Smart City – Smart Logistics Amalgamation

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***Abstract*—Goods movement into the smart city is critical from economic perspective. Hence, understanding the relationship between logistics of the goods flow and smart city operations is crucial in the policy deployment of future cities. Emerging smart logistics considers the inclusion of disruptive technologies – e.g., smart sensors within Internet of Things environment. However, there is no research work that studies the impact of smart logistics on smart cities sustainability considering firm-level technological viewpoint. Thus, this paper investigates empirically the effect of smart logistics on smart city sustainable operations, based on the foundation of organisational capability theory. For that purpose, a survey-based questionnaire is used to collect data from businesses that deal with logistics in Melbourne city (Australia). Then, the structural equation modelling technique is employed to analyse the relationship of smart logistics with smart city performance. Results show that smart logistics has a positive impact on smart city sustainable performance. Therefore, future urban projects will take into account this emerging logistics approach.**

Keywords—smart city, smart logistics, disruptive technologies, sustainable performance.

I. Introduction

The European Union defines a smart city as ‘a place where traditional networks and services are made more efficient through the use of digital and communication technologies for the benefit of its inhabitants and businesses’[1]. Accordingly, smart logistics refers to the products/services embedded with Internet-enabled communication technologies that help in their mobility from the source to the point of consumption. City logistics should operate with increased efficiency and effective delivery plan, where multiple stakeholders play critical role. While city residents and visitors need the goods and services for quality living within a smart city environment, the city retailers face ongoing challenges to serve them in full and on time, even they plan for the right suppliers for timely delivery of goods.

Nevertheless, the literature related to the effect of smart logistics on smart city sustainable performance is scarce. The study [2] analyses smart mobility initiatives (i.e. reduction of vehicular pollution, noise, transfer cost and speed, traffic congestion, and increasing people safety) in smart city context and investigates the role of Information and Communication Technology (ICT) in supporting these actions; ICT broadly facilitates the city dwellers to access the logistics information to stay aware of things availability in real time. A conceptual framework that includes smart city, supply network and governance is developed in [3], but without considering performance as the target outcome.

Besides, the work [4] proposes a decision support system for urban freight transport (UFT) planning considering the city culture and stakeholder engagement in the process. Authors in [4] state that UFT plays relevant part of modern city life providing economic benefits. However, there are multitude city-specific UFT issues (e.g., social habits and urban configuration) around delivery that hinders the logistics efficiency and user satisfaction, which are missing in their study.

Further, emerging technologies can value-add to the existing ICT infrastructure. Disruptive technologies, enabled by Internet of Things (IoT), are making their foray into the logistics movement which is getting smarter than ever before. These cutting-edge technologies refer to smart sensors, RFID, palm-held devices and smart mobile phones. In addition, as logistics and transport go together for cost-effective delivery of goods in smart city environment, the deployment of vehicle technology applications, known as Internet of Vehicles (IoV), facilitates every day urban life [5]. But, to the best of our knowledge, this has not been investigated in smart city operations context.

Therefore, as discussed before, there is no potential empirical research found on the causal relationship of how smart logistics influences smart city sustainable performance. Hence, the objective of this paper is to investigate empirically the impact of smart logistics on smart city sustainable performance. Thus, the following research question (RQ) is developed to guide this objective:

RQ: Does smart logistics influence smart city sustainable performance?

The remainder of the paper is organised as follows. First, the research framework is provided. Then, the context of Melbourne city status quo is detailed. The methodology section describes data collection and analysis techniques, followed by the discussion of results. Finally, the conclusion section presents the implications of this research.

