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Benchmarking Approach to Support Technology Investment Decisions: A Study of Technology Implementation in Last-mile Distribution

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Abstract. The rapid increase in business-to-consumer online retail has challenged the existing distribution models. Seamlessly integrated, more sustainable and digitalized last-mile distribution processes are vital to meeting the requirements posed by future online retail. Investments to new and more advanced technological solutions are needed to improve the operational performance and to meet all the external requirements. The variety of available technological solutions creates a significant, multi-layered challenge to individual organizations' ability to select the most fit-for-purpose technology for their own and their customers' needs. This is a well-recognized issue at the front end of the innovation process and it calls for deep insight before proceeding to actual product development. This paper describes how domain-specific benchmarking can be a valid tool for increasing strategic knowledge and supporting technology investment decisions. In this research, 16 technologies and technology topics applied to distribution logistics were evaluated in terms of the technologies' perceived feasibility. The feasibility comprised three technology dimensions – applicability, tangibility and maturity - as benchmarking indicators, chosen on the basis of literature. The demonstrated application of domain-specific benchmarking supports managerial evaluations of individual technologies, as well as enables further customizing the benchmarking indicators to be used in the proposed model.

Keywords: Benchmarking; Distribution; Last-mile distribution; Online retail; Technology

1. Introduction

The consumer goods value chain and distribution are influenced by several technology and market trends such as digitalization, individual selection, consumer-centric business, e-commerce and new service models (Alicke, Rexhausen, and Seyfert, 2017). In 2019, online retail constituted 14.1% of the total worldwide retail, and the turnover of online retail is projected to experience an annual growth of more than 10% (Statista, 2020). Efficient logistics and technological infrastructure are the key drivers of online retail. However, effectively organizing the delivery of physical goods from the producer to the consumer, especially in the context of last-mile operations, has been a challenge (Piroth Rüger-Muck, Bruwer, 2020; Hsiao *et al.*, 2018; Lim, Jin, and Srai, 2018, Vanelslander, Deketele, and Van-Hove, 2013). Generally, the last-mile section of the supply chain has been recognized as the costliest, and operationally and environmentally most ineffective, individual element of the entire process (Gevaers, Van-de-Voorde, and Vanelslander, 2014).

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The results of a recent study (Vakulenko *et al.*, 2019) highlight the crucial role of the seamless alignment of last-mile operations in the overall customer experience, further raising the importance of fluent operational performance. However, though multiple novel technologies exist for developing new distribution models, problems adopting them into the organization of efficient delivery have restricted the wider growth of online retail because poor execution of logistics demotivates consumers from using online stores (Lin *et al.*, 2016). Additionally, the environmental impacts of last-mile logistics are significant and therefore, new technological solutions are expected to provide greener alternatives (Kusrini *et al.*, 2020) and align with future regulatory requirements (Ranieri *et al.*, 2018).

Digitalization is rapidly advancing in the field of logistics, with numerous incremental changes occurring simultaneously in logistics processes (Yu *et al.*, 2017). Despite the range of new technologies available today, the challenge remains in how they could fully benefit and be customized to the specialized processes of particular domains like distribution logistics (Amling and Daugherty, 2018). A recent survey on the logistics of small and medium-sized enterprises (SMEs) (Kianto *et al.*, 2018) indicated a shortage of strategic knowledge management, especially regarding new technology. Durst and Evangelista (2018) made similar observations of Swedish and Italian third-party logistics companies andidentified organizational knowledge management to be a major performance driver in logistics.

New delivery technologies should also be risk-free (as far as possible), offer better consumer experiences, and fit their lifestyle to gain their acceptance (Zhou *et al.*, 2020; Wang *et al.*, 2018). Cano *et al.* (2021) highlight that securing logistics efficiency and maintaining competitive advantage are possible only by adopting and investing in advanced technological solutions. Technological investments are also needed in interfacing infrastructure and key human skills and competencies, and they will need to be made before, or at the same time as, substantial cash outlays are committed to the technology. In the worst-case scenario, investments in new technology solutions that eventually turn out to be unfeasible may cause devastating financial losses. In most business organizations, the question of technological uncertainties is a strategic one, as it is linked to managerial decisions on technology investments and gaining added value (Berawi, 2021). Due to the accelerating level of digitalization and turbulent global environments, many scholars (Gassmann and Schweitzer, 2014; Kim and Wilemon, 2002; Cagan and Vogel, 2002) emphasize the importance of gaining knowledge related to the front-end phase. In order to make successful investment decisions and overcome various uncertainties, such as being able to scope which technologies are the most fit-for-purpose for specific products, managers will be required to gather perceivable experiences to support the decision-making (Schweitzer, 2014; Cagan and Vogel, 2002). Kianto *et al.* (2018) further adduce the potential of increasing collective knowledge and reducing technological uncertainty, especially among SMEs in logistics, by strengthening technological knowledge-sharing platforms and procedures.

