cases, the dominant firm may provide technical support and would be able to share its experience with the adopting firms to ensure the quality and conformity of the technology adoption (Lai et al., 2006).

The institutional isomorphism type of mimesis is associated with the motivations (e.g. uncertainty) that encourage the imitation of practices. Mimesis happens when a firm has ambiguous goals and operates in a volatile environment and it models itself on other organizations (Lai et al., 2006). An extensive explanation on encouraging the imitation of practices is given by Lai et al. (2006) who describe that in the context of SCM, when seeking strategic SCM tools and practices to outperform competitors, firms

consciously or unconsciously mimic the practices of their SC partners for reasons that include having an easy access to supply chain management practices of their partner firms through information interchanges and inter-firm process integrations. Another reason is represented by the attributes that seem to account for the successful SCM practices of the partner firms that are easily observed by the mimicking firms in the SC. The third reason given highlights the case where partner firms are often willing to share SCM experiences and know-how with one another, as the sharing of information and knowledge benefits them as well while they serve the same supply chain. A normative process happens where firms in the supply chain are subject to the norms, standards, and expectations of their SCM in order to attain effective coordination. The organizations that take the normative institutional isomorphism approach standardize their supply chain by setting the required ICT and standards for managing information and product flows (Lai et al., 2006). Firms seeking entry to that SC network are expected to adopt the required ICT.

Institutional theory, as highlighted by Wong et al. (2009b), is useful to identify the organizations that exert institutional pressures requiring ICT development efforts. According to them in institutional theory the desire to reduce cost or improve efficiency with external entities and by organizational legitimacy represent drivers that foster the institutionalization of ICT development and at the same time it does involve ensuring continuous creation, being open to new information and being aware of more than one perspective. Wong et al. (2009b) used a comprehensive case of a container terminal to apply institutional theory, where the need to use ICT is to facilitate flows in transportation chains in order to comply with transportation policies and regulations and to ensure security. Furthermore, regarding institutional pressures exerted on ports, the researchers identified three groups of organizations that impose different influences on container terminal operations, namely private organizations that use port facilities for business purposes, public organizations that impose regulations on container terminal operations and rival organizations that compete for businesses. Customers usually include freight forwarders, shippers, logistics operators, and trucking companies. Typically, trucking/haulage companies send trucks to a container terminal to pick up and/or deliver goods, while the shipping lines call at the terminal to ship containers from or to another container seaport.

Following on investigating institutional influences, Lai et al. (2009) states that in order to comply with transportation policies and regulations, container terminal operations rely on the use of ICT to facilitate flows in transportation chains. Wong et al. (2009b) add that in adopting of a new information system, organizations would have to check compatibility with existing software and hardware of the firm as well as compatibility with the software used by its major suppliers and customers.

A significant number of studies have focused on the adoption of ICT and its contribution to port operations performance, but only a few have explored the institutional pressures that affect organizational IT management (ITM) (Somers and Nelson, 2004; Liang et al., 2007). Moreover, fewer studies have investigated how ITM can improve the development of ICT in meeting the institutional pressures faced by container terminals. In the view of Wong et al. (2009b) ICT development is not only affected by the operational needs of container terminals but also by the operations of its external entities (customers, competitors, regulatory agencies, etc.). The same researchers highlight the institutionalization of ICT development is driven by the target to reduce costs/improve efficiency and by organizational legitimacy.

Cepolina and Ghiara (2013) acknowledge ICT could play a strong supporting role accompanying the evolution path of port authorities and sustaining their growth strategies including marketing collaboration and institutional networking activities. Based on the case of the Genoa Port Authority, the researchers highlight the importance of ICT in the development of integrated logistics systems is directly connected to the central role that Public Bodies involved in the process can play in coordinating the different private players and in defining the element of qualitative control of the different system components performances. Lack of governance can result in a proliferation of independently customized ICT systems based on their specific goals and needs.

Institutional theory has been considered as a suitable choice for framing the research work presented in this paper however it may have been possible to include other theories. For example, resource-based view theory may be used to identify core capabilities which represent sources of competency, helping to distinguish a company's strength from that of other firms (Yang et al., 2009). Network theory in the view of Salancik (1995) is used to correct tendencies in organisational theory to focus on the trees rather than forest, on the actions of individual organisations rather than on the organisation of their actions. According to the researcher networks are constructed when individuals, whether organisations or humans interact and when many individuals are involved, the resulting structure can be analysed to derive many facts about the individuals or the network. System theory may offer an alternative to analyse the interaction of the various elements involved in the adoption of ICT applications. Von Bertalanffy (1950) mentioned that system theory defines the general principles of dynamic interaction which appears as the central problem of modern science. Using system theory it may be possible to explain the principles common to ICT adoption in seaport terminals which themselves represent complex entities. Nonetheless, because of space, time constraint and resources, this research focused on institutional theory.

Nowadays characteristics such as ubiquitous access, mobility, security, speed, the proliferation of heterogeneous technologies and the need for real-time track and trace characterize the use of modern ICT in complex business environments such as seaports. This situation gives the opportunity to revisit the use of institutional theory. Research work involving institutional theory for ICT adoption within the context of international ports offers great opportunities for theory building as Woo et al. (2011) and Pallis et al. (2010) agree that research on ports is still an emerging field characterized for its low coherence and small communities. Reasons given by the authors to support this assertion include the lack of strong underlying theories or limited consensus, hence the need for a comprehensive analysis on methodological perspectives of port research. Moreover, methodological issues have not been studied in port research compared to other related fields including logistics and supply chain management (Woo et al., 2011). According to Woo et al. (2010) the development of port research has received contributions not only from research demand derived from complex phenomena taking place in the port industry but also from the development of theoretical models and the introduction of appropriate methodologies. The qualitative research presented in this paper is integrative because it combines concepts from institutional-related theories for ICT developments/adoption and also concepts covering multi-modal logistics represented by terminal and haulage operations within the confinements of a port location. The rationale of this work is to explore and build-up theory on the differences that institutional-related theories influence the adoption of emergent technologies to enable interoperability and connectivity in port locations. The high level of specialization found in seaports regarding the use of ICT can be seen as a justification for the study of ICT adoption in such environment, as Verdegem and De Marez (2011) highlight that differences in segment size as well as determinants for different technologies require a product and segment specific approach when investigating the acceptance of ICT.

The review of existing theory presented in this section plays an important role in order to add validity to the conclusions drawn from data (Barratt et al. 2011) for that reason table 1 shows the representative institutional-related theories that have been considered for this research. The use of institutional-related theories suits this work as port research can be viewed and addressed from various perspectives, and because researchers with different disciplinary backgrounds can participate of it (Woo et al, 2011). This research focuses on the study of the seaport terminals as the party exerting institutional influences to drive organizations to adopt ICT.

[Insert table 1 about here]

The unit of analysis for this research is the port terminal. As terminal operating companies have grown, they have also been able to bring to ports an increased level of expertise as well as capital, and a greater awareness of the need to supply value added services (De Martino et al, 2013). This led to a greater attention to port customers' requirements so that performance attributes' gaps could be identified for improvement.

As global logistics and multi-modality grows in importance in different parts of the world, it is expected this research will make a contribution by expanding the knowledge available on the reasons dictating the adoption of ICT in seaports. Hence the review of the theories summarized in table 1 is used to formulate research questions that lead to theory building. These questions include:

- How the similarities and differences behind the types and functionality of ICT being adopted in seaports enable interoperability and connectivity in multi-modal operations?
- Why key elements of institutional-related theories influence and affect the adoption of emergent technologies in ICT to enable interoperability and connectivity in seaports?

The next section describes the methodology designed to address the research questions formulated based on the review of the relevant literature on ICT development/adoption that can be applied to ports.

3. Methodology

This research agrees with Woo et al. (2011) and Heaver (2006) assertion that seaports, transport and services have become complicated and sophisticated and a more integrated research approach is necessary. Regarding the methodologies that can be employed to undertake research on ports the same authors highlight that a number of research works on the subject have revealed a strong dependence on a positivistic paradigm approach. That entails the use of quantitative methods for the purpose of generating objective knowledge rather than the widespread use of constructivism based on qualitative methods. For example, the authors link ICT-related research such as management information systems (MIS) to a positivistic approach. On the other hand, they also indicate that case studies and conceptual works are two of the most representative methods used in seaport research with survey and interview methods showing potential for growth in use as these two have not been extensively used in this area. Barrat et al. (2011) define the qualitative case study as an empirical research that primarily uses contextually rich data from bounded real-world settings to investigate a focused phenomenon.

