Information Sharing in Sustainable Value Chain Network (SVCN): The Perspective of Transportation in Cities

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Abstract - The purpose of this paper is to explore the high-order themes to information sharing in Sustainable Value Chain Network (SVCN) with a focus on the applications of Internet of Things (IoT) as an enabling innovative technology from the perception of expert community. This research is an inductive study and adopts a multi-case study strategy in the context of smart transportation for freight flow in the UK. 20 Semi-structured interviews are conducted with experts in smart transportation projects. The phenomenon of information sharing is enabled by effective innovative technologies such as IoT. A conceptual framework is constructed by themes of IoT applications and information sharing in SVCN.

Keywords: Information sharing, Innovative technology, Internet of Things, Sustainable value chain network.

1. Introduction

A lack of information and understanding of transportation has a major role in smart cities. Improving such information is important for information sharing in sustainable value chain network (SVCN) of transportation in the smart cities. The phenomenon of information sharing is one of the key subjects to be enabled by effective Information and Communications Technology (ICT) such as Internet-of-Things (IoT) [1]–[3]. Optimising the transportation activities with innovative ICT is considering smart solutions to support freight flow in urban areas due to the complexity of the processes taking place in transport systems and often conflicting expectations of stakeholders [4].

In fact, there are a great number of initiatives that are very close as for their objectives but they do not have a common basis like standards, conceptions and strategies [5]. Since 2000, more than 40 different projects on smart transportation have been initiated in Europe [5], [6]. Nowadays, smart transportation of IoT includes not only a great variety of information but thousands of other systems using data to make intelligent transport-related decisions [7]. IoT technologies guarantee economic benefits as chain actors will be able to share valuable information and make decisions that are more reasonable. This is to reduce transportation time and transportation expenditures and to reduce the impact of transportation on the society and environment [8].

With visions from a multi-disciplinary perspective, the IoT has become the common paradigm of modern ICT area by enabling innovative applications in nearly all sectors of economy [8]. However, relatively little attention has been paid to the information sharing between actors enabled by IoT for smart transportation along the SVCN [3], [7]. Thus, this research aims to explore the high-order themes to information sharing in SVCN with a focus on the applications of IoT as a key enabling ICT innovative technology from the perception of expert community.

This study will use existing literature as well as case studies to examine the IoT application and information sharing for smart transportation for freight flow in SVCN. This could be by identifying the possible high-order themes to information sharing for smart transportation in SVCN with a focus on the applications of IoT as an enabling innovative technology. This can provide benefits in terms of sustainability chain performance [5], [7]. The study poses the following research questions:

> RQ1. How can key themes of the applications of IoT be associated for information sharing in SVCN?
>
> RQ2. How and why are these key themes effectively linked to information sharing in SVCN to improve value chain performance in practice?

This paper provides relevant views from the perspective of experts in smart transportation projects in the UK. The article starts with a theoretical background on SVCN, IoT and innovative technology and information sharing. Next, the research methodology is outlined. Then key findings and discussion are presented. Lastly, conclusions are provided with managerial implications.

2. Theoretical Background

SVCN has been affected by the digital revolution where actor's strategy is surrounded by this digital era that created a hub where everything will be connected to everything via internet [8], [9]. SVCN is considered as the theoretical base of the information sharing phenomenon. SVCN should present a framework to researchers for solving information issues such as sharing, visibility, environment, sources, technology and types [5], [8], [10]. The SVCN is an approach where delivery and transportation businesses are integrated with the growth of e-commerce in the EU. Hence, a roadmap for completing the market for transportation has identified the need for increased transparency and information to all chain network actors as a key objective for improving delivery operations and boosting e-commerce [10], [11] have identified that the revolution of IoT is reshaping the modern chain networks with promising business prospects in order to create sustainable values for freight flow. The development in transportation is one of the factors to indicate the wellbeing of the country. Totally optimising the logistics and transport activities with the support of advanced ICT in urban cities is considering the traffic environment, its congestion, safety and energy savings within the framework of market economy [12].