In sum, the challenges identified by the literature address the different needs of consumers, intermediate customers, and end customers, as well as understanding the risks and benefits of multiple available technologies, which make managerial decisions and choices a demanding task, entailing considerable uncertainties. Hence, this paper focuses on decision-making at the front end of the innovation phase of product development in the case of online retail-related last-mile deliveries. The paper has three aims: (1) to develop a conceptual model for classifying alternative technologies or technology trends to support decision-making, (2) to demonstrate the feasibility of the model for evaluating alternative last-mile technologies for online retail, and (3) to provide usable insight, especially for practitioners, on the applicability of different last-mile technologies. The first aim is clearly to present the model as a hypothesis, the applicability of which needs to be assessed by the managers of practice and the validity by the researchers. The second aim the demonstration will serve as a first-step model validity test. The proposed model is novel and the foremost contribution of this research. The model's application in this paper is primarily to measure the consensus of manager's perception of the applicability, tangibility, and maturity of alternative technologies when considering investment decisions. In a more general sense, the aim is to assist in better informed decision making and to reduce uninformed risks in technology deployment.

The emerging technologies are identified on the basis of a literature analysis. The third aim is conditional to the first two. Demonstrating the model to evaluate emerging technologies will provide direct information about their acceptability, maturity, and applicability if the model is deemed valid. The demonstration uses survey data from logistics and supply chain managers evaluating the identified emerging technologies. The model's demonstration is not validation, however, but yet a necessary step towards validation. The overall research design is constructive (Pasian and Turner, 2015). The proposed model represents the construct object. One application of the model is to use it as a measurement tool for applicability, tangibility, and maturity assessment of last-mile technologies.

2. Methods

2.1. Benchmarking

The methodological approach was done with a benchmarking (BM) method focusing on last-mile and online retail domain companies to gain and manage domain-specific knowledge. Mann *et al.* (2010) describe the key elements of BM as including 1) seeking the best solutions by learning from other organizations in the selected area, 2) analysis of the results to gain knowledge for one's own organization, and 3) the eventual implementation of the most suitable practices. The gained BM information allows organizations to recognize and effectuate corrective measures within their existing operations (Dobni and Klassen, 2021). BM supports the change process within organizations, upgrading their processes for future demands (Dattakumar and Jagadeesh, 2003).

Despite being a useful tool for raising awareness and supporting decision-making, BM information is really only a guideline. Beyond simply gathering information, the primary objectives of benchmarking can be summarized as learning and understanding how other organizations achieve superior performance, with further analysis aimed at aligning this knowledge with the strategic decision (Wudhikarn *et al.*, 2020). BM processes often consist of four main phases: (1) planning, (2) collection of the data, (3) analyses of data, and (4) integration of the BM results into internal decision-making processes (Kyrö, 2004). As the acquired BM results are generally targeted at continuous improvement (Wudhikarn *et al.*, 2020), the proposed model has been described as a BM circle needing regular updates (see Figure 1).