The case study methodology can be found in the academic literature on seaports. For example, in their investigation on logistics innovations in seaports, De Martino et al. (2013) recognise that ICT systems are

well established and available in the market to support strategic options aimed at maximizing throughput, improving shipping companies' satisfaction and increasing the efficiency of port operations. Interestingly enough, the case study methodology used by the authors comprises the use of deductive approach by applying theoretical notions about logistics innovation to seaports and inductively by presenting specific cases of seaports that have realized logistics innovations.

In the logistics and transportation field various research methods are available. Kovacs and Spens (2005) highlight that logistics research is interdisciplinary by definition as it stems from many different scientific traditions. According to the authors logistics research has favoured positivist approaches, while qualitative and interpretative research is rather scarce. Using the works by researchers like Taylor et al. (2002), Kovacs and Spens (2005) provide a comprehensive review of the use of deductive research which follows a conscious direction from a general law to a specific case. The authors point out that deductive positivism is the predominant research approach in business logistics research. A deductive research approach is most suitable for testing existing theories, not creating new science (Arlbjørn and Halldorsson, 2002). On the other hand, Kovacs and Spens (2005) state that the inductive research approach reasons through moving from a specific case or a collection of observations to general law, i.e. from facts to theory. An inductive approach is a theory-building process starting with observations of specific instances, and seeking to establish a generalisation about the phenomenon under investigation (Wilson, 2010).

In this research work involving ICT adoption in international seaports has elements of the field of information systems, as in this field the role of technology is a critical research element which separates IS research from research in other disciplines (Benbasat and Zmud 2003). According to Sarker et al. (2013) this is of particular importance in qualitative studies where authors frequently focus on the human/social dynamics and implications and, thus, can end up with studies that treat IT as an “omitted variable” (Orlikowski and Iacono 2001).

This research work has formulated explicit research questions which according to Dubé and Paré (2003) provide the direction of inquiry, and enable a connection between the research and its practical and theoretical contributions. In the view of Yin (1994) case study research should generally be used to answer *how* and *why* questions. Case studies can follow a deductive approach, a positivist case study deals with deductive theory testing, addressing, reliability and increasing degrees of freedom.

The multiple-case study is the preferred method for this research. One of the justifications for the use of multiple cases is what Meredith (1998) and Stuart et al. (2002) call the lack of suitability of existing perspectives for new contexts. Indeed, ICT support to seaport terminals is now being transformed due to the emergence of technological developments. By targeting multiple cases, this research addresses some key points highlighted by Miles and Huberman (1994) such as the possibility to understand processes and outcomes of cases and causality. An important element of the case study methodology is the unit of study which for this research consists of a seaport site that uses ICT solutions for the support of logistics operations involving container terminal operations and haulage vehicles.

In this research validity and reliability are addressed through the concept of theoretical engagement. According to Sarker et al. (2013) theoretical engagement is the means by which the researcher adopts and integrates up-front theory into the study, and/or develops theoretical contributions as “output” of the study. Institutional related theories that affect and influence the adoption of ICT to support interoperability and connectivity in multi-modal operations represent the up-front theory used in theoretical engagement related to this research.

The procedure employed for this research follows guidelines highlighted by Seaman (1999), where visits to the participating sites were planned to obtain first-hand information from tours of specific facilities and services, interviews with individuals or groups, or observations of specific activities at the sites. Following Seaman’s (1999) guidelines, visits were used to obtain reports, brochures, and examples of products or services made available at the sites, also enabling the opportunity to obtain first-hand information about users or activities in a particular setting. Another benefit is the ability to evolve the data collection strategies on site, depending on the topics the evaluator determines are important to probe for obtaining additional information.

During the visits, open questions in the format of semi-structured interviews were presented to participating managers. The emphasis on collecting data through the use of open questions was to accomplish what Bryman (2004) and Lockström et al. (2009) refer as ‘comparability while ensuring an unobstructed flow of narrations’. In this research the use of seven medium-to-large sized port terminals, three in Europe and four in Asia provides benefits such as increasing external validity which is linked to ‘within-case’ and ‘cross-case’ analysis (Yin, 1994; Lockström et al. 2009). In this study at least one manager for each site participated in the study, in some cases there were two. Managers interviewed at each site are the representatives of the organizations participating in the study. During the visits to the seaport terminal sites it was possible to see employees/end-users at work using the investigated port

terminal systems. End-users are provided with the training necessary to use the systems at each of the sites visited.

The case study methodology offers several benefits as identified by a number of academics. For example, Buganza et al. (2009) state that the case study methodology approach (which is the base for the methodology employed in this case), allows a holistic and contextualized analysis and it is properly suited for the initial phases of the exploratory nature of research work. Quantitative methods such as surveys do not provide the depth for investigating the phenomenon closely and identify the mechanisms by which the variables interrelate (Van den Hoed, 2004 and Yin 1994, 2004). Appendix *A* shows the statements/open questions investigated within the organizations that participated in this study. As part of the research protocol, those statements/issues were presented to port terminal operations managers for their answer/discussion.

4. Multiple Cases of Port Terminals Investigated

This research addresses the cases of seven medium-to-large sized seaport terminals, three of them located in Europe and the other four in Asia. Barrat et al. (2011) highlight that multiple cases can augment external validity and help guard against observer bias and for theory building purposes, the use of multiple cases is likely to create more robust and testable theory than single case research. Eisenhardt (1989) states the convenience of using 4-10 cases to capture the complexity of the real world. The next subsections discuss the following: the criteria and limitations faced during case selection and the operations details of participating port terminals.

4.1 Case selection criteria

Choosing the individuals/organizations to participate in a case study is always a challenging decision. In this research the number of seaport terminals participating was in part limited by the amount of financial resources available, in particular travel to different locations. Personal contacts and networks were used to approach managers in different sites to get them to agree to participate. Finding a suitable time was also another challenge faced. Nonetheless, with the resources available and limitations faced it was still possible to gather a diverse group of seaport sites, seven medium-to-large sized port terminals, three in Europe and four in Asia. Participating sites included port terminals located in the Humber Estuary, UK; Zeebrugge, Belgium; Busan, South Korea; Hong Kong; Shanghai and Xiamen, China and Vigo, Spain. The first seaport terminal contacted was the one in the Humber estuary as one of the researchers is based in the UK. These locations represent a diverse pool of participant sites, hence, these sites differ in terms of volumes handled, type of ownership, the approach used in the development and adoption of ICT

among others. For example, the seaports of Hong Kong and Busan have been considered global hub ports based on connectivity and cooperation indices (Low et al., 2009). All sites are privately owned and have in common the use of ICT solutions for the support of logistics operations involving container terminal operations and haulage vehicles at a time of increasing need for visibility and track and trace capabilities. Also it was considered interesting for this research to include sites from different geographic regions given the effects the economic crisis of 2008 had on European-based seaports and their Asian-based counterparts. It was the purpose of this research work to have a heterogeneous sample of port sites to appreciate the influence of institutional theory in the adoption of ICT. Overall, selecting a diverse group of sites represents what Snider et al. (2009) call 'polar types'. In the context of this research, 'polar types' are about some sites being more developed than others not to mention that every site possess individual characteristics.

The elements of the seaport terminals to be investigated are similar to those used by Wong et al. (2009b) in their research at Yantian International Container Terminal. In that piece of work the authors found that the port site has been developing IT to facilitate a central management of yard resources via information sharing amongst the various information systems, enabling the allocation of resources at the right time and place. In their research the authors focused on the use of ICT specifically to: (1) discharging and loading of containers; (2) yard resource allocation; (3) utilization of stacking areas; and (4) data sharing between port users. Regarding the use of technologies the authors identified the recent deployment of a tractor mobile terminal system with a Wi-Fi network for allocating a tractor in the container port to a grounding and pick-up location which significantly increased operational efficiency.

