Grocery retail supply chain planning and control: Impact of consumer trends and enabling technologies

Logan R. Vallandingham[1(✉)], Quan Yu[2], Nakul Sharma, Jo W. Strandhagen[2] and Jan Ola Strandhagen[2]

[1]Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Trondheim, Norway (email: logan.r.vallandingham@ntnu.no)

[2]Department of Mechanical and Industrial Engineering, Norwegian University of Science and Technology, Trondheim, Norway

Abstract: Grocery retail supply chains have in the past decades increased their efficiency which has led to cost-focused supply chains that are able to deliver high volumes of products at low prices. There is still continual pressure on price, although consumer trends are changing putting pressure on providing higher quality, availability, innovativeness and environmental performance. These trends are forcing grocery retailers to rethink their supply chains. To meet these increased requirements, enabling technologies provide opportunities to modify and improve the planning and control of grocery retail in order to effectively supply the market with grocery products. This paper investigates the consumer trends and enabling technologies, and conceptualizes how certain aspects of planning and control of grocery retail supply chains will differ in the future.

Keywords: Grocery retail, planning and control, supply chain management, enabling technology

1. INTRODUCTION

Grocery retail supply chains are important for the Norwegian economy, with a revenue of approximately 29 billion Euro in Norway in 2016 (Kjuus, Helland, & Vee Moen, 2017). Grocery retail supply chains have traditionally focused on reducing costs, in order to be efficient in providing high volumes of products at low prices to consumers (Dreyer, Swahn, Kiil, Strandhagen, & Romsdal, 2015). However, the consumer demands are changing which require tremendous efforts in balancing quality and availability of the products against the cost (Willems, Smolders, Brengman, Luyten, & Schöning, 2016). Some consumer segments focus on cost, whereas others have increasing requirements for convenience, customization or quality. At the same time, enabling technologies, such as Radio-Frequency Identification (RFID), augmented reality, big data and machine learning, are being developed (Hofmann, 2017; Nukala et al., 2016), which allows grocery retailers to better meet the changing consumer demands. This will require retailers to change the planning and control processes within their supply chains.

Grocery retail planning involves many actors and planning levels, and the consumer trends will put requirements on grocery retail supply chains to further integrate actors and change and improve current planning practices by using enabling technologies. Therefore, the purpose of the paper is explore how grocery retail supply chains will have to operate in the future, by conceptualizing the impact of consumer trends and enabling technologies on the planning and control of grocery retail supply chains.

The next section provides a brief overview of the main consumer trends within the grocery retail sector. Section 3 reviews enabling technologies and different application areas within supply chain operations. Section 4 connects the enabling technologies to supply chain planning and control, and the ability to meet consumer demands. Finally, in Section 5 there is a discussion of the feasibility of the proposed changes to planning and control within grocery retail, as well as future research topic suggestions.

2. CONSUMER TRENDS IN GROCERY RETAIL

The consumers' needs and behaviors in retail supply chains are constantly evolving (Nielsen Holdings PLC, 2016; Stolze, Mollenkopf, & Flint, 2016). The trends in these behaviors and needs gives insight as to how retail supply chains have to adapt to meet the market requirements. In discussing the needs from a supply chain perspective, we can look at the trends from a performance objectives perspective. Typical performance objectives include cost, quality, availability, features/innovativeness and environmental performance (Beckman & Rosenfield, 2008).

Many western grocery markets are showing trends within the cost focus of consumers (Fernie & Sparks, 2014). Consumers have greater access to information and ability to compare the prices between different retailers. In addition, sales and promotional activities influence decisions of shoppers (Nielsen Holdings PLC, 2016). This puts pressure on retail supply chains to keep costs down, yet still deliver a high value for money. However, consumers are increasingly willing to spend a bit more money on products, if the perceived benefits of the product are greater than the price.

Customers desire quality food products, such as artisan or handcrafted products (Dreyer, Strandhagen, Hvolby, Romsdal, & Alfnes, 2016). This can be considered food that is minimally processed, deemed healthy, and in contrast to

"industrialized" food. Quality produce is especially of importance for retail shoppers, with "all-natural" products becoming desired (Nielsen Holdings PLC, 2016). In addition, traceability of products from raw material, processing and sales is a key aspect that consumers deem important.