Historically, research on IoT has been linked to several themes, such as technology, collaboration, social networks, quality, costs, satisfaction, investment, system analysis, system control and connectivity [5], [7], [11], [13]. In this scenario, authors argued that it is important to identify a well-established approach to both IoT application and information sharing for smart transportation. Optimising the transportation activities with innovative technologies is considering smart solutions to support freight flow in urban cities due to the complexity of the processes taking place in transport networks [4]. Thus, this will be leading to improved performance for a set of actors along the SVCN rather than a single actor [11], [13]. Although research does not ignore the importance of the IoT in SVCN, they do not focus fully on the application of the IoT in the mechanism of information sharing and especially in strategic issues such as challenges and benefits.

European Commission Information Society [10] has defined IoT as "Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts". [14] defined IoT as a set of hardware, software, database, sensors, hub of database and systems for the support of people. A foundational technology for the IoT is the Radio Frequency Identifications (RFID) technology, which allows microchips to transmit the identification information to a reader through wireless communication [13]. In fact, the IoT is an enable tool that leads physical objects to be alive and perform actions by connecting these objects and then share information for better decisions and improved performance within SVCN [8], [15]. To make these objects smart, digital technologies such as communication technology, internet protocols, analytic systems, control system and embedded devices can be applied sensor networks [8], [16].

Researchers argue that SVCN concept allows the focus on moving from a transaction to a relational perspective that considers the environment around actors or firms or objects [4]. This concept is a great interest in applying the perspective of network to analyse information sharing within value chain of smart transportation for freight flow in cities [3], [7]. Thus, when analysing the association between IoT applications and information sharing, a lens should be highlighted on the cone-shaped concept map of the business network information ecological chain (BNIEC) illustrated by [13].

In SVCN, the first stage of value added is to create benefits and minimize challenges for the actors involving in smart transportation for freight flow [10], [11]. This focuses on various issues associated with information problems, improve information value and enhance performance for all actors [13]. This adds value for type 1 of stakeholders such as citizens, drivers, public transportation managers, and local city administration [17].

The second stage is IoT components: information, information technology, information subjects, and information environment. This is directly connected with the concept of smart transportation in order to deal with three main conceptions: transportation analytic, transportation control, and vehicle connectivity. This brings value assessment and business-technology application for type 2, which includes stakeholders such as data experts, database designers, transportation experts, traffic experts, logistic experts, communication engineers, network engineers, system designers and sustainability experts [17].

The third stage is the links between different actors and objects in the transportation systems. Surrounding the focal actor, all actors share information as different logical roles. This is to develop interaction between data hub and transportation system for type 3 of stakeholders, namely data source providers, local services, data management and communication technology. For example, the application of the road condition monitoring and alert systems are the most important of IoT transformation applications [2]. New distribution systems in cities are called to apply smart solutions to enhance transport for goods in cities in order to minimize the complexity of the urban transport systems and often conflicting expectations of the road users and other stakeholders of urban freight transport (city administrators, inhabitants, entrepreneurs and shippers) [18]. The main idea of the concept of smart transportation and green mobility is to apply the principles of crowd sourcing and participatory sensing. This can be supported via various data sources from vehicles, sensors, data centres, infrastructure, smart phones etc. in addition, smart transportation consists of key communication ways such as machine-to-machine (M2M) communications, which include vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications for better links.

The fourth stage and which is related to the phenomenon of the present research is information sharing in SVCN. This stage illustrates how IoT applications facilitate information sharing based on hosting an aggregative information field. This is where all actors or objects “things” of the above types share their hub or database contents with the potential actors (e.g. customer, middleman, retailer, service provider and object) for increasing more benefits and decreasing existing challenges.