Kim (2013) states that there are many different definitions used to explain the abbreviation of ICT, the term normally includes information or communication devices and software and parts in the ICT industry. Rather than focusing on one specific type of information system/solution, figure 1, the unit of analysis under study, illustrates the type of ICT arrangement investigated in the seven port sites that participated in this research. The ICT arrangement investigated comprises various technologies such as port site cellular/wireless communications, plate recognition access systems and keypads to control access to terminals and job scheduler applications used for planning the loading and unloading of vessels and trucks. Job schedulers are often linked to mission critical corporate systems such as ERP. In figure 1 haulage vehicles come to the terminal to load/unload cargo. Access to the terminal is granted through ICT-based systems while in the port area there is access to wireless signal (cellular or Wi-Fi). In the terminal also there is a central control room and job schedulers. Not all participating sites have the same degree of technological advances and sophistication in their ICT solutions shown in figure 1, however all

of them have in common the use of ICT to enable interoperability and connectivity in ports involving container terminal operations and haulage vehicles (internal and external) at a time of increasing need for visibility and track and trace capabilities.

[Insert figure 1 about here]

4.2 Operations Details of Participating Port Terminals

A description of operations for each of the seven port terminal sites that participated in the study based on the elements listed and depicted in figure 1 are provided in the following paragraphs.

Case 1. Humber estuary, UK – Humber-based Terminal Operator

The Humber-based terminal operator moves freight consisting of containers and Ro-Ro. The terminal is a Humber-based, wholly-owned subsidiary of a multinational shipping company. The annual volume of containers moved by the site is in the order of 800,000 TEUs. The daily volume of trucks coming to the site to collect or deliver containers and trailers is 500. An important aspect of the whole operation of the terminal relates to dealing with the trucks coming into the site. As the space available in the terminal is quite limited, personnel look at ensuring trucks do not spend unnecessary time within the seaport premises.

Case 2. Northern Europe Terminal – Port of Zeebrugge, Belgium

The terminal operator is based in Zeebrugge, Belgium and is dedicated to unloading containers from vessels and loading them on trucks. The company is part of a multinational shipping company. The annual volume of containers moved by the site is in the order of four million TEUs. The daily volume of trucks coming to the site to collect or deliver containers and trailers is 600. The average waiting time of a truck to get loaded is 35 minutes. But according to the terminal operations manager sometimes trucks overstay in the terminal when drivers decide to stop to have a break. This potentially can result in a backlog of trucks that need to be loaded or that try to leave the premises.

Case 3. Port of Busan – New Port-based Container Terminal

This terminal based in South Korea is part of the fifth largest container port in the world with an annual volume performance of 13,260,000 TEUs in recent years –this number includes all the terminals which are part of this port-. The port terminal represents state of the art facilities covering an area of 687,590 m² with a berth of 1.1 Km and water depth of 18 meters also this site has a maximum daily capacity of 68,800 TEUs.

Case 4. Port of Hong Kong – Kwai Tsing Container Terminal

At the time this research was conducted still the port of Hong Kong represented the third largest container port in the world with a volume of 24 million TEUs. The main container terminal in this port, Kwai Tsing, is run by the largest seaport container terminal operator in the world who has been recognized as one of the most important in terms of volumes handled, productivity and use of advanced ICT.

Case 5. Port of Shanghai – Zhanghuabang Terminal

The three terminals comprising Shanghai Container Terminals have handled about 25 million TEUs annually for the past few years. On its own Zhanghuabang terminal handled 3.6 million TEUs and the site operates a fleet of 80 yard trucks to handle and move containers within the terminal. The main purpose of the terminal is to serve as a domestic terminal from the south of China to the north of the country. Handled containers are used to carry mainly construction materials. The terminal also deals with international freight destined to Japan, South Korea and South East Asia. One berth in the terminal deals exclusively with containers to be shipped/coming from Japan.

Case 6: Port of Xiamen container terminal

In recent times Xiamen container terminals has handled 2 million TEUS per year. The site is capable of serving mega vessels as it has a water depth of 17.5 m with trans-ocean services to the USA, Europe, Mediterranean and Australasia. The terminal is a transshipment hub for smaller ports in Fujian province and it is capable of providing fast external tractor turnaround and cargo inspection waiting time of about 30 minutes on average. On-dock facilities and services provided include X-ray container scanning, on-dock fumigation, on-dock free empty storage, container maintenance and repair service. The terminal provides tailor-made service packages for shippers for facilitating inspection and clearance. The port of Xiamen serves 16 shipping lines and about 1000 road haulage vehicles are served every day.

Case 7: Port of Vigo container terminal

The port acts mainly as a feeder port and it handles about 380,000 TEUS per year with an optimum stacking capacity of 5,000 TEUS. The port terminal is operated by one company which operates no other terminal facilities. There is a wide use of multi-modal operations in the terminal as it has access to the motorway and railway network. The terminal sees the need for an increase in the use of railway to move goods in and out of the port. Each day the terminal experiences 600 unloading/loading movements related to 400 trucks.

Table 2 summarizes the operating details of the terminals that participated in this study. There are significant differences between terminals in terms of size and capacity, which can be appreciated in characteristics such as number of berths, total area and stacking capacity. Equipment used to handle containers such as quay cranes, gantry cranes and straddle carriers were also included.

[Insert table 2 about here]

5. Description of ICT Types and Use in Participating Port Terminals

The next paragraphs discuss the details of the ICT adopted in each of the seven port terminals that participated in the multiple case study. ICT support critical seaport terminal site operations including planning, execution and communication. The details provided cover what type of ICTs are used and the different uses found in each terminal. Similarities, differences and to what extent variances exist in ICTs adoption in the terminals are highlighted.

In the case of the Humber estuary, UK – Humber-based Terminal Operator, in particular container movement and scheduling, the terminal uses two bespoke, web-enabled, in-house developed information systems which wholly support the use of EDI for bookings. The information systems are used to handle queries related to: drivers delivering a trailer to a ship, trailers put in a ship and the exact location of the trailer in the ship. One of the bespoke systems is used to control container allocation in the terminal (by lane and by bay), as if it was a matrix. Within the terminal, cellular network technology is used for communications between individuals and between terminal-owned vehicles and the control room due to the lower rates negotiated with the network operator. No wireless communications and therefore exchange of information exist with external trucks coming into the terminal to collect/deliver containers/trailers. No Wi-Fi is used for communications inside the terminal. No GPS is currently in use, and a previous project on it was shelved because of costs. Apart from this site no other terminal investigated uses this type of ICT solution which is the simplest among the seven terminals investigated.

The Northern Europe Terminal – Port of Zeebrugge, Belgium uses a sophisticated state-of-the art, off-the-shelf application which optimizes and prioritizes job allocations. A total of 25 straddle carriers are used to move containers that are loaded on trucks coming into the terminal. The application is used to give operators instructions about the job they have to do. The application tells the operator of the straddle carrier where to go to pick a container and then the loading bay where to leave that container. Instructions to the operators of the straddle carriers are broadcasted by the system. Records of container boxes moved are kept in a database and updated every time the system issues a job about moving the

position of a container within the terminal. The site makes use of Wi-Fi, DGPS (Differential GPS) and UHF radio. DGPS is used to identify the exact location of a straddle carrier in the terminal. Instructions are sent by the job scheduling application to the operator of the straddle carrier using Wi-Fi. The Wi-Fi area covers the whole extension of the container terminal (600m by 1.3 km) with Wi-Fi antennas having less than 100 meters area coverage and mounted on light poles at 25 meters high. The system has double redundancy in case one access point (antenna) breaks down. UHF radio is used to contact operators in case a job is not completed or in case of warnings. Although DGPS and Wi-Fi are widely used in the terminal, the fact is that there are no reporting capabilities available with DGPS and there is no record of the movement of straddle carriers. Haulage vehicles from outside cannot be identified through the use of ICT or wireless communications (Wi-Fi). Hence, it can be said there are no reliable means available to monitor haulage vehicles entering the terminal to collect a container. Also the vendor did a good job to getting the port to buy this off-the-shelf solution. This is the only off-the-shelf ICT solution in use among participating terminals.

