Mastering Omni-Channel Retailing Challenges with Industry 4.0 Concepts

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Abstract

Omni-Channel Management is an important trend, which allows retailers to improve customer experiences. Notwithstanding, entirely seamless integration of all channels, for example, in terms of customer or pricing data or consistent product offerings, is still a challenging endeavor. Technological developments, such as Industry 4.0 (I4.0), lead to innovation opportunities in the production industry. As there are intersections between I4.0 and Omni-Channel retailing, we propose that prominent Omni-Channel retailing challenges can be overcome by integrating knowledge from both research domains. Therefore, the purpose of this article is to investigate, which I4.0 concepts are utilized in scientific literature to overcome challenges and how these concepts can be transferred to Omni-Channel Management. To make this knowledge tangible for retailers, this article deduces opportunities on the application of I4.0 concepts in Omni-Channel retailing. The results show that especially IoT networks offer numerous deployment options and even Cyber-Physical Systems and Smart Factories provide related potentials.

1. Introduction

It is known that technology plays an important role in improving the customer experience and interconnecting channels [8]. Indeed, due to the pressure from e-commerce, Brick and Mortar retailers started to follow Multi-Channel Management approaches to allow customers to choose their preferred sales channels. These channels were and often still are managed separately. Channel-crossing functionalities or services were first considered with the emergence of the Cross-Channel Management approach. While cross-channeling is still not offered broadly, the next generation of channel management, called Omni-Channel Management (OCM), has already emerged. With OCM, the channel borders disappear and a seamless switch between channels is possible in every step of the customer journey [6, 10, 40, 49, 50, 56]. This is enabled by a shift from a channel- to touchpoint-management approach [40, 56] and the digitalization of individual touchpoints [54].

This article argues that researchers might be able to guide retailers to overcome prominent Omni-Channel retailing challenges by more closely considering existing knowledge on the different I4.0 concepts in this regard. To make this knowledge tangible for retailers, opportunities on the application of I4.0 concepts in Omni-Channel retailing are deduced. Here, the technological opportunities of I4.0 concepts are understood as their action potentials considering retailing as the context of the application and the retailer or customer as the utilizing person. Therefore, the research question of this article is: *What are the opportunities of I4.0 concepts related to overcoming Omni-Channel retailing challenges, which are currently being discussed in the scientific literature?* To answer this question a literature review is conducted following Webster and Watson [58] and vom Brocke et al. [11].

The remainder of this article is structured as follows: Section 2 introduces the research background and embeds I4.0 in the context of OCM. Section 3 describes the chosen approach for reviewing the existing literature. Then, section 4 presents the synthesized results of the literature review and discusses the identified opportunities of I4.0 concepts for solving OC challenges. Finally, the article is concluded by discussing the results, their limitations, and by highlighting potential areas for future research.

2. Research Background

2.1. Retailing Channels and Touchpoints

Traditionally, retail channels were subdivided into four different types [49]: In the physical channel, stores of any kind are operated for providing personal assistance as well as the presence of products for customers to touch, feel and try them [1, 21, 22, 27]. On the direct marketing or catalog channel, retailers send catalogs to potential or existing customers so that they can purchase goods and services from home, e.g. via telephone, mail or e-mail, which are consecutively delivered to their homes or dedicated pick-up stations [1, 22]. In the online channel, retailers typically offer webshops and, thus, are able to provide round-the-clock access to their shops plus a wider product and information range than other channels. [1, 59]. The

URI: https://hdl.handle.net/10125/64404
978-0-9981331-3-3

digital (or mobile) channel consists of mobile devices to access online shops as well as branded apps increasing the accessibility of shops and product information in physical settings [39, 56]. Since each of these types offer specific advantages and disadvantages as well as distinct characteristics [1, 6, 49] a tailored (Multi/Cross)-Channel Management approach was already crucial before the emergence of OCM.