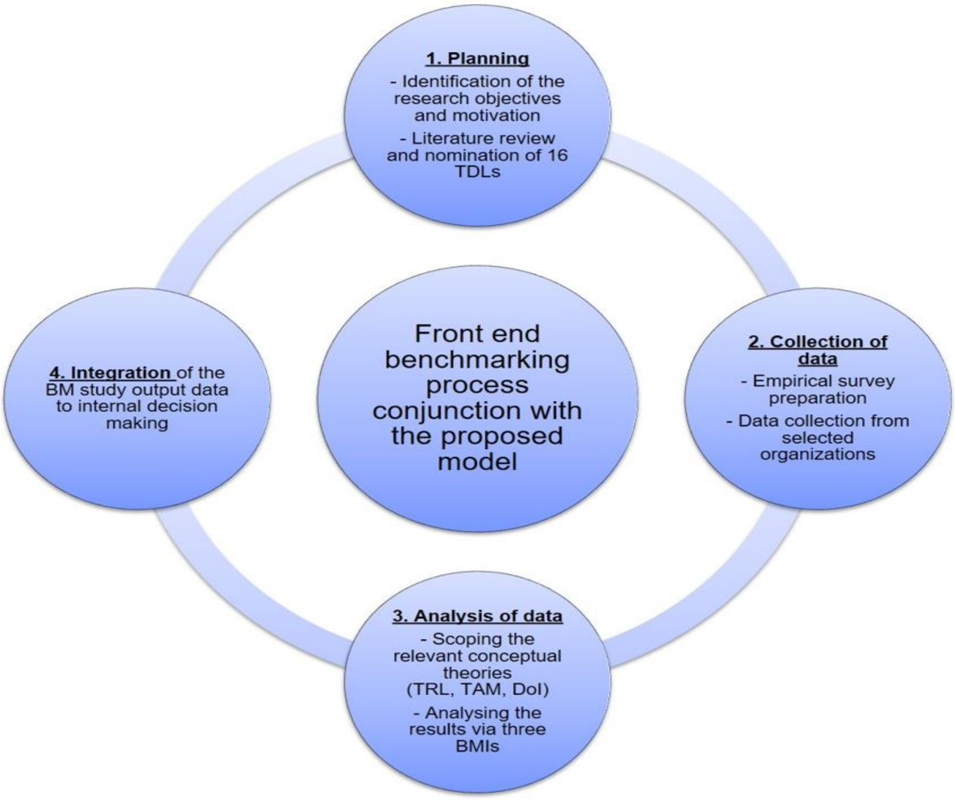

Figure 1 Front End BM Process Conjunction with the Proposed Model

2.2. Constitution of the Proposed Model

To develop an overview of emerging technologies and broader technology topics that potentially provide solutions for future distribution logistics in the online retail context, we conducted a literature review of journal articles and other scientific publications. The main method was an online search for articles published after 2014, i.e., within the last 5 years before the search began. The search criteria were combinations of the following words or phrases: retail, customer, consumer, last mile, delivery, distribution, emerging, digital, technology, ICT, online, supply chain, city, logistics, renewal, and B2C. The literature findings were analyzed qualitatively in a concept-driven way (Schreier, 2014), and the technology topics with links to distribution logistics (TDLs) were selected based on the analysis. The classification of technologies is a synthesis of the literature and is based on researchers' brainstorming. Hence, the process of classification was a heuristic process. The empirical part of this study evaluates the present role and attitudes of relevant stakeholders regarding emerging technologies. The evaluation includes 16 emerging technology topics chosen from the literature review, which concentrated on technologies already being used in production. The literature review process is summarized in Table 1.

The adoption of new technologies is a complex and multi-dimensional process with various dependencies that also need to be acknowledged in BM studies (Azadegan and Teich, 2010). The conducted literature review showed various models on how to evaluate the development of technologies and categorize the factors related to the adoption of different technologies. Models and theories typically focus on either the developmental stages of a technology over time or describe the processes of adoption and commercialization potential. After scoping the research literature, the considered benchmarking indicators (BMI) in this study are the Technology Acceptance Model (TAM) (Marangunić and Granić, 2015), the Technology Readiness Level (TRL) (Olechowski *et al.*, 2020) and the Diffusion of Innovations theory (DoI) (Rogers, Singhal, and Quinlan, 2014).

The three BMIs selected to measure the emerging technologies' perceived development stages were (1) 'Range of application possibilities' / BMI_1, (2) 'Tangibility' / BMI_2, and (3) 'Maturity' / BMI_3.

Table 1 Inclusion, Exclusion, and Prioritization Criteria of Publications

Type	Criteria	Additional information
Inclusion	Abstract, concluding chapters and/or keywords indicate that last-mile logistics or delivery logistics in general are a key topic in the publication.	The search was not limited to specific journals in order to include all potentially relevant publications.
	Publications are written in English.	English is the most common language in international logistics research.
Prioritization	Peer-reviewed publications were prioritized as the most important sources.	Peer-reviewed publications support the quality control of the work.
	Abstract, concluding chapters and/or keywords indicate that last-mile operations and emerging technologies in that field are key areas of focus in the publication.	
Exclusion	Studies that are clearly focusing on other transportation research domains than last-mile distribution processes. In line with earlier studies (Huebner, Kuhn, and Wollenburg, 2016) last-mile distribution can be considered an individual research area with its' own characteristics.	