In fact, there are a great number of initiatives which are very close as for their objectives and tasks but they don’t have a common basis like standards, conceptions and strategies [5]. Reviewing the milestones have been reached in Europe, for example, the first research programs for cooperative smart transportation date back to the 1980s; the European project PROMETHEUS (1987–1994) by using inter-vehicle communication in the 57 GHz frequency band [6]. By 2000, a new technology was initiated worldwide, triggered by the availability of GPS, embedded systems, and WiFi. In Europe, more than 40 different projects on cooperative smart transportation have been initiated since 2000 [5], [6]: initial feasibility studies (i.e. FleetNet and NoW), technology state and standardization (i.e. SAFESPOT, GeoNet, SEVECOM, CoVeL, and COMeSafety), field operation tests on safety and traffic efficiency (i.e. DRIVE C2X, SIM-TD, SCORE@F, etc.), cooperative automated driving (i.e. AutoNet2030 project. Actually, by means of information sharing among vehicles, as well as between vehicles and the roadside infrastructure, vehicles transform from autonomous systems into cooperative systems [5]. Nowadays smart transportation associated with IoT is the largest and the most versatile group. It includes not only a great variety of information, road, navigating, car systems but insurance and control systems for a vehicle/ driver (telematics) and thousands other systems using data to make "intelligent" transport-related decisions. IoT technologies guarantee enormous economic benefits as both carriers and transport users will be able to make more reasonable decisions to reduce passengers and cargo transportation time and to cut transportation expenditures and delays. In addition, “green” IoT, apply technologies to reduce the impact of passengers and cargo transportation on the environment.

3. Methodology

This research is an inductive qualitative study and adopts a case study strategy. From a multi-disciplinary perspective, a conceptual framework can be developed from both existing literature and contextual field data [19]. The cases are projects in the context of transportation for freight flow in the UK. 20 Semi-structured interviews are conducted with experts in these projects. This research applies within case and cross-case analyses [20]. By defining the themes of the associations between IoT applications and information sharing in SVCN it became possible to develop the framework. These projects are selected because they have smart ICT technologies (e.g. IoT) for transportation, and have focus on information sharing in their SVCN. Experts as key informants are chosen because they provide an overview of the IoT application, information sharing and their projects as a whole. The aim is to gain rich understanding of what are the applications of IoT in smart transportation, how far IoT enable information sharing between actors, and what the roles of information sharing in SVCN. UK is one of the key countries which has initiatives in applying IoT to support sustainable development in sectors especially transportation in cities.

The sampling selection is based on advanced research of the online directory of sustainable projects in the UK and it included projects that have been applied for smart transportation for freight flow in cities. This led to a list of 30 projects, which were then shortlisted to 10 projects based on three steps: satisfactory achievement records, positive email responses and an initial phone interview. Then, two experts in each project were asked to identify a network of smart transportation for freight flow in order to form the unit of analysis as a SVCN. This is where 10 different projects (Case: 1-10) of similar 10 SVCN (unit of analysis) of two different experts (sub-unit of analysis) are examined. Table 2 illustrates the selected projects and their details.

Table 2-Case study in the context of SVCN in the UK.

Case	Interviewee	Unit of Analysis	Project Years	Project Status	City
SVCN 1	Public transportation manager, local city administration	Type 1	2016-	Active	London
SVCN 2	Public transportation manager, local city administration	Type 1	2016-	Active	London
SVCN 3	Public transportation manager, local city administration	Type 1	2016-	Active	Bristol
SVCN 4	Data expert, sustainability expert	Type 2	2016-	Active	Birmingham
SVCN 5	Communication technology manager and service manager	Type 3	2017-	Active	Cambridge
SVCN 6	Communication expert, network expert	Type 4	2017-	Active	London
SVCN 7	Public transportation manager, local city administration	Type 1	2015-17	Inactive	London
SVCN 8	Data expert, sustainability expert	Type 2	2013-17	Inactive	Bristol
SVCN 9	communication technology manager and service manager	Type 3	2010-13	Inactive	Birmingham
SVCN 10	Communication expert, network expert	Type 4	2010-12	Inactive	Newcastle

Source. The author own work

Each SVCN is formed of a set of stakeholders: type 1 of citizens, drivers, public transportation managers and local city administration; type 2 of data experts, database designers, transportation experts, traffic experts, logistic experts, communication engineers, network engineers, system designers and sustainability experts; type 3 of data source providers, local services, data management and communication technology; type 4 of all stakeholders. The interviews were conducted and recorded by the author in person, who were asked the same questions. The interviews were also transcribed and then sent to the experts for revisions. The approved interviews were used to develop the case studies, which were analysed through cross-case analyses [20].

