Opportunities and challenges of Retail 4.0 in grocery stores: a conceptual framework

Idoia Martin Elias*, Damiana Chinese**

** Idea prototipi Srl, Basiliano (UD) ** DPIA - University of Udine, Via delle Scienze 206, Udine*

Abstract: In recent years, the concept of Industry 4.0 has been extended to the retail world, leading some authors to introduce the notion of Retail 4.0. This paper highlights that the current understanding of this concept is not limited to omnichannel retailing, but rather is driven by the use of key 4.0 enabling technologies such as Data Analytics, Machine Learning, Augmented Reality, Virtual Reality, Cybersecurity, and Robotics. While some sectors of the retail industry have experienced a rapid transition to e-commerce (Retail 3.0) and are now moving to Retail 4.0, grocery retail is still concentrated in bricks-and-mortar stores. Some of them are losing revenue and being forced to evolve due to changing consumer habits and competition from other service providers. The aim of this paper is to investigate how 4.0 technologies could be implemented to help small grocery stores to overcome their daily challenges. To this end, the Soft Systems Methodology is used, a method based on systems thinking that provides a structured process for dealing with situations that are perceived as problematic and in need of improvement. The initial stage of the method, known as Rich Pictures, allowed to frame the problem situation of technological innovation in grocery shop management based on interviews with stakeholders. Subsequent stages, including the so-called CATWOE analysis and conceptual system modelling, allowed for the construction of a descriptive baseline model of the current service. This model was then aligned with the 4.0 Retail technologies to determine which phases they could be integrated into, and with the problematic aspects identified in the first phase, evaluating feasible innovation paths. Among the various technologies, electronic shelf labels emerge as the most feasible and useful technology for initial implementation. It is also desirable to introduce some application supporting home deliveries, which has also a social value within ageing customers in rural areas.

Keywords: Retail 4.0, Problem Structuring Methods, Soft Systems Methodology, Grocery stores

1.Introduction

Ever since the concept of Industry 4. 0 was first presented at the Hannover Messe in 2011, the idea of a fourth revolution rooted in advanced technologies such as the Internet of Things (IoT), Cyber-Physical systems (CPS), Big Data Analytics, automation and Artificial Intelligence (AI) has been rapidly borrowed from sectors other than industry and manufacturing. This is due both to the appeal of this catchword and to the objective transversality of many of these technologies and of the leap in organisational and business models that they entail (Pfeiffer, 2017). In the tertiary domain, most of the expansions of the Industry 4.0 concept are, predictably, in the servitisation of manufacturing and industry, but the latest expansions also include finance and retail (Mariani and Borghi, 2019). As far as retail is concerned, the recently coined term "Retail 4.0" does not yet have an agreed definition and is relatively unexplored: searching for it as a keyword on Scopus only 15 articles can be found that contain it in their title, abstract and keywords. For the sake of comparison, a similar search using "Industry 4.0" as a keyword returns more than 34000 papers. In this context, this study explores the applicability of the Retail 4.0 concept in supermarkets, with particular reference to small enterprises in the grocery sector in Italy.

1.1 Grocery stores in Italy

The Italian groceries retail market is highly diversified. Hypermarkets/supermarkets, convenience stores, large discounters and discounters and specialised stores coexist with traditional corner grocers and open-air markets. Unlike other European countries, the Italian food retailing and distribution sector continues to resist consolidation, with small, traditional grocery stores representing the largest segment of the food retailing, followed by open-air markets (Payaro and Papa, 2021). According to Federdistribuzione (2021), the number of traditional grocery shops has remained stable in our country at least until 2020, while it is mainly non-food shops that have suffered a crisis caused by the expansion of e-commerce. This is in line with literature observations that despite the enormous growth of general online shopping, e-grocery historically had a very limited scope in Italy (Maltese et al., 2021). In most European countries, the proportion of individuals buying any kind of product online is much higher than in Italy (on average 74% compared to 58% in Italy). However, in all European countries, the online shopping of groceries remains static at around 6% market share, whereas the market share of supermarkets has held steady for years at 37.2% (McKinsey, 2024).Within the large-scale retail trade in the food sector, the number of "free service" shops (between 100 and 400 m^2) but also of hypermarkets has declined significantly, to the benefit of supermarkets of intermediate sizes (between 400 and 4500 m^2) and above all of discount outlets. The behaviour of Italian consumers has changed structurally, with more selectivity, awareness and concern for waste. In this