With OCM, a company simultaneously provides all channel types, which allows customers to trigger the full interaction and/or the retailer can utilize the full integration of all channels permanently. Thus, customers can, for instance, utilize coupons or return products on every channel regardless of the channel where they received them. Also, the offering is consistent and further data, such as customer, inventory, pricing data, is shared across all channels [6:173f.]. In addition to this, Verhoef et al. [56] further distinguished Multi- from Omni-Channel retailing by emphasizing the fact, that the scope of the latter includes social media plus other available customer touchpoints, one-way advertisement as well as brand relations in addition. Also, they argue that channel borders begin to disappear. This is why Lemon & Verhoef [40] argued that there needs to be a shift from managing channels to managing customer touchpoints in a holistic manner. When reviewing the multidisciplinary efforts on the channel management approaches, a related evolution of the term touchpoint can be observed [29]. Neslin et al. [45:96] considered a channel as a "customer contact point or a medium through which the firm and the customer interact". Now, channels and touchpoints can be differentiated by stressing that channels comprise several customer touchpoints. These can be seen as interaction points between companies and customers or between different customers offered over different interfaces [29]. To manage and integrate the many different touchpoints, the 'Omni-Channel' (OC) should be considered as a system of interconnected customer touchpoints [29]. However, up to now, research on the actual management of this system is still missing.

2.2. Challenges of Modern Channel Retailing

While there is a growing body of literature on OCM, empirical research is still sparse [10]. One reason for this might be the fact that practice is still far away from operating a fully interconnected OC system. Indeed, becoming an OC retailer is not an easy endeavor. Challenges in the context of OC retailing are diverse and partly overlapping so that a clear list of those is not provided by scientific literature, yet. Notwithstanding, von Briel [10] conducted a four-step Delphi study including 18 international retail experts such as consultants, analysts, and professors, within others, to identify major challenges related to OC retailing. Besides, a few publications can be identified, which complement these challenges [1, 34, 45, 59].

(1) Friction Reduction: One challenge is the reduction of negative friction along the entire purchasing process. In practice, negative friction is referred to as any distraction, impediment or interruption of customers' purchasing process and experience [26]. Kowalkiewicz et al. [34] identified exemplary friction points such as too expensive products, which may be offered at lower prices on other media, such that the customers need to compare these; transport options not suiting customer's requirements; no direct interaction of touchpoints belonging to additional media with the physical one; time-consuming payment and checkout procedures, or sales staff not being able to provide the required level of customer assistance or experience e.g. because of lacking additional information.

(2) Holistic Channel Integration: A second challenge is the *realization of a full Omni-Channel integration* including the unification of all touchpoints across each medium as well as the integration and provision of the entirety of data e.g. regarding customers, products, inventories or prices [10, 56, 59].

(3) Customer-centricity: Next, the *achievement of customer-centricity* and, therefore, a personalized customer experience is also identified as a challenge. This may be achieved by various means, such as offering personalized goods, a better understanding of customers' processes plus their purchase history for tailoring the purchasing process including the requirement of technologies for collecting, analyzing, and predicting their behavior [10, 59].

(4) Real-time Inventory Visibility: A further challenge is *realizing real-time inventory management across all channels and touchpoints* necessary to enable quick fulfillment of customer orders regardless of the chosen medium. This requires real-time visibility of different inventory types for both online and local store stocks [10, 59].

(5) Operations Improvement: A further challenge identified is the *improvement of related operations* comprising various facets as the crucial increase of speed, flexibility, and reliability of order or return fulfillment regardless of the chosen medium or offering of customized products to provide seamless channel experiences. Hence, the entire Supply Chain (SC) is considered [10, 59].

(6) Pre- and Postconditions: Finally, a challenge identified by von Briel [10] relates to the *necessary pre- and postcondition*. In an OC context, a company has to establish an enabling mindset first and the required capabilities to accomplish an OC environment. Furthermore, the increased connectivity requires the firm to ensure data security, privacy, and confidentiality.

Currently, there is only some guidance for retailers to solve these challenges. This highlights the need for further theorizing about OCM from new perspectives.

2.3. Industry 4.0 Core Concepts

The idea of I4.0 was promoted initially in 2011 describing the fourth industrial revolution [53]. Since then, a large body of knowledge accumulated from scientific as well as practical publications. These provide different views on the key concepts and technologies of I4.0, some containing a rather business and others a more technical focused view on different levels of abstraction. Hence, previously no generally accepted definition and specification of the I4.0 core concepts did exist [4, 5, 28, 32]. To overcome this issue and provide a coherent definition, Hermann et al. [28] conducted an exhaustive literature review for defining the term Industry 4.0 and its core concepts. The authors define I4.0 as "… a collective term for technologies and concepts of value chain organization" [28]. Following this definition, IoT, Cyber-Physical Systems (CPS), Internet of Services (IoS) as networks, and Smart Factories can be considered as I4.0 core concepts.