II. RESEARCH FRAMEWORK

As a supply chain is working behind smart logistics, many stakeholders such as retailers, 3PL service providers, shippers, warehouse and urban transporters are engaged to this end to complete the task to customer satisfaction. Technologies in retail store environment include hand-held devices, Point-of-Sale (POS) devices, hand-held sensors, video analytics (facial recognition for customer recognition and context-aware offers), IP Cameras, barcoding (i.e., Laser, LED scanners and camera based scanners) and Mobile payments (including Apple Pay). In warehousing environment, customer order is received in hand-held devices (PDAs), which are useful to communicate the order for picking and confirming it as fulfilled. Picking at warehouse is simplified by use of voice pick system that works together with Warehouse Management System (WMS) for order fulfilment (e.g., Aldi). In UFT context, modern transport technologies are much in use [6]. IoT retina scanners in the trucks can monitor driver fatigue by tracking pupil size and blink frequency. IoT in fleet management can monitor how often a truck is sitting idle by analysing the transmitted GPS data. IoT-enabled vehicle track & trace systems and route optimisation can cut costs and improve supply chain efficiency [7]. This is already being applied by Linfox Australia.

Smart city is not only built on ICT capability, but the capability needs to be updated with emerging technologies from time to time [8]. We therefore build on the premise that adoption of disruptive technologies adds to the existing ICT capability that can enhance the smart city sustainability.

From organisational capability (OC) theory perspective, a firm's capability (dynamic) should be able to acquire and implement new technologies [9]. The investigation in [10] argues that ICT itself cannot have a direct effect on performance; rather it depends on the release of other organizational resources (e.g. Human and financial resources) for performance improvement. The authors in [3] claim that smart city gets smarter when it uses existing resources smartly while adopting the emerging ones on timely manner. Here we refer the technologies such as IoT in the form of RFID, sensors, short-range wireless technology, palm-held devices and smart mobiles. The adoption of disruptive logistics technologies can address public issues via ICT-based solutions transforming the work and lifestyle of residents by providing free mobile access anywhere in the city. This will lead to an environment of information sharing, collaboration, and seamless experience facilitating smart governance (i.e., e-governance ensuring basic services are fully available online).

Talking about the emerging technologies, the work presented in [11] discusses that perceived usefulness and perceived ease of use not only define the intension to adopt, but the institutional theory in the market plays critical role in adoption intention. Smart city operating in technologically turbulent environment is more likely to adopt disruptive logistics technologies. Smart city has some level of technological breadth (i.e. technologies already in use), but the question is to what extent it expects the logistics providers adopt a range of tools that will help address the goods delivery for the residents.

Fig. 1 shows the theoretical framework of this research work. This study tests the following model, to check the

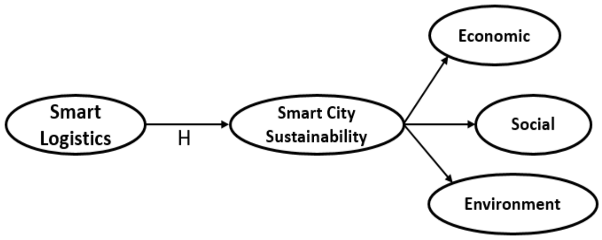

Fig. 1. Conceptual model of smart logistics and smart city sustainable performance relationship.

effect of smart logistics on smart city sustainable performance. Thus, this can be hypothesized as follows:

H: Smart logistics has a positive effect on smart city sustainable performance.

III. MELBOURNE CITY CONTEXT

Literature sources provide no evidence of Melbourne being a 'Smart City'; rather Brisbane appears as a smart city in Australia. Nonetheless, Melbourne is already running with so many initiatives underway.

Some of the initiatives are city lab (working with community to future-proof the city through human-centred design), open data (used for research, data visualisations and online applications for the city's customers), free wifi across the city (free outdoor wifi services for residents and visitors), 24-hours pedestrian counting system (how do people use city), smart bins (to keep the city cleaner) and urban forest visual (explore Melbourne's tree data). The Open Data platform is a unique data set to monitor 24-hour pedestrian counting system which helps understanding the pedestrian activity within the business district.

Other initiative includes the investment in knowledge economy with the help from Melbourne University and RMIT University in the North of city. This aims to provide opportunities for knowledge workers, researchers, students, business and community organisations to create innovative ideas for the city that can continue to be named as the world's most liveable city [12].