context, a return to proximity is emerging, with out-of-town and large shops particularly affected, especially regarding food shopping. The breakout of Covid-19 has put the grocery sector under severe strain. To maintain customers and comply with sanitary regulations, many retailers adopted an omnichannel strategy offering their products both online and in-store. A rise of pure online grocery sales took place in this period (Marcucci et al., 2024), but also a re-discovery of small local grocery shops, due to the constraints of mobility in the vicinity imposed on citizens. The impact of innovations in the Covid-19 period and the evolution in the future is uncertain. The most recent statistics show that proximity is still a value: people make around 60% of their grocery purchases in channels that are less than a 15-minute walk or 5-minute drive from their home. Almost 80% of customers continue to buy food in traditional shops and 57% in local markets, especially in Central and Southern Italy and especially among families with underage children, the elderly, pensioners and generally among those on low incomes. Nevertheless, small shops have also evolved with a greater propensity for digitalised payments, multichannel shopping, and a greater offer of pre-cooked or ready-to-cook meals (Manuelli, 2024). Federdistribuzione (2021) emphasises as well how the consumer purchasing journey is evolving rapidly, with greater interaction between online and offline and the shift from multi-channel to omnichannel, partly since smartphones make access to the internet and social networks easy even for the older or less educated population.

2. Research goals

As customers have displayed new needs linked to new technologies and the omnichannel approach, and as grocery retail businesses, even small ones, have shown that they are able to implement some innovations to satisfy these needs, it makes sense to take a more comprehensive view of integrating the most advanced ICT technologies into business models, with an overall paradigm such as Industry 4.0, by asking the following research questions:

RQ1. How can Retail 4.0 be defined in terms that are appropriate to the context of the grocery stores?

RQ2. How could the change represented by Retail 4.0 enabling technologies be implemented in small grocery stores?

3. Research methodology and structure

To answer the first research question, a definition of Retail 4.0 is drawn in section 4 based on the 15 articles that could be found in Scopus up to 29 April 2024 using the keyword "Retail 4.0". Due to such limited number of contributions in the literature, a structured review was not attempted, but additional papers retrieved either with a snowball approach from the first set of papers or by re-quering the *Scopus* database using the keyword combination "Industry 4.0" AND "Retail" AND "Grocery stores" were also examined to draw a definition.

The second question is addressed in section 5 using Peter Checkland's soft systems methodology (Checkland, 1981). Soft Systems Methodology (SSM) has been selected as it is a recognised methodology for creating business models, i.e. "*Conceptual tools that contain a set of elements and their relationships and allows expressing the business logic of a specific firm*" (Sewchurran and Petkov, 2007). SSM has been mainly applied to problem situations related to the management of change, particularly in the context of ICT systems design. In retail and distribution, SSM was applied around 30 years ago to an organisational change project in Tesco stores (Winter, 2006). More recently, SSM has been partially applied to the development of a traditional supermarket's online presence to provide an alternative service to online grocery players in the Covid-19 period (Merrit and Zhao, 2021), and also partially by Ayotunde et al. (2021), who explored the possibility of introducing smart mirror fashion technology (SMFT) to improve the service quality of bricks-and-mortar clothing retail chains. There are no known full applications to the grocery sector in a comprehensive exploration of new 4.0 technologies.

4. Defining Retail 4.0 through enabling technologies

The literature review reveals an evolution in the concept of Retail 4.0. Initially the concept is identified tout court with omnichannel. Lee et al. (2017) stated that "*multichannel retailing is moving to omnichannel retailing, leading to the fourth-generation retail revolution*". For Sakrabani et al. (2019) "*Retail 4.0 is defined as omnichannel retailing whereby customers are not restricted to 'in store' or 'online shopping' but are also able to shop via a combination of both channels.*" Nevertheless, they observe that Retail 4.0 "*utilizes multiple technologies from Industry 4.0 to provide customers with the best shopping experience, service and products*".