It has to be noted that Perales et al. [47] extended these concepts to reflect the collection and utilization of data in I4.0 environments. However, this extension has an enabling role in terms of I4.0. Big data and Cloud Computing can be considered as "data services, which utilize the data generated in Industr[y] 4.0 implementations [31:605–606]" [28:8]. Indeed, Big Data requires "new forms of integration to uncover large hidden values from large datasets that are diverse, complex, and of a massive scale" [24:100]. Thus, this article considers Big Data technologies as those that support the management of the four V's of Big Data – volume, velocity, variety, and value [24]. Beyond that, "Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services" [2:50]. What is more, Cloud Computing and Big Data technologies are closely connected, as the underlying engines of Big Data technologies are often implemented on or provided by cloud infrastructure [24]. Therefore, this article considers them as enablers of the I4.0 core concepts explained below:

(1) Internet of Things (IoT). The first concept, IoT, is a broadly utilized and not precisely defined term. It describes an infrastructure of connected physical as well as digital objects equipped with (radio-based) identification technologies such as Radio-Frequency-Identification (RFID), Near Field Communication (NFC) or Beacon chips, but can also comprise mobile or smart devices. These objects communicate, interact or cooperate with each other and the environment using the IoT network by exchanging and processing information to achieve common goals [5, 20, 28]. Based on this description, these objects can be understood as CPS, as well. For demarcation reasons, Hermann et al. [28] describe IoT as a network in which those objects can communicate and interact by enabling the information exchange.

(2) Cyber-physical Systems (CPS). As indicated, *CPS* are objects interacting by using the *IoT*. Moreover, they are systems seen as a merging of the dynamics of physical processes and the digital world (including embedded computation, information storage, and communication capabilities) enabling the modeling, analysis, monitoring, and controlling of both aspects. In this context, process or performance attributes of physical components of a *CPS* are recorded and processed. Furthermore, these attributes are digitally analyzed to evaluate the system's state or condition and react to these accordingly. Furthermore, real-time information exchange and processing are usually realized using e.g. RFID chips and sensors.

(3) Internet of Services (IoS). Next, the *IoS* consists of participants, services, a service infrastructure and related business models enabling vendors of services to provide them via the internet.

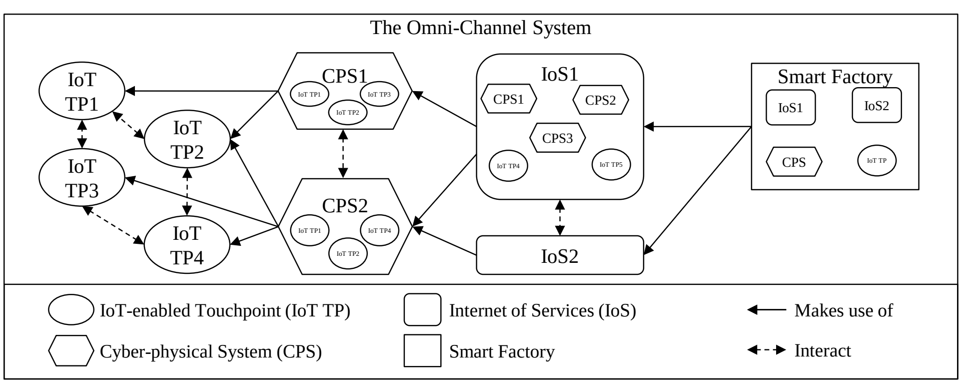

Figure 1: The Omni-Channel as a System Comprising I4.0 Concepts

They are usually combined into value-adding services of various suppliers and can be communicated or accessed via interaction interfaces offered by various media. Moreover, new distribution potentials of value chain activities and production are facilitated, as for example the construction of holistic value-adding networks consisting of various provided production technologies and capacities as an alternative to possessing single factories only [15, 28].