The availability of products, including a large variety and high degree of personalization, are important for meeting consumer demand (Nielsen Holdings PLC, 2016). In addition, consumers are requiring a higher degree of convenience as well as faster delivery times. This leads to consumer utilizing multiple channels to obtain the products they desire, such as at traditional "bricks-and-mortar" stores as well as online (Kjuus et al., 2017). Stores are now also becoming increasingly differentiated to meet specific consumer needs, and can include large supermarkets and small-format stores among others. Online food options desired are both simple grocery shopping, as well as pre-packaged meal options.

The standard products of last century's retail supply chains are boring to consumers. Now, innovation and features are important both in the product (Walton, Petrovici, & Fearne, 2017) and shopping experience (Nielsen Holdings PLC, 2016). The shopping experience can include using technologies, like mobile phones, to make shopping easier, faster and more interesting.

Sustainability issues, especially relating to environment and social are in the spotlight for grocery retail (Dias, Junior, & Martinez, 2016). Consumers are aware of problems happening in their local community as well as in the entire globe, relating to scarcity of resources, deforestation, global warming, pollution, and so on. These issues affect the choices and needs of consumers. Consumers try to limit the amount of waste, pollution, and overall impact on the environment.

Future consumers will be more demanding of products and services from the grocery retail supply chains, which will require a significant restructuring in the planning and control processes to be able to meet expectations.

3. ENABLING TECHNOLOGIES

This section provides an overview of the main enabling technologies in supply chains, as well as some potential applications in grocery retailing.

3.1 Enabling technologies in supply chains

Enabling technologies include many different types of technologies. These technologies with different maturity levels provide potential applications in supply chains. Some of the technologies are explained below. It is important to note that some of the technologies are interrelated and/or support each other.

Robotics and automation
Robotics and automation are used to develop machines and equipment that can achieve high efficiency with minimal or reduced human intervention. Robotics and automated machines have been widely used in warehousing to automate the material flow from inbound logistics to outbound

logistics. Mobile robots with low cost sensors (Stoyanov et al., 2016) and in-store self-navigated robots are new topics in retail scenarios (Bertacchini, Bilotta, & Pantano, 2017).

Computer vision
Computer vision is an interdisciplinary field that enables computers to gain high-level understanding from digital images or videos. Computer vision is commonly applied to robots and automation systems as a sensor system for data collection like "eyes" of the machines (Stoyanov et al., 2016).

Augmented reality
Augmented reality (AR) is a live, direct or indirect view of a physical, real-world environment whose elements are augmented by computer-generated sensory input. It is related to a more general concept called computer-mediated reality, in which a view of reality is modified by a computer. Augmented reality enhances one's current perception of reality, and are typically performed in real time. (Rese, Baier, Geyer-Schulz, & Schreiber, 2017).

RFID
Radio-frequency identification (RFID) is a key technology that uses radio-frequency waves to transfer information between tagged objects and readers without line of sight, providing a means of automatic identification. During the last two decades, affordable cost of RFID tags and standardization of the technology has allowed for its application in low-priced goods environment (Bardaki, Kourouthanassis, & Pramatari, 2012).

Internet of Things (IoT)
The Internet of things (IoT) is the inter-networking of physical devices, vehicles, buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to collect and exchange data. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention (Papert & Pflaum, 2017).

Cyber-physical systems (CPS)
CPS is defined as transformative technologies for managing interconnected systems between its physical assets and computational. It consists of two main functional components: (1) the advanced connectivity that ensures real-time data acquisition from the physical world and information feedback from the cyber space; and (2) intelligent data management, analytics and computational capability that constructs the cyber space. (J. Lee, Bagheri, & Kao, 2015)

Machine Learning
Machine learning aims at enabling the computer to learn without being explicitly programmed. It enables automated or assisted decision making according to data collected by sensor systems. It helps with local decision making e.g. path

planning for AGVs (Mühlbacher, Gspandl, Reip, & Steinbauer, 2017) and large-scale global decision making e.g. resource allocation.