More recently, researchers focus on key enabling technologies (KET) to define Retail 4.0. For Gawankar et al. (2020) Retail 4.0 "*is the use of internet of things, Big Data Analytics and related technologies by retail organisations to attract and retain customers*". Retail 4.0 thus emerges as a broader concept than omnichannel retailing, and particularly as a concept defined by its KETs.

The set of KETs considered is often a fraction of the nine "pillars" of Industry 4.0, as commonly understood in the literature and reported in the first column of Table 1. The most comprehensive definition of Retail 4.0 is provided by Loh et al. (2022), according to whom "*Retail 4.0 includes technologically advanced digitalization systems that integrate with smart objects and IoT..[...]. The set of technologies considered for Retail 4.0 mostly overlap with Industry 4.0 technologies and include artificial intelligence (AI), Internet of Things (IoT), cloud computing, Big Data Analytics (BDA), and augmented reality (AR)*". Also Loh et al. (2022) recognise omnichannel as a pillar of Retail 4.0, but they describe also self-service kiosks as an equally important element, incorporating technologies such as IoT, RFID, and AI (referred to as "intelligent vending

machines"). As evidenced by the systematic literature review by Bruni and Piccarozzi (2021), some 4.0 enabling technologies are at the centre of attention of researchers in the retail sector. This is the case, for example, of BDA and AR and Virtual Reality (VR), which are the most frequently investigated KETs. As summarized in Table 1, BDA in grocery could find application in more accurate demand forecasting to support, for example, automatic reordering and price adjustment policies. AR/VR is mainly applied in the omnichannel trade of clothing and furniture. For the grocery sector, the application of AR is proposed to support consumer orientation in the aisles of large retail establishments and the signalling of unhealthy food (Firoz and Ratnayaka, 2020).

Table 1: Key enabling 4.0 technologies for grocery retail

Enabling technology of Industry 4.0	Example applications in grocery Retail 4.0
IoT	Application of sensors systems for food traceability and monitoring at every supply chain level (Lagorio and Pinto,2021) Unmanned kiosks (Loh et al., 2022)
Big Data Analytics	Track new customers, track information about location and timing of sales, forecasting demand, making decision about prices (Bradlow et al., 2017)
Horizontal and vertical integration of systems	Data sharing platforms between actors at different levels of supply chains, Blockchain (Lagorio and Pinto, 2021)
Simulation and digital twins	Digital twins of warehouses and shelves for robotic systems design, automatic replenishment of perishables (Villani et al., 2022) (Tebaldi et al., 2023)
Cloud computing	Outsourcing of information value chain, cloud services in marketing management enabling omnichannel, shared management of inventories between central warehouses and stores.(Lee, 2017)
Augmented and Virtual Reality	Supporting navigation in aisles of complex brick-and-mortar stores. Creating virtual grocery stores to foster online shopping (Firoz and Ratnayaka, 2020)
Autonomous Robots	Autonomous or collaborative shelf refilling (Villani et al., 2022)
Additive Manufacturing	Postponement strategies, decentralised product transformation. 3D printed food (Lanz et al., 2024)
Cybersecurity	Protection of customer data, payments, unmanned stores (Bruni and Piccarozzi, 2021)

On the contrary, other Industry 4.0 KETs are scarcely studied in the literature for the retail sector: Bruni and Piccarozzi (2022) point out that this is the case for Cloud Computing, Cybersecurity, Autonomous Robots and Additive Manufacturing (AM). Along the integrated supply chain, Cybersecurity and Autonomous Robots are topics that are well known to operators in the logistics field but not understood in all their implications or unclear in their potential for end stores. Indeed, while backstore applications are common and commercially available, the front-store application in grocery of robots is the subject of recent studies and prototypes (Villani et al., 2022) both as autonomous and collaborative systems. An established and interesting prototype is the TallyRobot described by Tebaldi et al. (2023), a system integrated with RFID technology to track the locations and expiration dates of high-value, highly perishable goods such as meat. Tebaldi et al. (2023) note, however, that even the topic of Retail 4.0 enabled by RFID technology is a still poorly debated argument, and their study is the first scientific paper to address this topic. Lagorio and Pinto (2021) observe the same more generally for IoT for the specific area of grocery retail. AM per se remains limited in its application to the food sector, due to the low maturity of the technology and the resistance of consumers who associate 3D printed food with low healthiness (Lanz et al., 2024). Furthermore, in the food sector, AM seems to be associated more with industry and centralised preparation than with retail. On the contrary, it is the innovative business models made possible by AM for manufacturing (distributed production with postponement and customisation strategies) that are now spreading in food retailing, with activities that are actually very traditional but have been increasingly successful in Italy in recent years, such as the sale of products (detergents, cereals, legumes) in bulk with the customer's own packaging at the time of purchase, or distributed food processing activities (in-store preparation of ready-to-cook or ready-to-eat food) (Manuelli, 2024).