(4) Smart Factory. The fourth core concept, *Smart Factory*, can be defined as a context-aware environment, which is able to assist people and machines executing their processes or tasks. This assistance is based on the utilization of advanced ubiquitous computing technologies and tools for managing and coordinating real-time processes or occurring turbulences and problems. Smart Factories are realized by components working in the background, which comprise so-called context-aware applications and calm-systems. The former supports people and machines through real-time processing of context information, such as statuses of products or machines. This information can be of digital (e.g. results of process or production plan simulations) as well as physical nature (e.g. machine conditions). Calm-systems consist of the factory's hardware enabling the communication and interaction with the surrounding environment [28, 44]. With OCM, a set of touchpoints exists that are connected and integrated to form several *CPS*. As such, the OC system contains several *IoS* comprising participants, services, and a service infrastructure as well as its underlying hardware of various touchpoints. Within the OC system, a variety of these *IoS* exists, whose union can be considered as a *Smart Factory*. Figure 1 summarizes the relationships between the different I4.0 concepts in an OC system.

3. Research Approach

The literature review was conducted following Webster & Watson [58] and vom Brocke et al. [11]. The process comprised a scope definition, the creation of a search string, the extraction of relevant articles from the chosen databases, and the development of a concept matrix. Furthermore, the results were complemented using forward and backward searches [58].

Firstly, the scope was defined considering the presented research question and the taxonomy of literature reviews as introduced by Cooper [18]. Regarding the focus of the review, the research outcomes of the literature are reviewed for answering the articles' research question. Furthermore, the reviews' goal is the integration of OC challenges and concepts of I4.0 instead of a critical review or the identification of central issues. Besides, a neutral perspective of the results is chosen. As I4.0 literature is exhaustive and OCM literature is still in its early stage, a representative conceptualization of these relations is considered to cover the most important aspects and motivate further research. To organize the results, they are conceptually structured according to the tackled OC challenges. Finally, this article considers general and specialized scholars as an audience, as it tries to bridge the views of the different disciplines and stimulate further research.

Secondly, the search string was derived from the research question plus scope, so that it comprised keywords from three major areas, i.e. channel management, I4.0, and retailing. These keywords were based on the knowledge presented in the research background, the I4.0 search string proposed by Hermann et al. [28], and was further enhanced using keywords found in other related articles. Moreover, different spellings and abbreviations of specific terms were taken into consideration. For instance, 'cyberphysical system', 'cyber-physical system', 'cyber physical system' or 'CPS' were included. Besides, the wildcard notation ('*') was chosen so that different terms of the same word stem were included, as well (e.g. 'retail', 'retailer', 'retailers' etc.).

Third, the literature was extracted. In this regard, the major scientific research databases EBSCOhost, Scopus, ScienceDirect, and AISeL were chosen for obtaining the initial set of publications. Depending on the specific database and its search-related functionality, the search was conducted either as a title- only or as a combined title-abstracts-keywords-search. Due to the interdisciplinarity of the topic, the review was not restricted to contributions in the field of Information Systems. Furthermore, due to the research area's infancy, there was no restriction on the publication dates necessary, either. However, the database search was restricted to English articles only. Notwithstanding, if relevant articles in the German language were identified during the forward and backward search, they were included in the analysis. The extraction of articles from the databases resulted in an initial set of 557 distinct articles. Subsequently, this initial set was analyzed to determine the article's relevance for answering the research question based on each title and abstract. If no relation to the topic was found, the article was omitted. Afterward, the remaining 65 full-texts were screened to evaluate their relevance. Thereby, 19 representative articles could be identified. Moreover, six articles were found as part of a forward and backward search resulting in 25 articles in total. Finally, the findings of each article were structured using a concept matrix (see Table 1) as depicted in the following. The findings were then synthesized following the definition of research synthesis of Cooper et al. [17].