4. Findings and Discussions

The intention of the present research is to contribute to the body of knowledge by providing new propositions for information sharing in SVCN with a focus on the applications of Internet of Things (IoT) as an enabling innovative technology from the perception of project experts.

At the cross case level, to answer RQ1, key themes of the IoT applications that can be associated for information sharing in SVCN are explored. The exploratory case studies have indicated that the key themes should be categorized related to the four stages: stage 1- value added, stage 2- Linking IoT components to the concept of smart transportation in order to deal with IoT conceptions, stage 3- links between different actors and objects in the transportation system, and stage 4- all actors or objects "things" of the above types share their hub or database contents with the potential actors. The research applies this cross analysis to develop data exploration to enhance replication logic amongst the 10 cases (10 SVCNs), providing the views of 20 project experts. In Table 3, the cross-case matrix is to show the stages of IoT applications that smart transportation projects follow to create information sharing in SVCN with a focus on increasing benefits and decreasing challenges for better performance.

Table 3-IoT applications across the 10 cases of smart transportation projects.

Aggregate dimension	**Second order theme:** **First order themes**	**Case**									
		1	2	3	4	5	6	7	8	9	10
Stage 1	Benefits and challenges:										
	▪ identify information problems	X	X	X	X	X	X	X	X	X	X
	▪ improve information value	X		X			X	X			
	▪ enhance performance		X		X	X	X		X	X	X
Stage 2	IoT components:										
	▪ information	X	X	X	X	X	X	X	X	X	X
	▪ information technology	X	X	X	X	X	X	X	X	X	X
	▪ information subjects	X	X			X					X
	▪ information environment	X									X

	IoT main conceptions:										
	▪ transportation analytic	X		X	X		X		X		X
	▪ transportation control	X	X	X	X	X	X	X	X	X	X
	▪ vehicle connectivity	X						X			
Stage 3	Actor Interaction:										
	▪ data hub	X		X					X		
	▪ transportation system	X	X		X	X	X	X	X	X	X
Stage 4	Facilitating information sharing:										
	▪ increasing more benefits	X	X	X	X	X	X		X		X
	▪ decreasing existing challenges.	X	X		X	X	X	X	X	X	X

Source. The author own work

This analysis resulted in 14 first-order themes for IoT applications, which were then coded as 5 second-order themes that turned into 4 aggregate dimensions. These aggregate dimensions are associated to one overarching theme, information sharing for SVCN, in order to establish the theoretical association for the current study.

Researchers have proposed key findings to carry out development in SVCN for smart transportation in cities [4], [5], [8]. However, a wider body of knowledge about SVCN associated with IoT is needed to overcome overlapping concepts in order to generate consistent findings [5], [6], [13]. Thus, the intention of the current research is to contribute to the body of knowledge by providing new conceptual framework for information sharing in SVCN attached to IoT as an innovative technology in smart transportation. The framework in Figure 2 illustrates key themes effectively linked to information sharing in SVCN and thus, in order to improve value chain performance in practice. Amongst these, information sharing has become the central theme, which is formed by themes of IoT applications as antecedences for information sharing.