5. Soft Systems Methodology for grocery retail

The Soft Systems Methodology (SSM) is based on the recognition that most technical systems, including business and information systems, are in fact socio-technical systems with a purpose that benefits and/or harms people. They are therefore better described as Human Activity Systems (HAS), which include human relationships and their interdependencies.

5.1 Methodology

The SSM consists of seven steps:

1. Problem situation perceived: The first step is to recognise that, in a given context and time, there is a situation that stakeholders perceive as problematic or want to change.

2. Problem situation expressed: Consists of understanding the problem space and expressing the situation using diagrams or pictures, termed "rich pictures" by Checkland (1981).

3. Root definition of relevant purposeful activity systems: This involves formulating the root definitions and using the so-called CATWOE analysis to categorise the actors and

gain a better understanding of the purposes and interactions within the systems.

4. Conceptual models of the HAS named in the root definitions are developed, representing a structured set of activities that implement the root definition.

5. Comparison of the models with the real world: The developed conceptual model is compared with different ideas, contrasting views and key players in order to provide a feasible solution.

6. Changes: This step explores desirable and feasible changes to the developed model.

7. Actions to improve the problem situation: A final implementable model is developed to achieve the desired objectives.

Although it can be used in a purely exploratory and conceptual way, SSM is an action research method, based on intervention in real problems. In our case, the implementation started with informal inputs from the initiators of an ongoing regeneration project in a rural municipality about 20 km from Udine. The project aims at creating an e-commerce platform shared by several production and commercial activities in order to build a virtual commercial centre. A series of two interviews was conducted with the owners of a small grocery shop. Individual interviews were also conducted with the owners of two other shops in the area, but their shops specialise in a single type of food: the information they provided was treated as supporting evidence only. The study presented here only goes as far as the sixth step of the methodology and will need to be discussed with the initiators of the commercial district project to be completed in one or more actual implementations (step 7).

5.2 Application of SSM to the case study

The expression of the problem situation is achieved according to SSM by building a rich picture (Figure 1), which is a diagram that captures the essence of the issue, its conflicts, and the understanding of it as perceived from the stakeholder's perspective. Figure 1 is the result of informal discussions with the initiators of the commercial district project and mainly of the interviews with the grocery store owners, who are at the centre of the picture as they have the power not only of initiating the change project (automatizing or moving to online presence) but also of maintaining their activity in the long run. In fact, as highlighted in Fig.1, owners point out that the number of customers is constantly decreasing, and it is difficult to keep the activity going. In the 1980s, all the inhabitants of the village were customers of the shop, they came to do their daily shopping and six people were employed to run the business. Today, even though the owners have been quick and proactive in adopting innovations (PCs for accounting in the 1980s, barcode readers in the 1990s) and in joining a chain of franchisors, the volume of business has shrunk considerably, and only the two owners work, trying to satisfy the remaining customers with their individual requests. From a financial point of view, if not everything can be done by the owner with his own capital, banks or other (e.g. public) providers of funding also have the power to prevent the change or continuation of the system activity; they are thus partial owners of the process of innovation, if not of the entire activity.