Table 1: Concept Matrix on Industry 4.0 concepts in Omni-Channel retailing

Meta Information				Type of Paper					OC Challenge						I4.0 Components				Enabling Technologies		Source				
Author(s)	Year	Reference ID	Region	Conceptual	Analysis	Implementation	Evaluation	Overview	Friction Reduction	Holistic Channel Integration	Customer-Centricity	Real-time Inventory Visibility	Operations Improvement	Pre- and Postconditions	Internet of Things	Internet of Services	Cyber-Physical Systems	Smart Factory	Big Data Technologies	Cloud Computing	EBSCOhost	Scopus	ScienceDirect	AISeL	Forward/backward
Hansen and Loos	2008	23	Germany	x	(x)				x		x	x			x							x		x	
Wahlster et al.	2008	32	Germany	x				x	x		x				x										x
Bandyopadhyay and Sen	2011	3	India					x	x		x	x	x		x				x						x
Ping et al.	2011	48	China	x								x	x		x							x			
Brynjolfsson et al.	2013	12	USA					x		x	x				x						x	x			
Longo et al.	2013	43	Germany	x		x			x	(x)	x				x					x		x			
Cha et al.	2014	16	Taiwan	x		(x)	(x)		x				x		x				x	x		x			
Demirkan and Spohrer	2014	19	USA	x				x	x	x	x		x		x		x		x	x	x	x	x		
Lazaris et al.	2015	36	Greece		x			x	x	x	x				x									x	
Burnes and Towers	2016	14	UK	x					x		x							x			x	x			
de Kerviler et al.	2016	33	France	x	x				x	x	x				x							x	x		
Pantano and Priporas	2016	46	UK		(x)			x	x	(x)	(x)				x				x	x		x	x		
Bradlow et al.	2017	9	USA		(x)			x	x	x			x						x		x	x	x		
Burmester et al.	2017	13	Switzerland	(x)				x				x	x		x							x			
Hauser et al.	2017	25	Germany	x					x	x	x				x				x					x	
Kaczorowska-Spychalska	2017	30	Poland					x	x	x	x				x				x		x				
Krüger and Kahl	2017	35	Germany					x	x	x	x				x		x		x	x					x
Lee	2017	37	China	x	x	x			x	x			x						x	x	x	x			
Leukert and Gläß	2017	41	Germany					x	x	x	x	x			x				x	x					x
Satish and Yusof	2017	51	Saudi Arabia				x	x		x	x		x						x			x	x		
Scheer	2017	52	Germany					x		x	x	x	x		x		x	x	x						x
Trappey et al.	2017	55	Taiwan	x	(x)			x		x	x	x	x		x		x	x	x	x		x			
Betzing et al.	2018	7	Germany	x				x	x	x	x	x	x		x		x								x
Lee and Leonas	2018	38	USA					x	x	x	x				x							x			
von Briel	2018	10	Australia		(x)			x	x	x	x		(x)		x				x	x		x	x		
			Total	13	8	3	2	17	19	18	20	8	12	0	21	0	5	3	14	9	6	16	6	3	6

4. Results

4.1. Concept Matrix

The resulting concept matrix (see Table 1) provides an overview of the 25 considered articles classified based on six main categories: The meta information on the year and region of publication, the type of the paper, the OC challenge addressed, the concept of I4.0 featured, as well as main enabling technologies, and sources. Regarding the concept matrix and opportunities in the next subsection, I4.0 concepts are only considered when being explicitly mentioned by the authors. Nevertheless, (x) refers to a less direct relation either to the I4.0 concept or a challenge or to an analysis whose focus is not majorly on I4.0 aspects. For example, von Briel [10] investigates on the challenge of operations improvement, but without considering I4.0 concepts specifically, but digital touchpoints in general.

The type of paper refers to the way and the research focus with which the I4.0 concepts are investigated in terms of overcoming OC challenges. Therefore, it is differentiated between conceptual, analysis, implementation, evaluation, and overview articles. Comparing the scientific foci of considered articles, the applications of I4.0 concepts in OC retailing are often discussed within broader overviews. The second-largest share of the articles has a conceptual focus and designs holistic IoT environments comprising more specific elements or technologies to enhance the in-store purchasing experience [19, 51, 57]. Only a few articles analyze or discuss specific concepts in more detail and even less explain their actual implementations or evaluate these in field-studies. In sum, OC research overall and in particular with the application of I4.0 concepts in this context is a rather new topic so that current articles focus on providing broad and overall insights instead of proposing detailed analyses or evaluations on benefits of a certain concept related to a specific challenge. The publication years also undermine the novelty of this research area.

Related to the OC challenges, a rather balanced distribution can be found. One exception is the challenge regarding the improvement of operations efficiency, which is only featured in twelve articles [48, 52]. What is more, ensuring the necessary pre- and postconditions are just named once by von Briel [10] independently from I4.0.