However, there are pressing issues such as traffic jam, road network congestion, pollution, energy consumption, waste treatment, etc., arising from Business to Business (B2B) and Business to Customer (B2C) transaction. For example, the retail businesses operating within city need to get their merchandise delivered for the residents and visitors. This is where the goods delivery needs to be smarter. Although Melbourne has maintained its environmental sustainability while caring for its society and economic development [13], the city needs further improvement in logistics around goods mobility just to keep its position as world's best liveable city.

IV. METHODOLOGY

A survey-based questionnaire method was used to collect data. The questionnaire was designed on the multiple dimensions of smart city sustainable operations [6], with sub-constructs such as economy performance [14], environmental performance [2] and social performance [14]. The ten-items measures for smart logistics were adapted from an earlier study [15]. Here the measures used are smart logistics (10 items) and smart city sustainable performance (6 items on economic, 7 items on social and 7 items on environmental). The multi-item measures used in this study applied seven-point Likert scale, 7 being strongly agree to 1 being strongly disagree.

The multiple stakeholders, those who are associated with or work for smart city operations, include residents and visitors, business houses, service providers, road transporters, local council and so on. In order to avoid complexity in data collection, the survey was limited to business retailers who deal with goods and services for the residents and visitors. The other group of respondents was the suppliers and the service providers, considering the urban freight transporters those who come under the purview of smart mobility. So, the target group is B2B, who deals with smart logistics.

Thus, suppliers, wholesalers, retailers, urban freight transporters and IT vendors in Victoria were contacted through Linkedin. The survey received 109 responses from a total of 120 businesses that were conveniently contacted. After removing four incomplete responses, it resulted in 105 usable responses that represented a response rate of 89 percent. The responses were collected with the participants' prior consent that presented a higher response rate. Structural equation modelling (SEM) was used to test the hypothesized relationship between smart logistics and smart city sustainable performance.

V. Results

The majority of the respondents were male at 70.5 percent, while over 40 percent had a bachelor's degree or Master qualification. Almost half of them work for an organization that employs over 1000 workers, and around 70 percent have over AU$ 1000'000 annual turnovers. Their nature of business represented a broad range, representing a cross-section of Australian industries. Importantly close to half (45 percent) of them have made IT-related investments over AU$ 500'000. Over 57 percent of respondents had over 5 years of experience with their respective organizations, while the majority of the respondents belonged to the categories of CEO/Chairmen/MD//Director/General manager (14 percent), Operations/Supply Chain/Logistics Manager (35 percent), Middle management (12 percent) and IT manager (17 percent). Out of the sample population, 87 percent were involved in strategic decision making of their company.

Internal consistency is determined either by Cronbach's alpha or composite reliability (CR). The Cronbach's alpha value for smart logistics is 0.795, economic performance is 0.786, social performance is 0.837 and environmental performance is 0.853. These values are greater than the minimum acceptable value of 0.7, indicating a satisfactory level of internal consistency [16]. Further, CR values for smart logistics, economic, social and environment are greater than 0.7, indicating that constructs have good composite reliability in measuring the constructs [17]. Besides, all the item factor loadings are above 0.50 and significant ($p < 0.001$), showing high level of correlation between observed items and latent constructs.

Satisfactory convergent validity is attained with AVE value at a minimum of 0.5 [17]. Table 1 shows the AVEs in the range of 0.467 and 0.598 for all constructs that confirm the evidence of convergent validity of each construct. Discriminant validity is then evaluated using the square root of the AVEs compared to the correlation coefficients [16].

TABLE I. Correlation and discriminant validity. (N=105)

	EVN	SP	ECO	SMT	Mean	SD	α	CR	AVE
EVN	*.773*				5.418	1.065	.853	.856	.598
SP	.745	*.752*			6.055	0.556	.837	.838	.566
ECO	.577	.594	*.699*		6.000	0.572	.786	.792	.489
SMT	.513	.401	.273	*.683*	5.953	0.703	.795	.840	.467

Note: EVN: Environment, SP: Social performance, ECO: Economic, SMT: Smart logistics
Diagonal values represent the square root of AVE
Values below the diagonal are the correlation coefficient

Table 1 presents the square root of AVE calculation along the diagonal showing that the diagonal values are greater than the corresponding inter-correlation stated horizontally and vertically. The results verify the strength of its discriminant validity.