For the sake of generalisation, we have also included the point of view of possible employees of the shop who, like the owners but from a different perspective, would see both the opportunities and the risks of the new technologies highlighted in the picture. In line with the literature (Maltese et al., 2021) the potential new "lost" customers could be young people whose working hours are incompatible with traditional shopping (and who find more convenient to travel to large shopping mall by car), but also older people who do not have a car but who are no longer able to physically access the supermarket by carrying their shopping bags and who confess to miss the home shopping service offered by the store during Covid-19 emergency. This could be solved by an online presence - even a collective one - as envisaged by the commercial district project, but this would involve a significant change to the traditional bricks-and-mortar shop model, which was fully re-established in the post-emergency period.

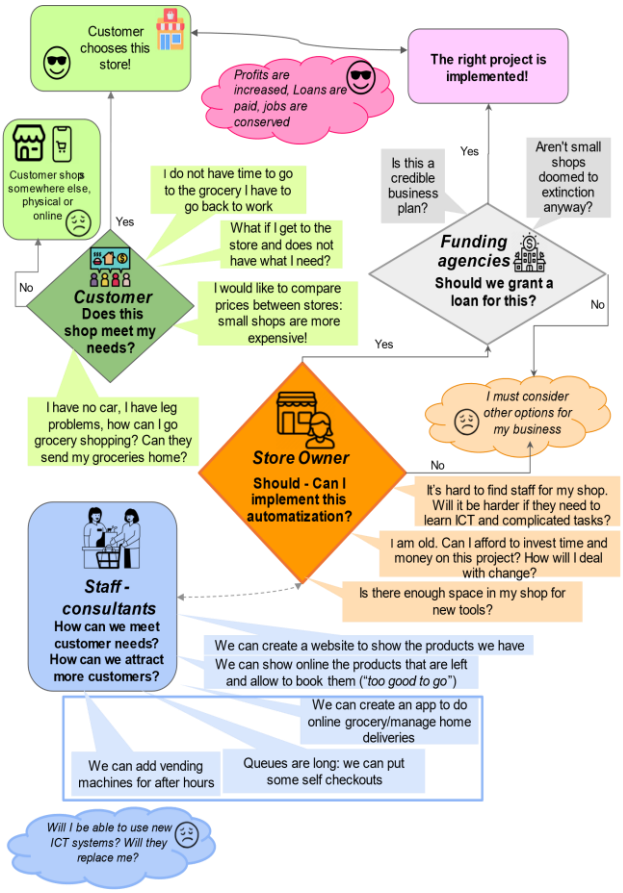

Figure 1: Rich picture of grocery store problem situation

It is precisely these differences that Step 3 in SSM, the construction of a targeted activity model, helps to highlight. The first task of Step 3 is to write the Root Definition (RD), a statement used to describe from a singular point of view the purposeful activity or transformation (T) process: the core of the represented HAS is an input undergoing a transformation process that produces an output. Inputs and outputs are not necessarily material: in a service offered

to people, the people themselves are the object of transformation.

Table 2 shows the root definition for a traditional bricks-and-mortar supermarket and a still conventional supermarket that also provides home delivery. It can be seen that the importance of the supermarket building and the transport service is different in the two definitions. According to SSM, the root definition must be tested against a checklist called CATWOE to prove its validity. Besides transformation T, the other elements of the CATWOE mnemonic are:

-The Customers (C), i.e. the beneficiaries or victims of the transformation;

- The Actors (A), i.e. the people who carry out the transformation activities;

- The Weltanschauung (W), that is the unquestioned worldview that makes a particular HAS a meaningful one to consider;

- The Owners (O), who stand out among the actors because they have the power to stop or change the proposed activity;

- The Environment (E), that is, what is considered to be outside the system boundaries. It cannot be controlled by the owner of the system, but it affects the degrees of freedom within the system by providing regulations, money flows and so on. In turn, the environment is also affected by the outputs of the HAS, e.g. it receives waste or intangible benefits or disadvantages.

Table 2: Root definition structuring

	Root definitions
Brick-and-mortar store	A privately owned system that enables the owners to make a profit by managing goods and information flows while buying, storing and partly processing produce, groceries and other toiletries to make them available for local customers in a building where they choose, buy and take home.
Brick-and-mortar store plus home delivery	A privately owned system that enables the owners to make a profit by managing goods and information flows while buying, storing and partly processing produce, groceries and other toiletries to make them available either for local customers to choose and buy them in an accessible building and take home, or for local customers to order and receive them to their homes or place of business.