Big data analytics

Big data is a term for data sets that are so large or complex that traditional data processing application software is inadequate to deal with them. It often refers simply to the use of predictive analytics, user behaviour analytics, or certain other advanced data analytics methods that extract value from data. Big data analysis commonly works in scenarios for strategic or tactical decision making (C. Lee, 2017). Challenges include capture, storage, analysis, data curation, search, sharing, transfer, visualization, querying, updating, and information privacy.

3.2 Potential applications of enabling technologies in grocery retail supply chains

This section will describe how the different technologies can and have been tested and applied in a retail setting.

Example 1: Quality control of perishables

Nukala et al. (2016) argue in favour of using IoT architecture to measure the freshness of the perishable food products. Integration of RFID and wireless temperature sensor networks can be used to monitor real-time temperature condition and subsequently, assure the quality of perishables (Aung, Liang, Chang, Makatsoris, & Chang, 2011). Such applications are important in predicting and prolonging the shelf life of the perishable products. Such types of applications ensure high quality and safety for foods which are deemed as one of the major concern by consumers.

Example 2: Dynamic pricing based of perishables

Dynamic pricing is currently implemented in hotels, airline ticketing, power distribution & entertainment sector. This is also possible in grocery retail by implementing a smart RFID price tag by identifying food quality features. Dynamic pricing of the perishable products takes the shelf-life dynamics during the production, transport, distribution and retail phase (Nukala et al., 2016). These applications allow for better judgement for shelf-life of products and hence, the prices can be adjusted based on the quality of the product. This could attract customers who prefer to pay the price for the exact quality of the product.

Example 3: Smart shopping carts in stores

Smart carts can be equipped with Bluetooth radios/ sensors and enables tracking in stores. Localisation in a smart retail environment display promotions and sales when the customer is moving around the aisle. It also helps the store manager to eliminate checkout lines (Higginbotham, 2015). Having such types of innovative features improve customer's shopping experience. Promotions displayed through these carts may encourage price-sensitive customers to shop.

Example 4: Vision picking using augmented reality

DHL rolled out its augmented reality program providing "Vision Picking" solution in warehouse operations, establishing a new standard in order picking. Pickers are equipped with advanced smart glasses which provide visual displays of order picking instructions along with information on where items are located and where they need to be placed on a cart, freeing pickers' hands of paper instructions and allowing them to work comfortably at faster pace and with reduced errors (DHL, 2016). Effective activities carried out though such technology have the potential to impact cost, quality, availability and delivery of the product to the customers.

Example 5: Automation in smart warehouse

Through IoT and RFID, mobile robots receive optimized route through the smart warehouse and manage the tasks of inbound/outbound logistics, order picking and packing without human intervention (Rüßmann et al., 2015). Automation in warehouse operations improve cost efficiency, especially in the countries where labour cost is high.

Example 6: Real-time inventory management

Smart and real-time inventory management utilize IoT and big data analytics. It includes electronically tagging products to enable tracking and identifying them while they are at manufacturer, supplier, distributor or retailer and move towards next consumer in the value chains. Smart inventory management also includes optimizing product inventory operations to reduce labour cost and time. This involves either automation via robotic transportation of products to and from storage to fill customer orders and at the shelf, or optimization of manual inventory tasks via smartphones or other IoT tracking devices that monitor and direct manual picking and storing activities (Georgakopoulos, Jayaraman, Fazia, Villari, & Ranjan, 2016).

Example 7: Advanced forecasting

Big data analytics along with machine learning can find predictable component of demands and can generate more accurate forecasts. It enables accurate capacity planning across the supply chain and in combination with IoT based architecture, it forms the foundation for collaborative planning and forecasting at various hierarchical levels by allowing access to real-time sales and inventory information (Hofmann, 2017; Wang, Gunasekaran, Ngai, & Papadopoulos, 2016). Forecast with less error helps increase availability.

Example 8: Last mile delivery using drones

Amazon is already delivering products through drones within 30 minutes of online ordering. Bricks-and-mortar stores will also be able to provide same-day delivery. Drones could also be used to deliver products to people who do not have access to modern road infrastructure (Fawcett & Waller, 2014). For the customers who do not prefer to go to stores for buying groceries, drones could be a potential solution. Customers would place orders online and stores will be able to deliver fresh product at their doorsteps.