In contrast, the I4.0 core concepts and enabling technologies are even less equally leveled. Regarding the core concepts, the major focus lies on the application of general IoT networks and environments [16, 43, 57] whereas CPS and Smart Factories are less frequently featured. These concepts are mainly dealt with in publications with a strong focus on the SC of retailers or on providing broad overviews of their potential integration into retail stores [14, 19, 52, 55]. Surprisingly, IoS is not directly featured in any of the 25 considered articles.

As discussed in section 2, many of the I4.0 concepts rely on technologies such as Big Data technologies and Cloud Computing as an enabler. To prove this, their occurrence in the context of I4.0 in OC retailing is recorded as well, showing that 14 of the publications feature Big Data and nine include Cloud technologies [16, 19, 35, 41].

4.2. Opportunities for Industry 4.0 Concepts in Omni-Channel Retailing

As depicted in the previous section, challenges of OC retailing are addressed through different I4.0 concepts, even though some concepts and challenges are more prominent than others. The resulting concepts applied and integrated as well as the resulting opportunities are discussed below.

(1) Reduction of Negative Friction. To solve the challenge of reducing friction across all channels, IoT provides promising application scenarios. First, an IoT in-store environment offers several related opportunities. This environment exemplarily comprises identification and tracking tags (such as RFID, NFC, Beacon, etc.) attached to products (in the following referred to as IoT-tagged products), sensors, ubiquitous cameras, or further tools to track these products or movement of customers. These components are connected to an overall IoT network.

Within others, this environment enables the seamless and automated checkout in stores, which can be realized by the automatic scanning of IoT-tagged products, providing automated payment procedures such as low proximity payment solutions, sending e-receipts to the customers' smart devices and finally unlocking any security mechanism based on IoT technology. For example, smart carts, which are equipped with IoT technology for interacting with the store environment, can be considered as one possibility to operationalize these opportunities [16, e.g. 33, 35, 46].

One related opportunity is the automated process adaption and improvement enabled through this IoT in-store environment. For instance, since the movement of products or customers can be tracked and analyzed in real-time, the number of cashiers can be adapted when identifying long waiting queues [e.g. 19, 36, 41, 57].

Moreover, an IoT in-store environment enables the analysis and prediction of purchasing behavior of customers based on data of the physical environment in a similar way as in online or digital media. To improve the prediction accuracy, it can combine data from all touchpoints. In addition, these predictions can be combined with another opportunity of IoT-tagged products to reduce friction in terms of unavailability and out of stock products. Both require an integration of Big Data technologies [e.g. 3, 30, 37].

Another opportunity for an IoT in-store environment is the reduction of search costs and efforts related to both products and prices. In the context of the former, smart devices of customers or smart carts connected to the IoT network can be used to guide a customer to pre-selected products within the store. Moreover, the introduction of smart fitting rooms or smart mirrors poses further opportunities. These digital touchpoints scan the products chosen by a customer and depict alternatives (e.g. different color, size, etc.) or complementary recommendations. Thereby, the customer does not need to search for product variations on his/her own or will be able to virtually inspect these in out of stock situations [e.g. 7, 23, 35, 36]. Additionally, this touchpoint can trigger sales staff to bring additional products to the customers' position. By distributing such touchpoints within the store and by tracking the customer movements and behaviors, the environment can react in a context-aware manner by depicting recommendations on screens nearby or customer's mobile device [e.g. 3, 7, 25, 38].

Regarding price-related search costs, the integration of digital signage instead of paper price tags enables real-time adaption and consistent pricing across all interaction points offered by different media. Also, these digital touchpoints enable dynamic pricing [e.g. 7] and allow to adapt the prices to the market. This might release customers from their search efforts for cheaper prices offered on other media [19, 35].

IoT-tagged products afford to reduce the friction of insufficient information by attaching a 'digital product memory' and making them accessible e.g. via customers' smart devices. These memories collect and provide comprehensive data about the specific product along with its entire life cycle and, thus, enable informed decision making of customers in stores without any further online search or similar [35, 57].

Besides considering the IoT in-store environment as subordinate CPS of the OC system, further self-contained CPS within the physical environment are able to reduce friction during the purchasing process in terms of providing automated customer assistance, as well. For example, they have the ability to automatically communicate and interact with customers, offer a variety of customer touchpoints and react to the encounters accordingly [7, 19].