The Port of Busan – New Port-based Container Terminal uses a sophisticated terminal automation system designed to support: *vessel operations*, whose tasks include container information check and location of cargo on board check; *yard control*, which comprises container information check, next location auto assignment and optimized work order receipt; and *loading of containers on trailer beds*, which comprises chassis alignment system for tandem and twin operation. The system is also used to control: *gate access*, which deals with container information check, pre-check issues, yard information, container damage check and container weighing scale; and *gantry cranes* used for container information check, remote control system, container weighing scale and chassis positioning. The use of radio frequency is fully widespread in the site and it is used in automatic recognition of truck passage and in the operation of gantry gates. In this location internal yard tractors and external trucks are RFID-enabled. At each terminal entrance there is an installed RFID reader that detects and monitors external road trucks and internal yard tractors. The system represents the best solution for a horizontal layout. Every single vehicle in the terminal, both internal yard tractors or external trucks use a mandatory RFID-card approved for use in the national road network.

At the Hong Kong Kwai Tsing (K.T.) Container Terminal the use of advanced ICT to support multi-modal operations is critical to the business. The terminal runs an advanced proprietary in-house developed system. The system has become the platform where all information regarding terminal operations is exchanged and processed. The system manages key operations within the terminal including: gate operations, vessel operations, yard operations, vessel & container documentation,

executive information system and customer billing. It also supports berth planning, ship planning and yard planning. The main characteristic regarding haulage vehicles coming to the terminal facilities is the existence of two different information exchange platforms, one for internal yard tractors and the other for external trucks. Internal vehicles use the container terminal's sophisticated '*ITS pager*' capable of Wi-Fi links and used in quayside operations directly linked to the main terminal system. The result is instant track and trace capabilities of internal yard tractors. Some of the characteristics of the ITS pager device includes: standard Wi-Fi connectivity, large external display, internal colour touch screen for driver and it runs on Linux.

External haulage vehicles at the Hong Kong Kwai Tsing (K.T.) Container Terminal do not have access to the same functionality in terms of wireless communications links inside the seaport terminal. The tractor identity card (TID) is the software solution used by external trucks coming to the terminal to pick or unload a container. In this terminal two areas directly related to multi-modal logistics (involving road haulage and sea transportation) are gate and quayside operations. In the case of gate operations, external haulage truck drivers can make appointments through a dedicated system (tractor appointment system) to collect or deliver containers. The checkpoint computer system scans the drivers' tractor identity card (TID) or entry verification code, and from there the drivers can proceed directly to the yard for container pickup or discharge or wait until further notice using either a mobile terminal device or a voice-based system. When exiting the premises, the drivers swipe their TID cards to verify their identifications and the trucks are free to leave the site.

The same parent company that runs the port of Hong Kong K.T. Terminal runs the Port of Shanghai – Zhanghuabang Terminal. This means the terminal runs a customized, in-house developed, terminal operating system, the same system developed by the parent company. It was explained that the Terminal Operational Procedure System (TOPS) comprises a number of modules used for vessel monitoring, planning and stowage as well as yard monitoring. The system has links to other external systems comprising wireless transmission, tariff management, Electronic Data Interchange (EDI), transportation positioning, customer search and statistical analytical system. The capability for vehicular communications within the terminal is subject to the use of a recognition card. Still the level of synchronization enabled by the system makes it possible to work step by step with the 3000 trucks per day coming to collect/deliver containers.

The Port of Xiamen Container Terminal is run by the same parent company that runs the port of Hong Kong's K.T. Terminal. A customized, in-house developed, terminal operating system like the one used in

the port of Shanghai – Zhanghuabang terminal is used in Xiamen. The terminal in the port of Xiamen uses a Container Terminal Management System (CTMS) for the loading and unloading of vessels, it uses a Radio Data System (RDS) to broadcast instructions to operators of cranes with handheld terminal systems used in the container yards to provide its customers with a free on-line logistics tracking system. The capability for vehicular communications within the terminal is subject to the use of a recognition card. The system is used to serve the 1000 trucks that come every day to collect/deliver containers.

The company who operates the port of Vigo container terminal has developed an in-house system which makes use of GPS automatic control. The purpose of the system is to control entry/exit containers which are tag-linked to the terminal. For every operation, the system confirms that the current position matches the assigned container position. Also the system provides advanced arrival information and handles electronic communications such as BAPLIE, MOVINS, COARRI, COREOR, COPARN and CODECO which are UN/EDIFACT specifications used in Electronic Data Interchange (EDI). The system enables the shipping lines to send information in advance and provides clients with web access for real-time track and trace. The system controls the access of trucks to the terminal by an automatic gate which is linked to the reception and delivery orders issued under electronic format. No haulage vehicles/internal tractors are used for internal moves of containers. Reach stacking equipment is used and the operator has a control screen where visual instructions are displayed. The reach stacking equipment is GPS enabled and external trucks coming to unload/load containers are recognized through a portable electronic identifier delivered to trucks upon entry.

Regarding the answer to the first research question on how the similarities and differences behind the types and functionality of ICT being adopted in seaports enable interoperability and connectivity in multi-modal operations the following points can be highlighted. The analysis of similarities and differences behind ICT support of operations shows that the majority of cases investigated use sophisticated systems developed in-house for the purpose of supporting operations such as planning, execution and vehicle communications. The exception to that approach was the port of Zeebrugge, Belgium which operated an off-the-shelf application from a vendor of ICT solutions for port terminals. The Humber estuary port terminal in the UK was the port terminal that used a simple but robust ICT solution to enable interoperability and connectivity. The extent of the variances in ICT adoption was clearly appreciated in the cases comprising the Hong Kong K. T. container terminal, the Port of Shanghai – Zhanghuabang Terminal and the Port of Xiamen. The largest seaport terminal that participated in the case study, Hong Kong K.T. container terminal, and two other port terminals operated by the same parent company run the same sophisticated bespoke information system, however this has to be customized according to the needs

of each location. This means that only Hong Kong K.T. used all the functionality available in the system mainly because the complexity and volume of its operations. On the other hand independent seaport terminals like the Humber terminal operator or the Port of Vigo container terminal were able to implement bespoke solutions based on their needs.

6. Identification of institutional-related theories in the adoption of ICT in participating terminals

The previous section discussed the similarities, differences and the extent of variance of ICT adopted in different terminals where it was possible to recognize the extended adoption of in-house developed ICT compared to the use of off-the-shelf ICT solutions. Furthermore this research addresses the presence of various institutional theories to explain ICT adoption in the seaport terminals that participated in this multiple case study. Based on the literature review presented in this research work, this section uses the Technology Acceptance Model (including diffusion), Institutional Isomorphism and Institutional Theory to identify key elements affecting the adoption of ICT in seaport terminals. The analysis focuses on the support of critical seaport terminal site operations including planning, execution and communication and the identification of institutional-related theories in the adoption of ICT in the seaport terminals that participated in the study.

6.1 Technology Acceptance Model – TAM

As defined in the literature review section the Technology Acceptance Model (TAM) encapsulates individual differences, system characteristics, perceived usefulness and its perceived ease of use. In the case of the Humber estuary, UK – Humber-based Terminal Operator, the widespread adoption and acceptance of cellular networks has elements that can be associated to TAM, given its usefulness and ease of use (Autry et al., 2010). Cellular networks are widely spread in supply chain/logistics and on this site they are used in port terminals applications.

In the case of the Northern Europe Terminal – Port of Zeebrugge, Belgium, the use of TAM reveals that the adoption of its sophisticated state-of-the-art, off-the-shelf-application is in part due to the characteristics of the site (layout, equipment used) and the facilitating conditions presented by the vendor of the system. In the Port of Busan – New Port-based Container Terminal, the use of TAM reveals the adoption of the solution as a whole can be attributed to influence from the South Korean Government. Multi-modal operations on site are represented by internal yard tractors used to move containers within the port facilities and external trucks used to move containers in and out of the port, more specifically in yard and gate operations. Gate operation relies on the use of RFID whilst the yard operation relies on the

use of an automated system labelled Automated Rail Mounted Gantry Crane (ARMGC) enabling a smooth operation.