Example 9: Customer profiling

Companies can track customer behaviour using big data at a real-time level. Such customer profiling can be used to

develop new products, manage product portfolios, redesign product displays, target promotions, and optimize pricing (Fawcett & Waller, 2014). Customer profiling helps stores to cater to individual demands of different customers. Individual promotions can be carried out based on consumption pattern of a customer.

Example 10: Automated replenishment of goods
Retailers can use combination of technologies such as RFID, CPS and IoT for automated replenishment of goods at the stores based on real time sales information, inventory levels and environmental factors. Replenishment request can be sent to suppliers automatically, and suppliers will be able to provide order status information (Kiil, Dreyer, Hvolby, & Chabada, 2018). Automated replenishment allows for stores to reduce food waste and also manage on-shelf availability of the products with different shelf-life. This ensures the availability of fresh food on the shelf for consumers.

4. FUTURE GROCERY RETAIL PLANNING AND CONTROL

This section will describe planning and control in a traditional grocery retail supply chain. A simplified framework is shown, and used to discuss the impact of technology and consumer trends on planning and control in future grocery retail.

4.1 Grocery retail supply chain planning and control

Grocery retail planning and control encompasses many different actors and processes along a supply chain, as well as many different time horizons. The literature covers many planning topics within grocery retail supply chains, which have been summarized in a holistic framework by Hübner, Kuhn, and Sternbeck (2013). This planning framework classifies planning tasks according to stages along a supply chain and planning horizons. The stages include the flow of goods through procurement, production, distribution and sales. The planning tasks can be grouped into long-, mid- and short-term tasks.

Long term planning illustrates the comprehensive character of strategic planning. It designs the overall configuration and requires long-term investments in the infrastructure such as procurement logistics, warehouse design, distribution planning and outlet planning.

Mid-term planning utilises the configuration design of the strategic planning and deals with the coordination and planning of aggregated operational units approximately 6-12 months in advance. It covers master coordination, product segmentation, mid-term planning for inbound, production, distribution and in-store planning for the sales area.

Finally, short-term planning specifies activities before execution. Action plans on hourly to weekly basis for action requirements and jobs are developed during short-term planning. It includes planning and scheduling for order, production, transport and in-store fulfilment.
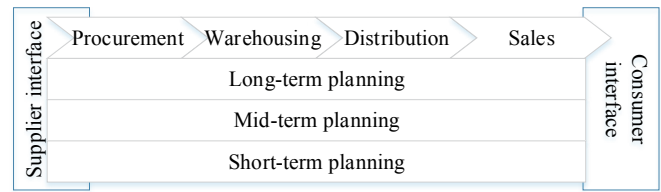

Fig. 1: Grocery retail supply chain planning and control framework, adapted from (Hübner et al., 2013)

4.2 Impact of technology and consumer trends

Grocery retail planning and control is directly affected by consumer trends and enabling technologies. Consumers are demanding faster, cheaper, personalized, more innovative and sustainable products and services from grocery retail supply chains. In order to meet these demands, enabling technologies and changing of the grocery retail planning and control will contribute to better fulfilling the market desires. We discuss the effects of technology in planning and control of particular activities within each domain according to the framework by Hübner et al. (2013), namely procurement, warehousing, distribution and sales.

Procurement: Firstly, technologies will affect the sourcing strategy. It will be easier to keep track of the supplier performance based on various parameters such as cost, quality, availability, innovativeness and environmental impact. Big data analytics will be able to select the best supplier according to their historical and expected performance, as well as market information. Secondly, product segmentation and allocation related to order patterns will be much more effective. Right product in right amount will be at right location at right time. Thirdly, transparency made possible through technology will manage supplier orders, and enable real-time decision support related to shipments. Use of technologies will enable suppliers to have access to Point of Sale (POS) data as well as inventory status in the value chain, which will allow for better promotion planning.

Warehousing: At the strategic level, planning for number, location, type and function of warehouses will be affected by increased decision-support provided by technologies. At an operational level, IoT, CPS, RFID and AR provide visualization of indoor positioning of all the products, machines, humans and hence, enable analysis of utilization of equipment and on-going tasks. Based on this, for example, mobile robots and humans can receive optimized route and other instructions for inbound and outbound order picking and thus, improve product handling. Furthermore, capacity planning can be optimized in order to accurately plan requirements for personnel, machines and number of shifts based on utilization and efficiency data.