2.3. Collection of Empirical Data and Nomination of TDLs

The selected $TDLs_{1-16}$ are presented in Table 2. These TDLs have already passed through the earliest stages of implementation and are being applied in some industries. However, they are not yet widely utilized in distribution logistics operations. The TDL variety serves the purpose of getting more information on the suitability of the proposed model, as it was expected that the survey respondents would use a wider scale in their rating if the TDLs were more divergent.

Table 2 TDLs and Their Possible Applications in Last-mile Distribution Context

TDL_n	Technology	Possible applications in last-mile distribution
TDL_1	Fifth Generation mobile communications technologies - 5G	Potentially, a wide range of solutions, where high reliability and low latency of 5G is beneficiale.g. real-time tracking of deliveries and vehicles. (Dekhne *et al.*, 2019)
TDL_2	Distributed ledger technology and blockchain	Recording transactions between delivery parties in a permanent and secure way and reducing the need for manual documentation. (Wang, 2019)
TDL_3	Self-driving vehicles	Automated last-mile deliveries to end-customers' doors. (Chen *et al.*, 2021)
TDL_4	Drones and robots	Deliveries of small items such as small food packages. These solutions are less dependent on the transport infrastructure. (Boysen, Fedtke, Schwerdfeger, 2021)
TDL_5	Internet of Things (IoT)	Service and product tracking. (Zhong, Tan, and Bhaskaran, 2017)

Table 2 TDLs and Their Possible Applications in Last-mile Distribution Context (Cont.)

TDL_n	Technology	Possible applications in last-mile distribution
TDL_6	Immersive technologies (virtual reality, augmented reality, mixed reality)	Route simulation and guidance. (Remondino, 2020)
TDL_7	Artificial Intelligence (AI) and machine learning	Demand forecasting and planning, dynamic and predictive solutions, and streamlined order-delivery process. (Giuffrida *et al.*, 2022)
TDL_8	Cloud computing	Optimization of multi-actor logistics operations and demand-driven city logistics. (Nowicka, 2014)
TDL_9	Parcel locker and post systems	More flexible deliveries and ease of access for the delivery service provider and customer. (Lemke, Iwan, and Korczak, 2016)
TDL_{10}	Online platforms & mobile applications	Interface of services for end-users/customers and an access point for a wide range of solutions. (Pigatto *et al.*, 2017)
TDL_{11}	Crowdsourcing	Broadening the scale of possible distributors and finding transport capacity during demand peaks. (Castillo *et al.*, 2018)
TDL_{12}	Wireless sensor networks (WSN)	Cold chain processes and managing food packages and their lifecycle. (Vanderroost *et al.*, 2017)
TDL_{13}	Data loggers, data-logging systems	Cold chain processes. (Trebar *et al.*, 2013)
TDL_{14}	Radio Frequency Identification (RFID)	Tracking of deliveries and identification of parcels. (Hinkka, 2012)
TDL_{15}	Big Data Analytics	Demand forecasting and planning and transportation management. (Wang, 2019)
TDL_{16}	Location technologies (Global Positioning Systems - GPS, etc.)	Scheduling and route optimization and predictions and communication on estimated delivery times. (Piroth Rüger-Muck, Bruwer, 2020)

3. Data and Results

3.1. Conceptual Models to Approach Technology Implementation

To evaluate the maturity of an individual technology, NASA has developed the Technology Readiness Level (TRL) concept, which also provides assessment tools. The TRL scale includes nine levels, starting from TRL 1 where only the basic conceptual idea of a technology has been reported, and ending with TRL 9 where the technological capabilities have already been verified in an actual operational system (Olechowski *et al.,* 2020). The European Association of Research and Technology Organisations, EARTO (2014), underlines that among EU member states, there is a need for a more comprehensive understanding of the TRL scale principles in order to have this visible in the technological research schemes of research institutes, industries, and governmental actors. This technology model is naturally associated with our survey's 'maturity' level assessment, which has been selected here as BMI_3