Table 3 presents the CATWOE analysis for the first construct of the root definition, which is the one we are assuming as system description for a conventional brick and mortar grocery store in the following.

The CATWOE analysis of the system helps to highlight that the main transformation, which takes place against payment of a price, is to satisfy the needs of the customers, who are essentially domestic and wish to have food available in their homes. Transportation of people and goods (to and from customers' homes, to and from the shop) is part of the environment and not part of the system in a traditional grocery store. The worldview is essentially that the objective is the generation of profits, which also justifies private funding institutions in maintaining or innovating the system to keep it that way, while the municipality (which provides services and constraints, e.g. town planning, and receives taxes) or even the local citizens as a community are part of the environment: the social influence of the activity is not considered.

Table 3: CATWOE Analysis

	Description
C	Customers living in the surroundings of the shop needing produce, grocery and other toiletries
A	Employees and collaborators of the shop, neighbours, suppliers of goods, space and technologies, franchisor
T	Households in need of groceries become households with groceries
W	A grocery store is an individual business which needs to make profits. Making a room accessible to customers, handling goods but also information flows are the main tasks to achieve the desired transformation
O	Shop owner, in part funding institutions
E	Market prices and conditions, transport of goods from and to the shop, municipality, other businesses in the area

Steps 1 to 4 are essentially back-office steps, while steps 5 to 7 take place in the presence of the customer and allow the building of a relationship and the collection of information useful for estimating demand; they are in fact linked to step 1.

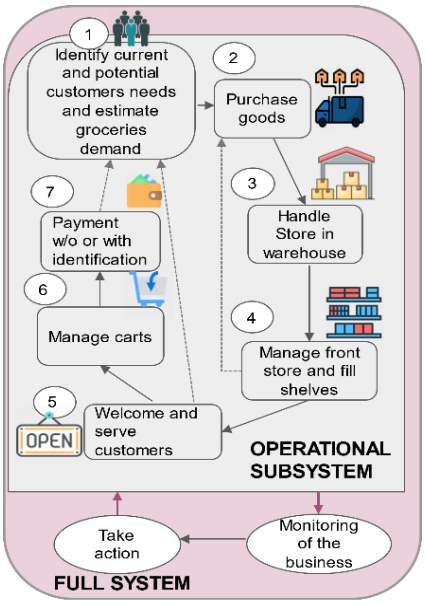

Figure 2: Conceptual model of brick-and-mortar store

Table 4 compares the conceptual model with the real world (Step 5 of the SSM) by verifying in the field how the identified steps are currently implemented. Table 5 instead implements Step 6 of the methodology, i.e. "Define changes that are desirable and feasible".

Table 4: Breakdown of conceptual model for current store

STEPS	CURRENT STORE PRACTICES
1 Demand estimation	Guts feelings. Store owners gather some verbal information on customer preferences. Fidelity cards enable the franchisor to associate customer profiles with purchase preferences.
2 Purchases	On a daily, weekly or monthly basis (depending on product categories) the store owners check the goods that are present in the store and make orders to the suppliers for replenishment. Franchisor's instructions are followed for specific products (e.g. special offers)
3 Warehouse	Goods arrive in trucks and are unloaded by the two owners. For big deliveries of non-perishable items (once every month) an on-call voucher system is used to get additional help. The staff checks pallets manually and places them in a small warehouse next to the store.
4 Shelves	Depalletization is performed in the front store to start filling shelves. Waste removal and store cleaning are also performed. The labelling of the product prices on shelves is done manually using the printed labels with the updated prices sent by the franchisor.
5 Serving customers	The owners welcome customers and perform weighing, portioning and packaging products in the fresh department. Personal acquaintance allows to offer a customised experience that generates a sense of belonging. During the Covid-19 emergency, long-standing customers placed orders for home deliveries via Whatsapp.
6 Carts	Some trolleys and baskets are available to customers, who reposition them at the till after payment. Fruit and vegetables are picked by customers in self-service mode in a department equipped with electronic scales. Home deliveries used to be delivered by shop staff.
7 Check-out	The payment is made at the computerised till, attended by one of the owners. The accountancy is done daily using a PC.