Three of the seaport terminals that participated in this research belong to the same operator, they adopted the same ICT. In the Port of Hong Kong – Kwai Tsing (K.T.) Container Terminal, the use of TAM reveals that the individual differences of the site compared to other locations have been a major driver to push the company to develop a state-of-the-art system (e.g. high throughput due to storage space restrictions). In both the Port of Shanghai – Zhanghuabang Terminal and the Port of Xiamen, the use of TAM shows that individual differences between these two sites and the flagship site in Hong Kong (e.g. *ITS* pager system) have prevented the adoption of all the functionalities available in the system. In part the explanation for that is that both sites do not have in place the same technologies and system functionality as the Hong Kong site. Certainly, both the Port of Shanghai – Zhanghuabang Terminal and the Port of Xiamen container terminal follow procedures and employ technologies that have been already developed and tested by their parent organization. The level of functionality available in the system is dependent on the particular needs of both the Port of Shanghai – Zhanghuabang Terminal and the Port of Xiamen container terminal which are smaller than the flagship site in Hong Kong.

The case of an independent seaport terminal operator, the Port of Vigo Container Terminal, TAM shows that the individual differences of this site have determined the route to follow in terms of ICT adoption. It is important to highlight that the terminal is run by a company which operates no other terminals and the development of ICT is the product of in-house initiatives to make the site more efficient with less human intervention and with the use of advanced technologies. The company has developed an in-house system capable of handling electronic communication standards in the transportation sector.

6.2 Institutional Isomorphism: Coercion, Mimesis and Normative

The presence of institutional isomorphism in its forms comprising coercion, mimesis and normative was evident throughout this research. This is relevant as seaport terminals can have unique characteristics. For example the research revealed institutional-related theories influence at the Port of Xiamen Container Terminal are affected by the fact that this terminal is a joint venture between the city's local port company and the largest operator of port terminals in the world. Coercion was found in various degrees in some of the seaports investigated.

Coercion

The literature review sections mentions coercive pressures are exerted on a dependent firm by other organizations and by cultural expectations in the society within which the dependent firms operates. In the case of the Humber estuary, UK – Humber-based Terminal Operator, cellular networks are widely spread in supply chain/logistics and on this site they are used in port terminals applications. However in this site a case for coercion was not evident as cellular networks have become ubiquitous technology used on a massive scale, relating more to a normative form.

The Port of Busan – New Port-based Container Terminal represents a unique example where coercion related to the adoption of ICT in the terminal has been dictated not by the terminal operator or the largest operator in the area but by the South Korean government. The coercion exerted by the government to adopt RFID tags has resulted in a normative process where RFID tags have been adopted by a significant number of organizations. The ICT infrastructure and platform used in this terminal reveals a policy towards maximizing the benefits of initiatives launched by the government and associated to the deployment of technologies on national roads.

As mentioned above the Port of Hong Kong – Kwai Tsing (K.T.), the Port of Shanghai – Zhanghuabang Terminal and the Port of Xiamen belong to the same operator and use the same ICT solution. In the Port of Hong Kong – Kwai Tsing (K.T.) Container Terminal a clear example of coercion can be seen in the use of the TID solution by external haulers coming to the terminal. Given the preliminary role of this terminal as being the flagship site that develops and rolls out ICT solutions, the terminal also is in the position to exert pressure on other sister sites run by the same operator in terms of forcing the adoption of ICT solutions. In the Port of Shanghai – Zhanghuabang Terminal coercion is exerted from the container terminal to the road haulers coming to the terminal to load/unload a container. Also in the Port of Xiamen Container Terminal coercion is exerted from the container terminal to the road haulers coming to the terminal to load/unload a container as they have to use a recognition card. Only those road haulage companies that adopt the recognition card can do business with the site.

In other cases examined coercion was not evident. From an institutional isomorphism perspective, the Northern Europe Terminal – Port of Zeebrugge, Belgium shows that the terminal operator exerted no coercion on external haulage vehicles to adopt new technologies. In the case of the Port of Vigo Container Terminal there was no coercion exerted on the terminal to adopt its current system or that the terminal forced others to use its systems.

Mimesis

The definition of mimesis used in the literature review says mimesis is associated to the motivations (e.g. uncertainty) that encourage the imitation of practices. In the case of the Humber estuary, UK – Humber-based Terminal Operator the case for mimesis was not evident as in this site the adoption of a cellular network-based application relates to the desire to improve efficiency by facilitating communications between the port terminal and the internal haulage trucks that handle the containers moved by the shipping lines. In the case of the Northern Europe Terminal – Port of Zeebrugge, Belgium there is no evidence of haulers mimicking the practices adopted by the terminal operator in terms of adopting ICT solutions used to interchange data between the terminal applications and straddle carriers/yard tractors.

Mimesis at the Port of Hong Kong – Kwai Tsing (K.T.), the Port of Shanghai – Zhanghuabang Terminal and the Port of Xiamen can be examined together. In the case of the Port of Hong Kong – Kwai Tsing (K.T.) Container Terminal, no mimesis is present as this is the flagship site of the terminal operator, however the other two sites do imitate this container terminal. In the Port of Shanghai – Zhanghuabang Terminal, it is a real possibility this container terminal may adopt a mimicking approach as a way to mimic the practices taking place at the group’s flagship terminal in Hong Kong. A similar approach to mimesis was observed at the Port of Xiamen Container Terminal.

The research shows the Port of Busan – New Port-based Container Terminal was not using mimesis regarding other terminals but also other terminals were not mimicking the site. In the case of the Port of Vigo Container Terminal it was possible to appreciate a similar situation, neither the terminal was using mimesis regarding other locations, nor was imitated by others.

Normative

The normative component of institutional isomorphism which refers to firms subject to the norms, standards and expectations in order to attain effective coordination was less evident among seaport terminals compared to coercion or mimesis. In the Humber estuary, UK – Humber-based Terminal Operator the use of normative processes is reflected in the use of cellular networks which is the technology used for data interchange and coordination between vehicles and the container terminal. Cellular networks have become ubiquitous technology used on a massive scale (normative). In the case of the Northern Europe Terminal – Port of Zeebrugge, Belgium, in terms of normative processes, any adoption of technology (e.g. Wi-Fi) from external haulage vehicles is voluntarily and therefore unable to exploit the track and trace functionality currently available only to yard vehicles such as straddle carriers.

6.3 Institutional Theory

The concept of institutional theory identified in the literature review section refers to the desire to reduce cost or improve efficiency with external entities and by organizational legitimacy represent drivers that foster the institutionalization of ICT development. Based on this definition it was observed in the Humber-based Terminal Operator the adoption of a cellular network-based application relates to the desire to improve efficiency by facilitating communications between the port terminal and the internal haulage trucks that handle the containers moved by the shipping lines. In this port terminal, local government and larger competitors were not seen as entities exerting influence on ICT adoption.

In the case of the Port of Zeebrugge, Belgium from an institutional theory perspective it is evident that government and competitors did not exert influence on this port terminal to adopt its off-the-shelf application. The terminal bought the system from the ICT vendor based on its need to make operations more efficient. In the Port of Busan – New Port-based Container Terminal from an institutional theory perspective public organizations (Government imposing regulations) exert the strongest influence on system adoption and at the same time affect private and rival organizations equally. In the Port of Busan – New Port-based Container Terminal, devices based on RFID technology already in use for electronic toll collection are used for identification purposes and their use represents several benefits in terms of costs and familiarity with the technology. There are no switching costs associated to the adoption of RFID tags for haulers that operate in the port. However, the main disadvantage of a system based on RFID for track and trace purposes is its dependence on the distance separating the RFID readers, however this problem can be solved with the simultaneous use of GPS technology. External haulage vehicles may model themselves based on the container terminal.