Technologies will require an extensive end-user portfolio if they are to be widely recognized, and various factors affecting the acceptance of new technology also depend on the individual characteristics of the end-user. According to Marangunić and Granić, (2015), external variables such as social influence play a crucial role when end-users are introduced to new technology and are developing their overall attitudes and intentions regarding the technology's potential practical applications. These influencing factors are further divided into perceived usefulness and perceived ease of use. The former portrays the level of usefulness of a new technology to be used as a part of or replacing an existing process. The latter describes how easily the new technology can be used based on the end-users' experiences. (Venkatesh and Davis, 2000). In addition to the conceptual framework linking the result demonstrability directly to the perceived usefulness, there are also empirical studies that have demonstrated a correlation between result demonstrability and intent to use the particular technology (Venkatesh and Davis, 2000). This model corresponds to our survey's assessment of 'tangibility', as it is assumed that the tangibility of a given technology is elementally associated with the prospective use. Therefore, this technology model has been selected as BMI_2.

There can be a variety of heterogeneous end-users using the same technologies in different business areas. The end-users can be differentiated based on their individual capabilities and business models. The different types of user categorization are based on their general willingness to adopt new innovations like new technologies. Widely cited theory of Diffusion of Innovations categorizes adopters into five groups depending on their capability and willingness to adopt new innovations. The categories were (1) innovators (2.5%), (2) early adopters (13.5%), and (3) early majority (34%), late majority (34%), and laggards (16%) who are the most reluctant to adopt new innovations (Rogers, Singhal, and Quinlan, 2014). Based on this model, it can be assumed that when a technology is being widely used and/or utilized in the everyday lives of the general public, it has already passed various phases and adopter categories. The diffusion process is linked to our survey's BMI_1 'range of applications', as it is expected that the more there is 'range', the higher is the probability of diffusion.

3.2. Empirical Survey among Last-mile Organizations

The developed model was tested by conducting an empirical survey. The main target group of the survey was professionals in Finland dealing with distribution solutions of online retail from different perspectives, including companies operating in nine individual business sectors. The survey link and/or email invitation were sent to 241 email addresses of relevant organizations located in Finland. It was estimated that the majority of the leading experts in the field in Finland belong to that group. Even if the respondent rates typically remain modest in these kinds of surveys, it was also estimated that number of responses would be appropriate for model testing purposes, even if a smaller number of respondents would mean higher deviations.

A survey related to this research was published online from 9 November to 15 December 2019. The survey received a total of 35 responses. Respondents were asked to give a score of 0–10 points for each BMI per TDL or select the option "I cannot say". With 16 different TDLs and three dimensions/$BMI_{1\text{-}3}$, the survey included a total of 54 questions, along with several background questions including, "What type of organization do you work for?", "Which sector of the organization do you work for?" and "What is your role in the organization?". The survey data was analyzed quantitatively to create an overall picture of the respondents' attitudes towards the TDL under review. The average score (avg.), standard deviation (SD) of the responses, and number of respondents (N) answering the question were calculated. The survey results are presented in Table 3 and Figures 3-4.

The number of responses (N) per dimension was a maximum of 35. The total number of responses per TDL (N_{total}) is the sum of responses per dimension, with a maximum of 105 (3*35). This value indicates how well-known each technology was among the respondents. Location technologies and self-driving vehicles received the most responses (N_{total} = 103).

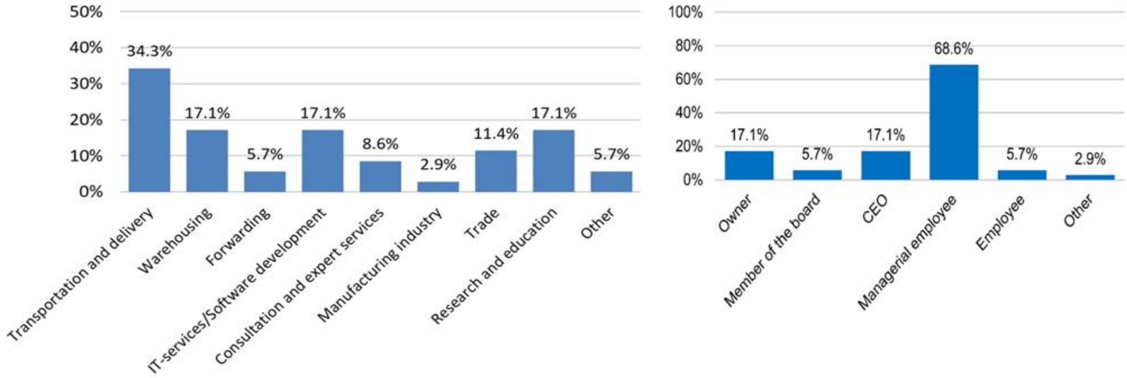

Figure 2 Respondents Business Sectors (a) and Respondents' Roles in Their Organizations (b)