The final path model confirms that the model fits with $\chi^2 = 136.626$, $p = 0.351$, $\chi^2/df = 1.043$, GFI = 0.886, TLI = 0.991, CFI = 0.993 and RMSEA = 0.020. This model is accepted as a good model fit. The fit statistics are provided in Fig. 2.

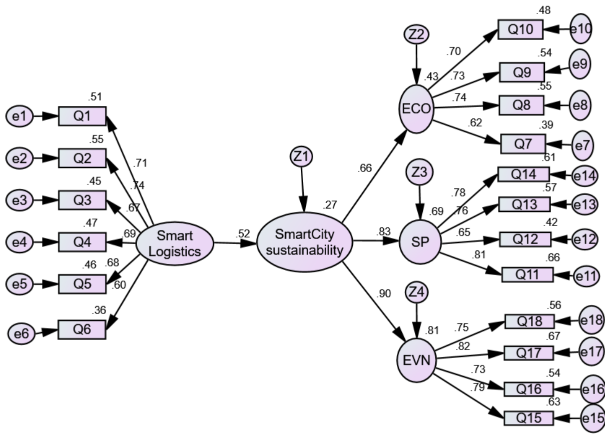

Fig. 2. Structural model with path coefficients.

The results demonstrate that smart logistics has a significant impact on the smart city sustainable performance with 0.52 ($p<.05$). This supports the hypothesis (H) that smart logistics can significantly influence the smart city sustainable performance enhancing the economic, social and environmental aspects of the city.

VI. Conclusions

This work is the first to study empirically the impact of smart logistics on smart city sustainable performance. Drawing on a survey-based and SEM approach, the findings indicate that smart logistics has a positive effect on smart city sustainable performance. Therefore, both retail businesses and their suppliers will likely to use the cutting-edge technologies employed in smart logistics enhancing the economic, social and environmental benefits of smart cities. Moreover, project managers will consider this emerging logistics approach in their future urban projects.

Theoretically, this study examines the relationship between urban goods movement and smart city operations, which is first of its kind in smart city literature context; it significantly increases the knowledge base in logistics as well, both from a technological and managerial point of view. The proposed emerging technology adoption in logistics, employing a diverse sample of stakeholders across multiple functions and industries, provides an opportunity for greater theoretical development of the technological adoption and dissemination at the firm level. While most of the earlier studies are rhetoric on improving the smart city operations from multi-stakeholders perspectives, this work offers an empirical research establishing a significant relationship between ICT-enabled logistics mobility that are perceived to enhance the sustainable performance of the city. Consequently, the interdisciplinary approach of this research, which combines business and engineering disciplines, will lead to more competitive projects for the College of Business, Schools of Engineering and University in general.

Practically, this research has the potential to improve the liveability of cities through economic and social prosperity, while reducing environmental impact on inhabitants, via enhanced ICT-enabled logistics. Thus, it will provide insights to urban planners and policy makers, so they will communicate with the parties responsible for moving goods. Logistics managers also see the feasibility of products being delivered on time and in full by adopting right-sizing transport, suitable time windows and schedules, and even paying fines as it may apply. In this manner, stakeholders can realise the potential of the emerging technologies in logistics mobility. In this way, both businesses and residents will benefit from these smart environments.

Nevertheless, this study is restricted to the business respondents within Melbourne city, so it could limit the generalisability of the findings. Thus, future research should include other cities around the world (e.g., Bilbao and Brisbane) for holistic views. Furthermore, the involvement of other stakeholders like residents and visitors, who are at the centre of the smart city, will reflect the quality of life being realized of this effort. Hence, the extension of this study to other stakeholders in the smart city remains as an interesting future task.

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