The 4.0 technologies presented in Table 1 are examined and office and process automation technologies already present in the shop are matched with the operational steps identified in the conceptual model. The simplest and most immediately useful change would be automatic pricing with electronic labels. Automatic systems for unloading and checking orders would be desirable, but the physical space and the variety and number of suppliers that would need to work together are a barrier. Owners are willing to consider participating in online sites and communication channels to provide the home delivery service that customers still want after Covid-19, but owners are currently unable to provide. This would also have a social value for the elderly in a small community.

Table 5: Proposed implementation of Retail 4.0 enabling technologies

STEPS	IMPLEMENTATION OF RETAIL 4.0
1 Demand estimation	Edge computing could enable BDA, integrating personal knowledge of customers by shop owners to improve sales predictions.
2 Purchases	Current sales monitoring system allows to place orders to suppliers and to return unsold products. Horizontal and vertical integration of systems could be enhanced to track products in store and to place orders.
3 Warehouse	Automation of depalletization and of order delivery check is desirable. RFID, together with Cloud Computing could reduce times and improve agility compared to barcodes.
4 Shelves	Automatic update of sales price via digital pricing screen system integrated with automatic sales is a feasible option. TRL of robotic shelf filling is still too low and costs too high. Autonomous robotic cleaning is an option.
5 Serving customers	Moving toward omnichannel, by implementing Cloud computing, is an option to better manage home deliveries, to offer new services and to attract, profile, and retain customers.
6 Carts	Automatic shop navigation apps and push notifications on Whatsapp can replace paper flyers and facilitate customers moving in the store.
7 Check-out	Self-checkout for quick purchases could reduce queues at peak times. Payment systems for home deliveries should be implemented.

6. Conclusions

To answer the first research question RQ1 on the definition of Retail 4.0 and enabling technologies for food, this research highlighted, as its main contribution to theoretical knowledge, that the current understanding of Retail 4.0 for grocery stores goes beyond pure omni-channel retailing to include, for example, self-service kiosks and all possibilities of automation in food retailing. Retail 4.0 can be defined as the variety of transformations of traditional forms of commerce (in this case, food) made possible by 4.0 technologies. Despite the fundamental role of IoT, it remains relatively under-researched in the grocery sector.

VR is a challenging issue in the touch-sensitive food sector, and some business practices linked to AM are more likely to be embraced by the food sector than actual 3D printing. Nonetheless, all pillars of Industry 4.0, including robotics and Cybersecurity, should be considered within the Retail 4.0 business model framework. Regarding RQ2, a practical outcome of this research is to demonstrate how SSM can be used to map the necessary and qualitatively feasible changes in an existing small grocery store to address a problematic operational situation by implementing Retail 4.0 tools. SSM is therefore a useful method to frame the content of the problem situation, focusing on identifying the core transformation and functions performed at the store, how they are currently performed and how they might change in a Retail 4.0 perspective. Thus, the answer to RQ2 can justifiably be "with the support of SSM". The focus here has been on content, i.e. what Checkland and Winter (2006) call SSMc, the variant of the methodology that focuses on the content of the situation perceived as problematic. A complementary step can be to re-apply SSM by orienting it towards the process of change, i.e. what the same authors refer to as SSMp, which is dedicated to the "intellectual process of system intervention" and the steps to be taken to bring about the identified changes.

References

Ayotunde O., Rahman M., Islam N., Hasan R. (2021), Smart mirror fashion technology for the retail chain transformation, *Technological Forecasting and Social Change*, 173, 121118

Bradlow E.T., Gangwar M., Kopalle P., Voleti S., The Role of Big Data and Predictive Analytics in Retailing, *Journal of Retailing*, 93(1), 2017, 79-95

Bruni R., Piccarozzi M. (2022), Industry 4.0 enablers in retailing: a literature review, *International Journal of Retail & Distribution Management ; 50(7):816-838, 2022.*

Checkland, P. (1981) *Systems Thinking, Systems Practice*. John Wiley & Sons, New York

Checkland, P., & M. Winter. (2006). Process and Content: Two Ways of Using SSM. *JORS*, 57(12), 1435–1441

Federdistribuzione (2021) https://www.federdistribuzione.it/app/uploads/2021/09/Mappa-del-sistema-distributivo_2020.pdf

Firoz, Abdulqader & Ratnayaka, Ms. (2020). ShopLister -A Grocery List Management Application. 10.1109/ICIP48927.2020.9367367.