Several SDs were calculated for each dimension and were between 1.61 (SD value of maturity of wireless sensor networks) and 2.60 (SD value of maturity of crowdsourcing). The average values of the SDs are shown in the second column from the right and reflect the unity of answers for each technology topic. In other words, the smaller the average of the SDs, the more consistent were the views of the respondents towards the technology. Based on the average values of the SDs, location technologies, IoT, AI, machine learning, and WSN had the most consistent responses. Crowdsourcing, self-driving vehicles, and blockchain technologies had the highest average SDs (>2.24). Under each BMI, the leftmost column in the group shows the average score for each dimension (avg.). The rank column shows the order of the TDLs in the range of application possibilities and was therefore ranked first under this category. The average score of the three BMIs was calculated for each TDL and is shown in the rightmost column. The survey results are presented as a spider diagram in Figure 3. The technology topics have been arranged based on the average score of the three BMIs (Tot. Avg.), resulting in a clockwise decrease in scores.

Table 3 The Detailed Survey Results

		Range of application possibilities				Tangibility				Maturity						
TDL	Technology	Avg.	Rank	SD	N	Avg.	Rank	SD	N	Avg.	Rank	SD	N	N_{total}	Average of SD	Tot. Avg.
1	5G	7.81	7	1.87	27	6.70	11	2.40	27	4.30	14	2.31	27	81	2.20	6.27
2	Blockchain technologies	7.16	14	2.28	32	5.84	17	2.27	32	4.47	13	2.18	32	96	2.24	5.82
3	Self driving vehicles	7.40	12	2.02	35	6.82	10	2.39	34	3.65	17	2.47	34	103	2.30	5.96
4	Drones and robots	6.29	18	1.99	34	6.03	14	2.19	33	3.48	18	2.05	33	100	2.08	5.27
5	Internet of Things. IoT	8.00	6	1.91	33	7.03	9	1.87	33	6.03	8	1.90	33	99	1.89	7.02
6	Immersive technologies (VR. AR. MR)	7.03	16	1.98	32	5.91	15	2.23	32	4.13	16	2.19	32	96	2.13	5.69
7	AI and machine learning	8.65	1	1.80	34	7.21	8	2.05	34	5.47	9	1.99	34	102	1.95	7.11
8	Cloud computing	8.15	4	1.90	27	7.41	6	2.06	27	6.70	5	2.49	27	81	2.16	7.42

Table 3 The Detailed Survey Results (Cont.)

		Range of application possibilities				Tangibility				Maturity						
TDL	Technology	Avg.	Rank	SD	N	Avg.	Rank	SD	N	Avg.	Rank	SD	N	N_{total}	Average of SD	Tot. Avg.
9	Parcel locker and post systems	7.62	9	2.28	34	8.71	1	1.77	34	7.24	2	2.30	34	102	2.13	7.85
10	Online platforms and applications	8.35	2	1.78	34	7.47	5	2.10	34	6.74	4	2.15	34	102	2.02	7.52
11	Crowdsourcing	6.63	17	2.37	27	5.85	16	2.49	27	5.37	10	2.60	27	81	2.49	5.95
12	Wireless sensor networks	7.44	11	2.17	27	6.67	12	2.09	27	5.19	11	1.61	27	81	1.97	6.43
13	Data loggers. data logging systems	7.48	10	2.01	29	7.48	4	1.99	29	6.66	6	2.19	29	87	2.07	7.21
14	RFID	7.32	13	2.15	34	7.59	3	2.06	34	7.06	3	2.39	34	102	2.20	7.32
15	Big data analytics	8.18	3	1.99	33	7.21	7	2.17	33	6.18	7	2.02	33	99	2.06	7.19
16	Location technologies (e.g. GPS)	8.03	5	2.05	35	8.41	2	1.82	34	8.09	1	1.79	34	103	1.89	8.18