Finally, Smart Factories enable a fast reaction to individual demands and a high availability of customized products, when deployed as small versions in the physical environment. Having such small Smart Factories within or close to the store, personalized demands or design specifications of customers can be recorded and directly transferred to these Smart Factories to produce personalized products in a fast and efficient manner, so that customers can collect them after short waiting times [14].

(2) Full Omni-Channel Integration. For realizing OC linkage [29], the IoT again provides several opportunities. On the one hand, it helps to establish an integrated customer database and on the other hand, it facilitates the integration of information provided by the retailer. In this context, Big Data and Cloud technologies allow the integration and consecutive analyses of all types of unstructured data coming from the different environments at large scales [e.g. 9, 37].

As indicated regarding reducing friction, an IoT in-store environment enables the collection of customer- and purchasing-related data in a similarly exhaustive way as on other media (e.g. Social Media). Examples are data related to customer movement within the store, the time a customer spends looking at or holding specific products. These provide insights into their decision-making processes. When integrating Big Data and Cloud technologies for high scale data collection and analyses, the creation of holistic customer profiles covering each medium within the OC is enabled [e.g. 10, 43, 51]. Similar to holistic customer profiles, OC customer accounts can be enabled through IoT in-store environments, as well. Such an environment can identify customers while entering stores, e.g. based on smart devices, tracking their behavior and integrate relevant information into their online-shop accounts, such as electronic receipts or warranty documents. Besides, customers can scan products using their tags and save them in their OC account for a later purchase [16, 19, 38].

Furthermore, IoT-tagged products can improve the integration of product information, such as specifications or reviews, across all touchpoints, so that customers within stores can e.g. utilize smart devices to automatically access information regarding a specific product. Similarly, the real-time availability of specific products for each medium within the OC can be checked [3, 7, 35, 52]. These checks are enabled by the IoT in-store environment since IoT-tagged products can be automatically scanned and the resulting data can be transferred to connected touchpoints within the OC system [25]. Also as mentioned above, an IoT in-store environment containing micro digital price tags enables real-time adaption of pricing data across the physical, online, and mobile environment [19, 35].

(3) Customer-Centricity. Regarding the third challenge in OC retailing, IoT in-store environments provide relevant opportunities for improving customer-centricity, as well.

Within others, by identifying customers, tracking their location and analyzing their behavior, the OC system can proactively react location- or behavior-based in terms of promotions sent to the customers' smart devices. Thus, the personalization of the customer experience is enhanced through customized marketing [7, e.g. 19, 41, 43]. Another opportunity is to provide personalized in-store recommendations for e.g. complementary products [e.g. 7]. Due to the large scale, different structure, and type of collected data, both opportunities are again enabled by Big Data and Cloud technologies [e.g. 23, 25, 30, 38, 55].

Similarly, this IoT in-store environment can provide tailored additional information to customers directly e.g. regarding product specifications, reviews, etc., which are either send to their smart devices or depicted in-store e.g. in smart fitting rooms. The integration of the previously depicted digital product memory is relevant for this centricity [e.g. 7, 52, 57].

When providing sales staff with devices integrated into the OC system, they are able to access different types of data and offer services that are tailored to customers [10, 36].

In addition, further in-store self-contained CPS offer two opportunities for achieving higher customer-centricity: Firstly, when deployed in stores, the service encounters of different touchpoints, respectively their processing, can be personalized while still being autonomous. Hence, these systems can automatically interact with customers while analyzing their behavior and react in a context-aware manner. Examples are interactive robot receptionists in stores, which can dynamically adapt themselves based on the customer's request [19, 55]. Secondly, when stores are equipped with tools for customizing offered products, automated small-scale customization of standard products such as printing of cloth can be offered to customers. Thereby, their shopping experience becomes more personalized [52]. Similarly, small versions of Smart Factories located close to stores enable the production of highly customized products almost from scratch, instead of only minor adjustments [14].

(4) Real-Time Inventory Visibility. Although potential applications of IoT technologies for enabling real-time inventory visibility are not as widespread as the previously depicted challenges, the attachment of tags to goods and scanning within stores or along the entire SC as, for instance, within warehouses, offers the required prerequisites to overcome this challenge. As explained before, real-time in-store visibility can be realized by scanning the location as well as the purchase of goods in real-time. This scanning can be realized e.g. through smart shelves or supporting checkout systems [3, 7, 13, 48].