Distribution: Technologies discussed in the previous section have the potential of overhauling distribution structure by optimizing frequency of deliveries, route plans and amount to be delivered. Quality of the perishables products during the

distribution phase can be monitored by integrating RFID and wireless sensor networks. The administrative burden on inbound logistics will be reduced, as automated inbound logistics will allow for seamless information flow regarding incoming goods.

Sales: At retails stores, subsystems and processes can be integrated in a cohesive manner through CPS, IoT and RFID, giving rise to the possibility of automated shelf management and subsequently, unmanned stores where resources and entities interact with each other without human control. For example, IoT based architecture enables precision in On-shelf availability and eliminate the need of manual stock counting practices. Big data analytics and machine learning will allowing for effective assortment and promotion planning by combining historical data, footfall data and market related information. Using these technologies, it is possible to profile consumers based on their demand patterns and then, personalized advertisement and promotions can be created. In addition, at the strategic level, types and locations of the stores can be planned according to customer profiling, aggregated sales data and advanced forecasting.

	Procurement	Warehousing	Distribution	Sales
Long-term	**Strategic supplier selection** Decision support using supplier performance data, and market information to select the most appropriate suppliers, enabled by big data analytics and machine learning	**Strategic warehouse analysis** Big data analytics of previous and current performance of warehouses, product flow and forecasted demand patterns to allocate activities, functions and locations of warehouses.	**Distribution structure** Big data analytics of costs and demand patterns to optimize the degree of in-house and outsourced distribution services, and corresponding structure.	**Retail store planning** Big data analytics using customer profiling, aggregated sales data, and forecasts to determine appropriate number, location and types of stores in retail network.
Mid-term	**Product allocation** ICT integration combined with advanced forecasting using POS data and inventory level information for improved planning of which stores and warehouses should receive which products.	**Warehouse management** Product flow, layout and storage area planning within the warehouses, with rapid reconfiguration of AGVs and storage systems through CPS.	**Delivery planning** Optimized and dynamic delivery planning of frequency, amount and routing, with real-time status of deliveries using IoT.	**Assortment and promotion planning** Dynamically plan assortment using footfall data, inventory levels, POS data, and market data. Promotion planning using customer profiling and individualized promotions.
Short-term	**Supplier order management** Optimized dispatch of orders based on forecasts and inventory levels, with real-time tracking of shipments from supplier.	**Product handling** Automated warehouse operations using mobile robots with route optimization within the warehouse. Augmented reality for efficient picking of goods by workers.	**Automated outbound and inbound logistics** Using RFID and IoT, an automation of the outbound and inbound logistics to ensure high efficiency and accuracy of product handling.	**Instore operations** RFID, IoT, and vision technology enable automated shelf management for instore personnel.

Fig. 2: Concepts of future grocery retail supply chain planning and control

5. DISCUSSION AND CONCLUSION

This paper has conceptualized the planning and control for future grocery retail supply chains. With a basis in the consumer trends, enabling technologies allow for improved performance in regards to the typical performance objectives (cost, quality, features/innovativeness, availability and environmental). Future grocery retail supply chains will have end-to-end visibility with real-time access to supply chain insights, leading to improved agility and efficiency. The benefits from technologies include optimization, automation, reduced waste, as well as monitoring possibilities along the supply chain for full transparency. It makes supply chain planning more dynamic, flexible and holistic. Vital information becomes available at a much higher frequency, as actors can cooperate and share insights across the supply chain. This allows shortening of planning cycles and planning with higher levels of detail, leading to more effective planning and control in grocery retail supply chain. Such technologies have the potential to enhance the decision support and provide more automated decision-making.

The concepts for future grocery retail supply chain planning and control (see Fig. 2) are not necessarily applicable in all situations or for all products. Certain technologies require further development before the described situations can be feasible, due to both costs of technologies, cost of implementation and functionalities of the technologies. For example, using RFID for automatic inbound goods registration has potential, although it might require one or more other technologies to verify accuracy of goods registration. Analysis of large amounts of data requires expertise, high computation power and close collaboration between supply chain managers and data analysts, such that the results can be meaningful in the supply chain environment. This shows a host of challenges both in terms of technological, organizational, and trust between food suppliers and grocery retailers. Nevertheless, many of the concepts are feasible to a certain degree already today.