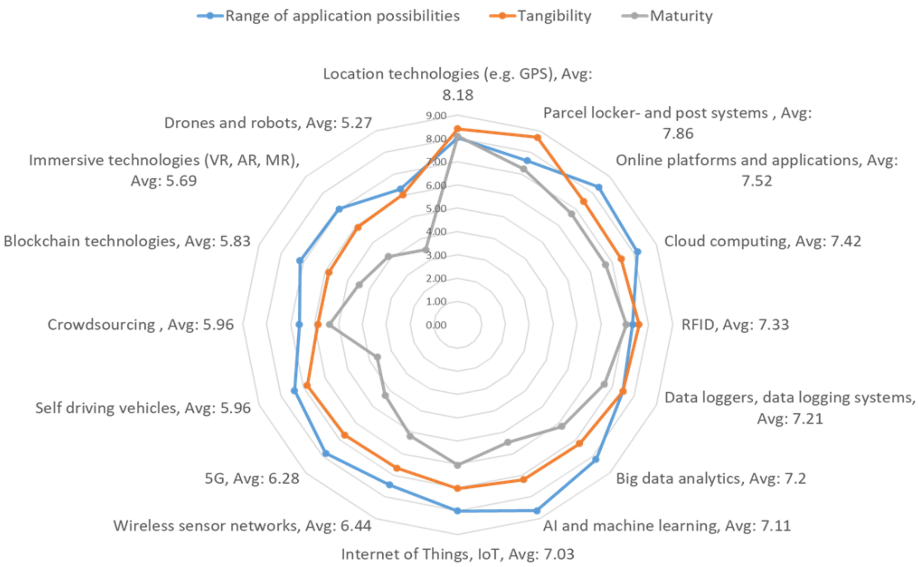

Figure 3 Spiderweb Diagram of the Survey Results

4. Discussion

4.1. Analysis of the Survey Results

The goal of the conducted survey was to gain a picture of online retail and distribution professionals' views on the range of possibilities for applying the chosen technologies. Based on the results. there are generally high expectations that digitalization will significantly improve various aspects of logistics. However. as history has shown. not all technologies maintain their position and they can quickly give way to a more suitable innovation. Other aims of the survey were to analyze how clearly these technologies are linked to practical operations in last-mile logistics. how specific the solutions are that these technologies can offer (tangibility). and how advanced. proven. and ready-to-implement (maturity) the technologies are perceived to be. All of the technologies received an average score above 5.0 on a scale of 0–10 for tangibility and range of application possibilities. This indicates that the chosen 16 technologies based on the literature review findings have at least some levels of support among logistics experts.

The maturity score varied from 3.48 (drones and robots) to 8.09 (location technologies. GPS). which was to be expected. given that some of the technologies are broadly used in other industries and/or the logistics sector. while others are clearly at an earlier phase of deployment — especially from the perspective of last mile distribution. Technologies that are already widely used tend to receive high ratings in maturity and tangibility (location technologies. RFID. smart locker. and post systems). This may partly reflect the extensive use of these technologies in some industries where their implementation has reached all groups of technology adopters presented in the Diffusion of Innovations theory (Rogers. Singhal. and Quinlan. 2014). Figure 4 visualizes the unity of answers and their potential impact on general awareness of technologies.