In the Port of Hong Kong – Kwai Tsing (K.T.) Container Terminal it can be added that this flagship terminal can influence other sites run by the same company because ICT solutions are developed in-house by a team of developers. Given the degree of influence seen in this case, a private organization that commands a high degree of influence in its business environment it may find itself in a position to influence government policies as well. For the Port of Shanghai – Zhanghuabang Terminal, the Hong Kong-based company that runs this port terminal is the main source of influence for the group's port terminals in the region. Similarly for the Port of Xiamen Container Terminal, the Hong Kong-based company that runs this port terminal is the main source of influence along with the local authority which operates a logistics container hub where containers export/import are processed in a short period of time.

In the case of the Port of Vigo Container Terminal institutional theory can be used to confirm that not private organizations, public organizations and rival organizations have exerted dominant influence on this site regarding the adoption of ICT.

For the second research question on why key elements of institutional-related theories influence and affect the adoption of emergent technologies in ICT to enable interoperability and connectivity in seaports terminals, the use of TAM revealed three streams regarding ICT adoption: 1) usefulness and ease of use of a widely proven technology (use of cellular-based networks); 2) the facilitating conditions presented by the vendor and site layout for the only site running an off-the-shelf application (port of Zeebrugge) and 3) government influence and individual differences, the last one actually pushing sites to develop in-house solutions. On the theory of institutional isomorphism the study shows that the coercion exerted by government legislation about the adoption of ICT can ultimately have a major impact on the interoperability and connectivity achieved between the port terminal and haulage vehicles serving it. Though ICT vendors have been considered powerful, the fact is that in the cases examined they did not represent an element of coercion in the adoption of ICT in the port terminals. Only one of the port terminals that participated in the study had an off-the-shelf solution bought from a vendor, the rest run their own in-house solutions. Decisions on ICT adoption in port facilities can have a significant impact not only on the performance of typical port operations but also in the success of regional initiatives as ports are seen as contributors to regional economic activities.

To a certain degree mimesis can be used to explain the extent of the variance in ICT adoption in seaport terminals. The case of the Port of Hong Kong – Kwai Tsing (K.T.) Container Terminal, the Port of Shanghai – Zhanghuabang Terminal and the Port of Xiamen Container Terminal belong to the same group and run the same ICT application but with different levels of functionality and customization. Both terminals in Shanghai and Xiamen can increase the level of mimesis regarding the operations of the flagship site by upgrading the level of functionality of the adopted ICT solution based on their needs and growth. This means increasing future functionality can reduce the variance of ICT adoption among terminals belonging to the same operator.

From an institutional theory perspective the cases show situations where private organizations running medium-sized port facility still had the freedom to implement widely-tested technologies, for the purpose of improving efficiency through better communication, as it is the case of the adoption of cellular networks in the Humber port facility. The same can be said about the port of Vigo where the organization running the port had complete freedom to develop a bespoke system with the technology that better fits its

needs in terms of efficiency. Figure 2 summarizes the above results regarding the identification of institutional-related theories in the adoption of ICT in the participating seaport terminals.

[Insert figure 2 about here]

7. Discussion on findings

The results presented in the previous section can be further expanded if we consider that ICT adoption in the terminal sites can be associated to three main groupings or clusters. The first one cluster can be labelled as ‘independent local influence’ where the main particularity here is that decision to use an ICT solution was made by the sites themselves and not as part of external influence or pressures on them. The second cluster, labelled ‘dominant organization influence’ can be associated to situations where a flagship site of a major organization enforces the acquisition of an ICT system to other sites. The third cluster labelled ‘government legislation influence’ occurs when standards and legislation stated by a government shapes the adoption of ICT in a given site.

It was noticeable in the study that strong influence is exerted by government legislation imposing technological regulations and by private organizations that command a high degree of power in their business environment which may eventually put them in a position to influence government policies. The port of Busan can be associated to ‘government legislation influence’ and the ports of Hong Kong K.T., Xiamen and Shanghai-Zhanghuabang and the port of Xiamen can be associated to ‘dominant organization influence’. In the case of the Port of Busan – New Port-based Container Terminal the government has shaped the adoption of the ICT solution employed on this site and nationwide. In the case of Hong Kong K.T., the site uses all the functionality available in the system while Shanghai-Zhanghuabang and the port of Xiamen run the same bespoke information system developed in-house but without all the functionality available and customized according to the needs of each location. In the absence or weakness of dominant organizations and government legislation influences port sites have the possibility of being placed under independent local influence (themselves) and enabling them to adopt bespoke or off-the-shelf ICT solutions according to their needs (examples include the Humber, Zeebrugge and Vigo sites). The particularity here is that decision to use ICT in these three sites was made by the sites themselves and not as part of external influence or pressures on them. The study may suggest that sites under regional player influence may be susceptible of being moved away toward government legislation or dominant organization influence as these two can become manifest through actions such as new government legislation or company acquisition/takeover.

Figure 3 depicts three groupings/clusters comprising ‘independent local influence’, ‘dominating organization influence’ and ‘government legislation influence’. These three are represented along institutional-related theories applicable to ICT adoption in port terminals which include institutional isomorphism, institutional theory and the use of TAM. The characteristics of the information systems adopted are also indicated in the diagram.

[Insert figure 3 about here]

Elements of institutional-related theories reviewed for this research showed degrees of overlapping and quite few of them coincided to explain ICT adoption influence in the sites investigated.

The results presented in the study are based on a representative group of port terminals that handle medium to high volumes. Researchers, managers and practitioners may use the results to envisage the future development of common ICT platforms/solutions that addresses the logistics needs of port terminals and the interaction with road haulage to create a truly interconnected multi-modal logistics operation.

The identification of specific groupings, ‘independent local influence’, ‘dominating organization influence’ and ‘government legislation influence’ linked to institutional-related theories allowed a better understanding about the adoption of ICT in port terminals given the needs for interoperability and connectivity. It seems that ports which belong to the ‘independent local influence’ group might not be able to remain independent as the other two groupings ‘dominating organization influence’ and ‘government legislation influence’ will prevail and dominate in the long term.

Overall, this research supplements well recent research work on seaport terminals and ICT like the ones by Cepolina and Ghiara (2013), Cetin and Cerit (2010) and De Martino et al. (2013) to mention just a few. The fact is that there are very few studies addressing ICT issues in seaport terminals from the perspective of institutional theory.

8. Conclusions

The study of ICT adoption in seaports terminals provides unique opportunities given the conditions these sites face in terms of proliferation of technologies, inter-organizational collaboration, interoperability and connectivity not to mention the need for real track and trace and the economic impact they have among others. This paper confirmed that seaport terminal operators rely heavily in the use of information

systems to support day-to-day operations but in particular the adoption and use of solutions that enable interoperability and connectivity between a terminal and haulage vehicles given the multi-modality environment characterizing ports. The cases investigated show different approaches and technological developments by the port terminals and the inevitable impact to the visibility and coordination of their operations. The characteristics of ICT adoption in the participating sites show a widespread use of different technologies including Wi-Fi and RFID-based devices mainly used in internal yard tractors.

ICT adoption in the context of growing multi-modal transport suggests that future efforts will be canalized toward harmonization of technology which can be of two types. First, this can be seen as the government launching initiatives that make compulsory the adoption of a certain standard or particular technology. As the case in South Korea shows, harmonization in the use of ICT to enable track and trace and its impact on visibility has to come from government initiatives that make compulsory the adoption of a certain standard or particular technology. It would be necessary to investigate if the influence of government legislation will prevail over a multinational dominant organization. Second, there can be port operators with enough leverage power to force other players to adopt technologies/solutions developed in-house by them. Institutional-related theory can be used to link harmonization of technology to coercion in the adoption of ICT. Governments or logistics bodies/associations will have to play a major role in reaching agreements that can lead to the standardization of future technologies (e.g. use of a common technological platform) in order to reduce and mitigate the problems associated with ICT adoption and technology proliferation. Future efforts will have to be directed toward the definition of future ICT platforms that clearly identify the role of emerging technologies capable of providing new elements of functionality to ports terminals.

The use of elements of institutional-related theories helped to explain different policies surrounding the operation of large and medium-sized port terminals, even when they are operated by the same parent company. For example, mimesis can be used to explain the Port of Xiamen, a port terminal run by the largest operator in the world and which runs its flagship site at Hong Kong Kwai Tsing, uses an in-house application developed by the parent company but without all the functionality available.