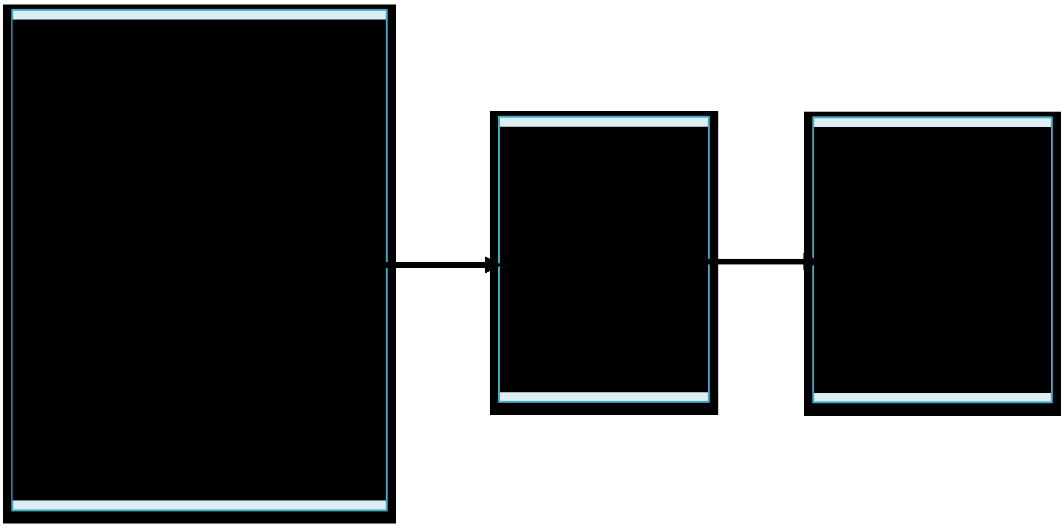

Figure 2-*A conceptual model for IoT applications and information sharing in SVCN*- Source. The author own work

There has been an important interest in applying the concept of sustainable network to understand complex interaction and applications within value chains [4], [5], [13], [21], [22]. The research proposes the conceptual framework that encompasses three key aspects of sustainable network: Innovative technology (IoT application), information sharing and value chain performance for smart transportation in cities. The present research provides brief explanations for each part of the proposed framework. First, the IoT application [13]. IoT as an innovative technology is proposed from the application used by various projects in smart transportation in the five cities undertaken in this study. The key findings highlight the importance of the four stages of IoT application to create information sharing in SVCN. The experts indicated that nine themes, namely identify information problems, enhance performance, identify information, information technology, transportation analytic, transportation control, transportation system, increasing more benefits, and decreasing existing challenges, are the highest important concepts and activities that should be included in IoT applications. The experts also indicated that five themes, namely improve information value, information subjects, information environment, vehicle connectivity, and data hub are the lowest important activities that can be included in IoT applications. The proposed framework indicates a set of recommendations for policy makers and projects' management.

In total 14 themes linked to the four stages of IoT applications have impact in creating information sharing in SVCN for smart transportation in cities. This in turn can bring improved value chain performance with a focus on sustainability aspects of economic, social and environmental issues. The experts in all cases have illustrated the importance of these sustainability issues that has the potential to improve an efficient and effective transportation system for smart cities.

For example, key enabling innovative technologies including M2M, V2V, V2I are IoT application technologies of communications for better links amongst actors. With multiple visions from various viewpoints, the IoT has become a key strategy in many smart cities [4], [5], [13]. IoT offers key benefits to various actors along the value chain including business to business and business to consumer, in addition to private and public sectors by enabling innovative applications. These applications provide a hub of information sharing for all actors based on combination of information technology, telecommunication and objects, allowing the provision of valuable information on time. This can increase benefits and decrease challenges providing promising potentials to address visibility and controllability challenges and to focus on more sustainable benefits along the value chain of smart transportation.

5. Conclusion and Contributions

This research responds to calls for a holistic perspective on understanding of how information sharing contributes towards improving SVCN through focusing on innovative technology [7], [23]. A holistic perspective is a need for increased transparency and shared information for all actors as a key objective in SVCN for improving smart transportation operations by IoT.

With multiple visions from different viewpoints, the IoT has become the common paradigm of modern ICT area [24]. It offers immense potential to consumers, companies and public sectors by enabling innovative applications. This focus is attracting increasing attention from both policy makers and academics where prior research has suggested that this focus exhibits many unclear characteristics [25], [26]. There is a lack on how IoT applications can improve businesses in a sustainable way. Thus, this research aims to explore the high-order themes to information sharing in SVCN with a focus on the applications of IoT in transportation operations as a key enabling ICT technology from the perspective of expert community along the value chain. In this research, a conceptual framework for information sharing in SVCN associated with IoT for transportation operations is then proposed.

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