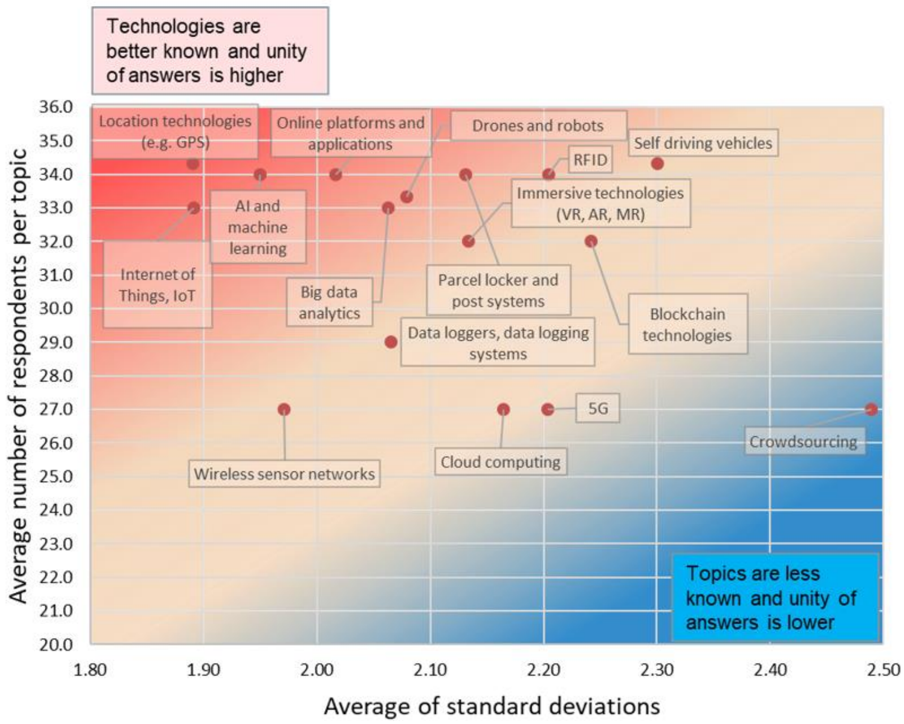

Figure 4 Mapping of TDLs based on Their Average SDs and Number of Respondents

ICT technologies. such as Big Data analytics. AI and machine learning. cloud computing. and online platforms and applications. were perceived to have a high range of application possibilities but had relatively average scores for maturity and tangibility. This suggests that the potential of these technologies has been noted but there is some uncertainty as to their possible roles in distribution logistics. From the perspective of TAM (Marangunić and Granić. 2015). the perceived usefulness is still incomplete. and the concrete benefits are unclear. The technology concepts that received a relatively low score in the range of application possibilities and tangibility were crowdsourcing. drones and robots. immersive technologies. and blockchain. This indicates that these technologies are still mostly used by early adopters presented in the Diffusion of Innovations theory (Rogers. Singhal. and Quinlan. 2014). and their perceived usefulness (Venkatesh and Davis. 2000) in the daily operations of distribution logistics is less clear compared to technologies that received higher technology dimension scores. Technologies such as location technologies (e.g.. GPS). online platforms and applications. AI and machine learning. and IoT received a high number of responses with low SDs. The respondents' familiarity with these topics may indicate the widespread visibility of these technologies.

4.2. Limitations and Future Research Perspectives

Despite the fierce competition and regulatory limitations affecting especially what type of information horizontal competitors are able to share. it is claimed that regular BM studies arranged regularly by an impartial organization could improve the awareness of technology trends within the specific domain. The limitations. however. steer the selection of BMIs. as they are not allowed to have economic or otherwise sensitive dimensions. Therefore. it is proposed to use non-confidential BMIs and perceived dimensions reflected from well-known theories. The obtained general trend information can further be utilized in decision-making processes at the front end of the innovation phase. at a time when considering technology investments and their feasibilities for specific purposes are particularly relevant. The proposed model is scalable. and the number of BMIs can be increased if they are considered useful in future studies. Additionally. the BMIs can be adjusted to incorporate other noticeable dimensions for each TDL. like disruptive potential. sustainability. or any other dimension based on the focus of future studies. The number of emerging technology topics continues to grow while others are being replaced or merged. Therefore. the selection of TDLs for inclusion in a BM study should be updated regularly.

5. Conclusions

This BM survey was used to demonstrate the use of the conceptual model that assessed the emerging technologies in terms of their maturity. acceptability. and applicability. The proposed conceptual model was based on BM methodology. technology adoption theories. and trend scoping. The model was demonstrated to be usable in mapping and measuring the perceived potential and suitability in the selected scope of online retail-related last-mile logistics. The results of the survey data used for demonstration confirmed the applicability of the proposed conceptual model. but the wider application and use require more research. Intuitively. the proposed model should be applicable to almost any domain for the assessment of technology and. therefore. could assist in decision-making regarding technology investments. The role of technologies in logistics is growing along with digitalization. The proposed model and its demonstration can help bring clarity and understanding to the prospective. yet in many respects. uncertain and risky technologies. The theoretical contribution of this paper is the merging of different technology models and their inherent perspectives into a framework that can be used for technology evaluation before significant investments and commitments are made. While the emphasis is on bringing forth a tool for the practice. the proposed conceptual model is novel and. therefore sets a hypothesis to be tested further by future research and practice. However. to genuinely test the proposed model. the results should be investigated after couple of years to see the actual development in the industry. Then. it would be possible to research the weaknesses of the model.

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