The cases investigated in this study show different approaches to the adoption of ICT in port terminals specialized in container-handling operations. Most research work involving seaport terminals have looked at large port sites but little can be found related to the adoption of ICT in large but also smaller container terminals and more importantly how the characteristics highlighted in the groupings and their association to institutional-related theories may dictate and affect the evolution and development of

seaport terminal solutions such as logistics clusters. Indeed, future research work may look at how initiatives such as multi-modal-based solutions such as the creation of logistics clusters may be affected by the adoption of ICT as this concept requires having an ICT infrastructure that facilitates interoperability and connectivity to all members of the logistics cluster and these may be affected by government legislation, a dominant organization or by independent companies.

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APPENDIX A

Statements/issues investigated during the visit to participating port terminals.

Terminal characteristics

Details to be completed for each participating terminal site.

- Container berth length (m): _____
- Berth number (no.): _____
- Water depth (m): _____
- Total area (m²): _____
- Stacking capacity (TEU): _____
- Container quay cranes (no.): _____
- Rubber tire gantry cranes (no.): _____
- Rail mounted gantry crane: _____
- Straddle carriers: _____

What are the volumes handled by the container terminal? and the contribution % to the business?

Multi-modal operations

Describe the movement of containers within the terminal site.

ICT use in planning, execution and communications

Provide details of ICT solutions used on-site for planning, execution and communication capabilities.

Identify which of the technologies have been deployed in the terminal site.

- e.g. GPS/satellite tracking, cellular networks, Wi-Fi, WiMax, RFID, Dedicated Short Range Communication (DSRC)?

Describe the whole process of track and trace of road haulage vehicles coming in and out of the terminal

Identify if the technology offered on-site is capable of the following:

- Generate and access a daily activity log
- Send messages to drivers (real-time)
- Access to historical file for each vehicle

What are the future plans for deploying new technologies?

To what extent is there any advance towards a common information exchange infrastructure support not only traffic and safety needs but also commercial?

- DSRC @ 5.8 GHz?
- RFID cards installed onboard vehicles?

APPENDIX A (continued)

Statements/issues investigated during the visit to participating port terminals.

Note for interviewers: The use of the semi-structured interview format is to facilitate interviewed managers give an unobstructed narration of events.

Discussion on ICT adoption – institutional-related theories

Explain the motivations and details behind the adoption of ICT solutions used on-site.

Note to interviewer: encourage narration of events regarding the acceptance and adoption of ICT in the seaport site.

Explain the extent ICT solutions can be fully customized according to your changing needs.

Note: interviewer to encourage interviewee the identification of institutional theory -coercion, mimesis and norms-.

Explain the extent the intervention of government is required to enforce the adoption of the technologies used on the site.

Note: interviewer to encourage interviewee the identification of institutional theory -coercion, mimesis and norms-.

The ICT solutions adopted are capable of enabling 100% inter-firm data sharing with other sites (delivery/shipment).

Explain the flexibility provided by your ICT solutions enable the automation of activities.

Discuss the extent ICT solutions enable visibility to customers.

Discuss the extent ICT solutions on-site are capable of incorporating without delay the changing requirements of your customers.

TABLES

Theories	Purpose
Supply chain acceptance and adoption model (Autry et al. 2010) based on the technology acceptance model (TAM) (Parasuraman, 2000), (Teo et al., 2003)	Individual differences, system characteristics, perceived usefulness of the technology and its perceived ease of use.
Diffusion (Hu et al., 1997, Lai et al. 2006)	Based on the assumption that rational adopters make decisions and choices based on the information that is received via communication and social networks but fail to address institutional isomorphic processes.
Institutional isomorphism (DiMaggio and Powell, 1983)	Constraining process that forces one unit in a population to resemble other units that face the same environment conditions.
Major types of institutional isomorphism (Lai et al. 2006; DiMaggio and Powell, 1983)	Base decisions on three major types: Coercive pressures are exerted on a dependent firm by other organizations and by cultural expectations in the society within which the dependent firm operates. Mimesis is associated to the motivations (e.g. uncertainty) that encourage the imitation of practices. Normative firms are subject to the norms, standards, and expectations in order to attain effective coordination.
Institutional theory (Wong et al., 2009)	The desire to reduce cost or improve efficiency with external entities and by organizational legitimacy represent drivers that foster the institutionalization of ICT development.

Table 1. Various institutional-related theories used to explain ICT adoption in ports

TABLES

Terminal Characteristics	Humber estuary – Humber-based Terminal Op	Northern European Terminal - Port of Zeebrugge	Port of Busan - Busan New Port Terminal	Port of Hong Kong – Kwai Tsing Container Terminal	Port of Shanghai – Zhang huabang Terminal	Port of Xiamen - Container Terminal	Port of Vigo - Container Terminal
Container berth length (m)	240	1300	1100	5000	784	1083	750
Berth number (no.)	2	3	3	14	3	3	4
Water depth (m)	10.36	16	18	14.2	12.5	14	14
Total area (m2)	182,108	480,000	696,300	1,400,000	304,589	720,000	130,000
Stacking capacity (teu)	N.A.	-	68,800	90,000	21,736	60,000	8,000
Container quay cranes (no.)	N.A.	7	12	55	7	13	3
Rubber tyre gantry cranes (no.)	-	-	-	146	22	40	7
Rail mounted gantry crane	-	-	42	24	-	4	-
Straddle carriers	-	23	-	-	-	-	-

Table 2. Details of the port container terminals investigated

FIGURES

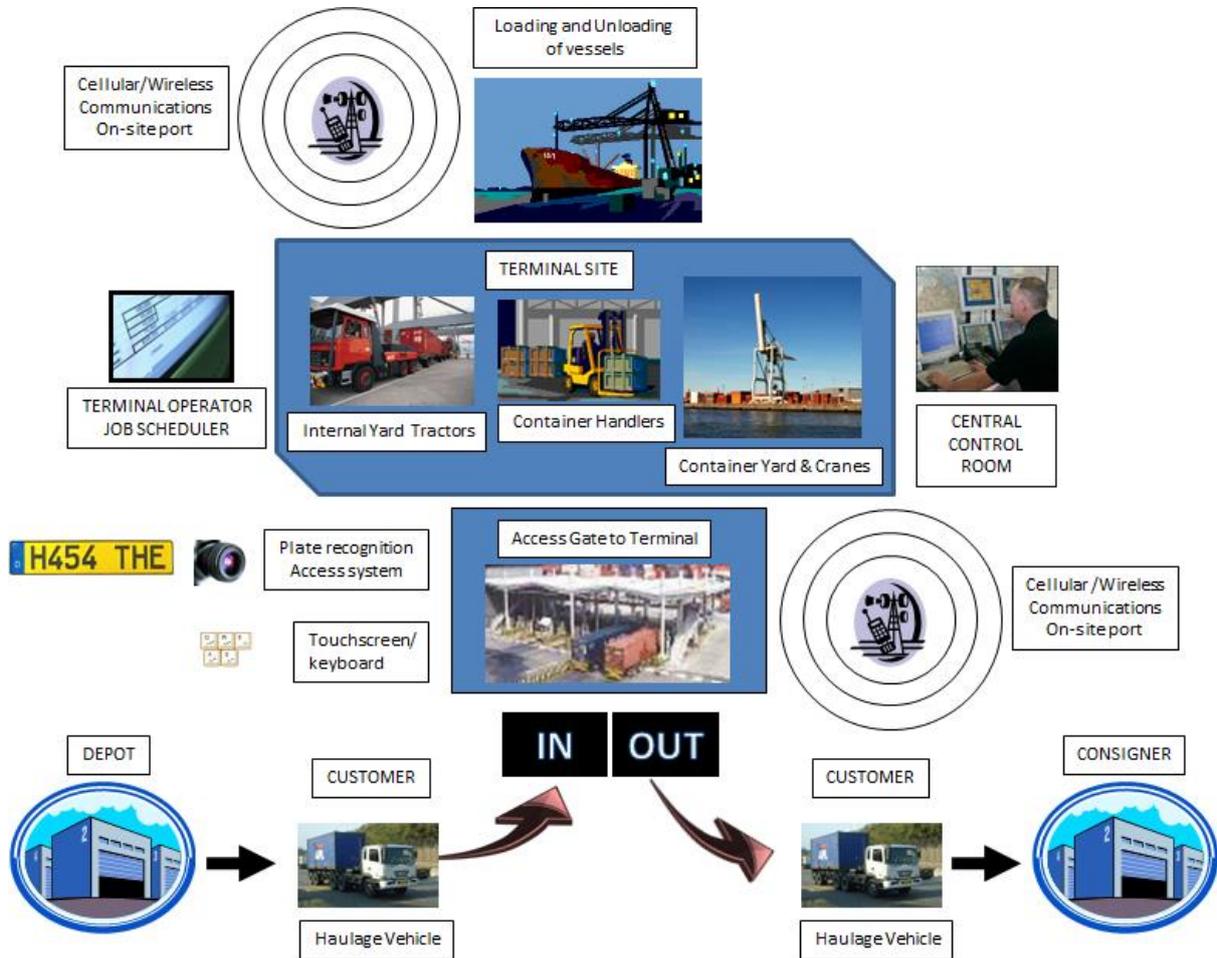


Figure 1. Depiction of ICT solutions comprising the structure of seaport terminals investigated in this research work.