(5) Operations Improvement. In relation to the fifth identified challenge, an IoT environment integrated into the entire SC – or at least relevant parts of it – provides opportunities for improving the efficiency of the operations of retailers. Indeed, technology, which enables channel integration, was discussed not only to have the ability to improve the customer experience but also to increase the retailer's productivity [10].

As discussed above, an IoT SC environment allows the tracking of goods and materials along the entire SC and, thus, provides enhanced monitoring of the SC's efficiency to support optimizations. In addition, the speed of the information flows can be increased [3, 13, 41]. For example, based on the real-time visibility of goods and products in stores as well as along the entire SC plus a prediction of customer behavior and purchases, the velocity, and accuracy of replenishment can be improved [13]. Apart from that, IoT environments, both in-store and along the SC, offer improvements in efficiency and automation of all kinds of processes. Exemplarily, RFID chips and sensors can automate goods receipt processes or they can simply be used as security mechanisms to prevent theft. Moreover, the introduction of digital touchpoints can automatize processes. For instance, automatized checkouts and e-receipts can automate payment or warranty processes and digital signage integrated into the IoT environment can automate activities for changing prices [3, 7, 19]. The final opportunity of IoT SC environments related to operation efficiency refers to an improvement of the overall Supply Chain Management (SCM). Because of the previously depicted opportunities such as real-time monitoring of processes and goods, automated decision making, business process analysis plus optimization enable more efficient collaborative SCM approaches, such as Vendor Managed Inventory [3, 48].

Regarding these opportunities, Big Data and Cloud technologies are crucial, since they allow the analyses of OC- and SC-related data to predict customer behavior. Thereby, they enable efficient reactions as anticipatory shipping and prevent over- or underproduction. Additionally, they help to reduce the analysis costs as they are more efficient than other technologies [e.g. 9, 37, 51].

5. Discussion and Conclusion

This article aimed at deriving the opportunities of I4.0 concepts related to overcoming OC retailing challenges based on currently discussed concepts in the scientific literature. The opportunities have been identified based on a literature review as proposed by Webster & Watson [60] and vom Brocke et al. [11]. The resulting opportunities exist of five different categories: (1) reduction of negative friction, (2) full Omni-Channel integration, (3) customer-centricity, (4) real-time inventory visibility, and (5) operations improvement.

The results have several theoretical and managerial implications. From a theoretical perspective, the results represent a first attempt to bridge knowledge from the I4.0 and OCM domains to identify existing intersections. By considering the OC as a system [29], which is similar to a Smart Factory, scholars can systematize their efforts and establish modular components (i.e. IoS) and system parts (i.e. IoT-enabled touchpoints or CPS), which tackle specific OC challenges or implement concrete OC services. From a managerial perspective, the results can improve decision support towards digital innovation in the context of OC retailing emphasizing that even concepts like small Smart Factories or CPS may provide benefits to retailing companies. Moreover, by depicting crucial OC challenges and potential concepts for overcoming them, this research identifies potential gaps to be addressed both from a scientific and a managerial perspective.

As with every research, this work is subject to some limitations. First, as the opportunities were derived from literature, further empirical research is required to investigate, whether or not they materialize in reality. Second, the relation and the possible combination of the opportunities within the OC system (i.e. Smart Factory) as a whole should be considered. This might support retailers to increase the impact of their Omni-Channeling efforts. Third, due to the low coverage of the other concepts in the existing literature, this article possesses a stronger IoT focus. Further research should investigate the opportunities for applying the other concepts in more detail. Fourth, the results showed that the concept of IoS and the challenge of reaching the necessary pre- and postcondition were not yet considered in any of the analyzed articles. Therefore, research should focus on these aspects in more detail. Fifth, as the literature review focused on retail publications, the results just uncovered the current state of research concerning the application of the I4.0 concepts in Omni-Channeling. Therefore, further research might be able to uncover more opportunities or transfer additional knowledge [42] considering, for instance, general I4.0 literature. Finally, the majority of the analyzed articles are rather broad conceptualizations and overviews of a number of possible applications of those concepts. Further research should investigate concrete applications in more detail.

6. Acknowledgments

This work is part of a project that has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie Grant agreement No 645751.

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