Gawankar, S. A.; Gunasekaran, A.; Kamble, S (2020). A study on investments in the big data-driven supply chain, performance measures and organisational performance in Indian retail 4.0 context. *International Journal of Production Research*, 58:5, p. 1574–1593

Lagorio A., Pinto R. (2021), Food and grocery retail logistics issues: A systematic literature review, *Research in Transportation Economics*, Volume 87, 2021, 100841

Lanz M., Hartmann C., Egan P, Siegrist M. (2024), Consumer acceptance of cultured, plant-based, 3D-printed meat and fish alternatives, *Future Foods*, 9, 100297

Lee C.H.K., (2017) A GA-based optimisation model for Big Data Analytics supporting anticipatory shipping in Retail 4.0, *International Journal of Production Resea*rch, 55:2, 593-605

Loh L.H., Umi K.R., Lee T.C., Seah C.S, Loh Y.X. (2022), Revolution of Retail Industry: From Perspective of Retail 1.0 to 4.0, *Procedia Computer Science*, 200,pp. 1615-1625

Maltese I., Le Pira M., Marcucci E., Gatta V, Evangelinos Ch., (2021) Grocery or @grocery: A stated preference investigation in Rome and Milan, *Research in Transportation Economics*, 87,101096

Manuelli M.T., (2024) https://www.ilsole24ore.com/art/i-negozi-alimentari-cambiano-volto-sono-sempre-piu-specializzati-e-digitali-AFxXLrYC

Marcucci E., Gatta V., de Oliveira Leite Nascimento C., Aziz S., Ayagah P., Montero T. (2024) The environmental impact of buying groceries online/offline pre and during Covid-19. Any changes?, *Transport Policy*, Volume 149, 2024,pp. 222-233

Mariani M., Borghi M., Industry 4.0: A bibliometric review of its managerial intellectual structure and potential evolution in the service industries, *Technological Forecasting and Social Change*, 149, 2019, 119752.

McKinsey, The State of Grocery Retail Europe, 2024 https://www.mckinsey.com/industries/retail/our-insights/state-of-grocery-europe-2024-signs-of-hope

Merritt, K., & Zhao, S. (2021). An innovative reflection based on critically applying ux design principles. *Journal of Open Innovation: Technology, Market, and Complexity*, 7(2), 129.

Payaro A., Papa A.R. (2021), Online Grocery Brick and Mortar Retailers. State of the Art in Italy, But Is It a Profitable Strategy? *Management Studies*, 9(1), pp.14-23

Pfeiffer, S. The Vision of "Industrie 4.0" in the Making—a Case of Future Told, Tamed, and Traded. *Nanoethics* 11, 107–121 (2017).

Sakrabani, P., Teoh, A.P. and Amran, A. (2019), "Strategic impact of retail 4.0 on retailers' performance in Malaysia", *Strategic Direction*, Vol. 35 No. 11, pp. 1-3

Sewchurran, K. Petkov, D. (2007). A Systemic Framework for Business Process Modeling Combining Soft Systems Methodology and UML. *IRMJ*. 20. 46-62.

Tebaldi, L. Reverberi, D., Romagnoli, G. Bottani, E., Rizzi A.,. (2023). RFID technology in Retail 4.0: state-of-the-art in the Fast-Moving Consumer Goods field. *International Journal of RF Technologies*. 13. 1-29. 10.3233/RFT-221505.

Villani, L., Natale, C., Beetz, M., Siciliano, B. (2022) *Robotics for Intralogistics in Supermarkets and Retail Stores*. Springer Tracts in Advanced Robotics, vol 148

Winter M. (2006). "Problem structuring in project management: an application of soft systems methodology (SSM)," *JORS*, 57(7), pp. 802-812