FIGURES

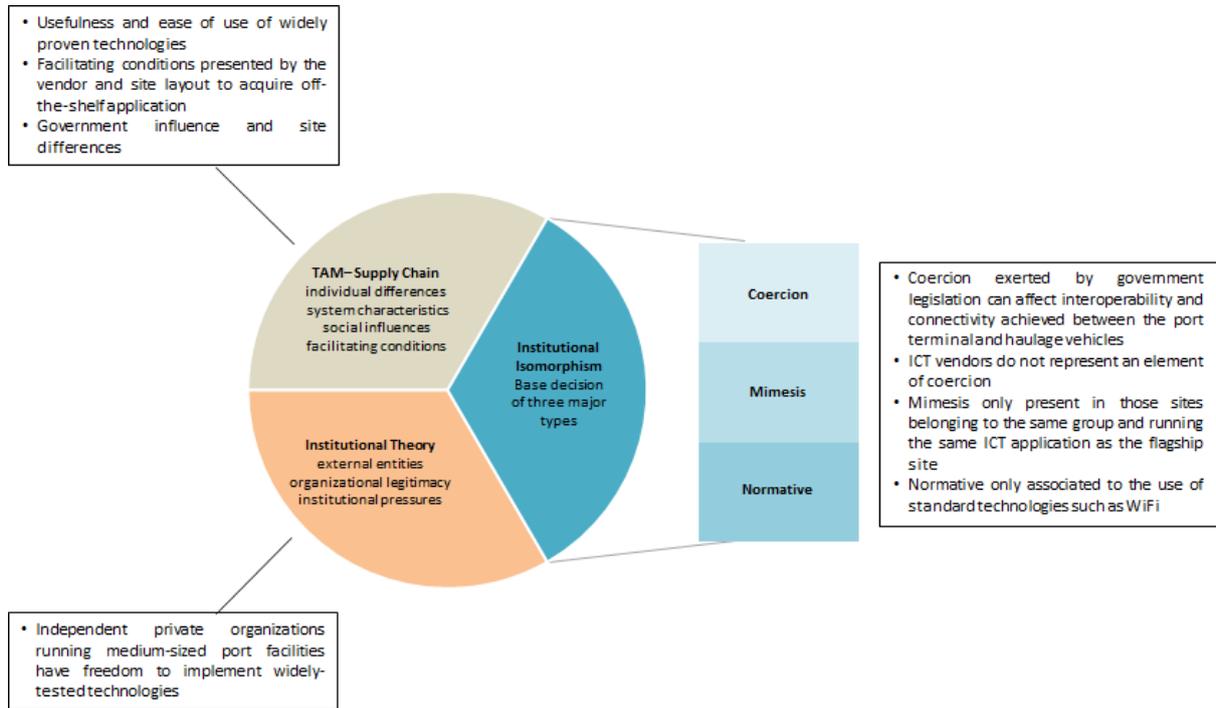


Figure 2. Summary of findings related to the identification of institutional-related theories in the adoption of ICT in participating terminals.

FIGURES

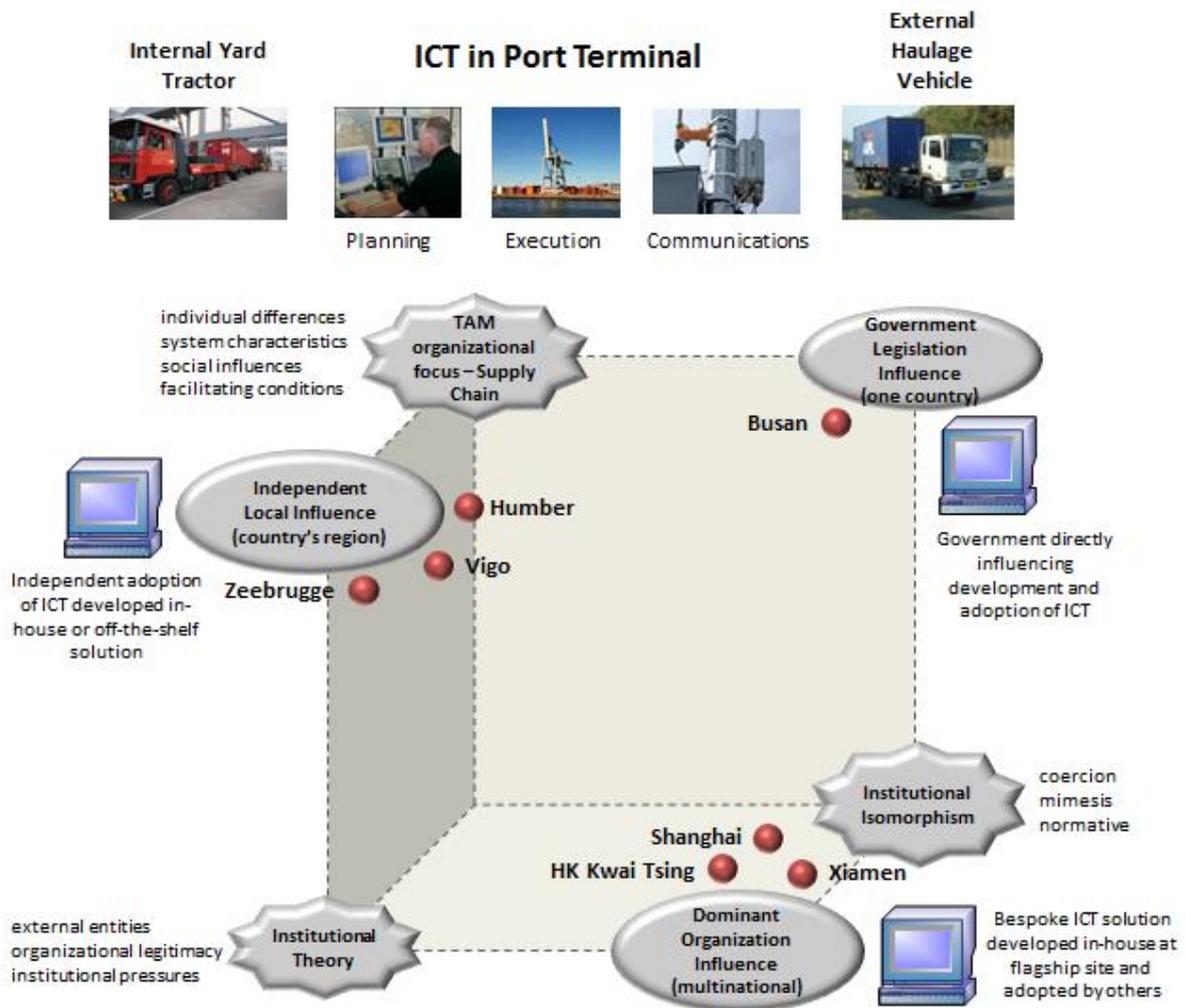


Figure 3. Representation of participating seaport terminals using institutional-related theories and influence groupings affecting ICT adoption.