This paper has showed how enabling technologies can be applied in grocery retail supply chain planning and control in order to better meet consumer demands. The concepts are shown in relation to long-term, medium-term and short-term planning and control levels, to give context of the type of requirements necessary for the outcomes.

Grocery retail supply chains have many actors involved, all with the goal of supplying food products to end consumers. New enabling technologies allow grocery retail supply chains to meet consumer demands more effectively and efficiently,

though there is still large potential in implementation. Future research should therefore investigate in which situations certain technologies or groups of technologies should be used to enhance planning and control of grocery retail supply chains, as well as the quantifiable impact they have in terms of the performance objectives.

REFERENCES

Aung, M. M., Liang, F. W., Chang, Y. S., Makatsoris, C., & Chang, J. (2011). RFID-and WSN-based intelligent cold chain management. *International Journal of Manufacturing Research, 6*(2), 91-109.

Bardaki, C., Kourouthanassis, P., & Pramatari, K. (2012). Deploying RFID-enabled services in the retail supply chain: Lessons learned toward the internet of things. *Information Systems Management, 29*(3), 233-245.

Beckman, S. L., & Rosenfield, D. B. (2008). *Operations strategy: competing in the 21st century*: McGraw-Hill/Irwin.

Bertacchini, F., Bilotta, E., & Pantano, P. (2017). Shopping with a robotic companion. *Computers in Human Behavior*.

DHL. (2016). DHL ROLLS OUT GLOBAL AUGMENTED REALITY PROGRAM. Retrieved from http://www.delivered.dhl.com/en/articles/2016/06/dhl-rolls-out-global-augmented-reality-program.html

Dias, K. T. S., Junior, S. S. B., & Martinez, M. P. (2016). Reverse Logistics Analysis and Results Applied to the Grocery Retail. *International Business Management, 10*(18), 4403-4410.

Dreyer, H. C., Strandhagen, J. O., Hvolby, H.-H., Romsdal, A., & Alfnes, E. (2016). Supply chain strategies for speciality foods: A Norwegian case study. *Production Planning & Control, 27*(11), 878-893.

Dreyer, H. C., Swahn, N., Kiil, K., Strandhagen, J. O., & Romsdal, A. (2015). *The Responsiveness of Food Retail Supply Chains: A Norwegian Case Study.* Paper presented at the IFIP International Conference on Advances in Production Management Systems.

Fawcett, S. E., & Waller, M. A. (2014). Supply Chain Game Changers—Mega, Nano, and Virtual Trends—And Forces That Impede Supply Chain Design (i.e., Building a Winning Team). *Journal of Business Logistics, 35*(3), 157-164. doi:10.1111/jbl.12058

Fernie, J., & Sparks, L. (2014). *Logistics and retail management: emerging issues and new challenges in the retail supply chain*: Kogan page publishers.

Georgakopoulos, D., Jayaraman, P. P., Fazia, M., Villari, M., & Ranjan, R. (2016). Internet of Things and edge cloud computing roadmap for manufacturing. *IEEE Cloud Computing, 3*(4), 66-73.

Higginbotham, S. (2015). Grocery shopping might be less painful with this smart cart. Retrieved from https://gigaom.com/2015/02/11/grocery-shopping-might-be-less-painful-with-this-smart-cart/

Hofmann, E. (2017). Big data and supply chain decisions: the impact of volume, variety and velocity properties on the bullwhip effect. *International Journal of Production Research, 55*(17), 5108-5126.

Hübner, A. H., Kuhn, H., & Sternbeck, M. G. (2013). Demand and supply chain planning in grocery retail: an operations planning framework. *International Journal of Retail & Distribution Management, 41*(7), 512-530. doi:doi:10.1108/IJRDM-05-2013-0104

Kiil, K., Dreyer, H. C., Hvolby, H.-H., & Chabada, L. (2018). Sustainable food supply chains: the impact of automatic replenishment in grocery stores. *Production Planning & Control, 29*(2), 106-116. doi:10.1080/09537287.2017.1384077

Kjuus, J., Helland, S., & Vee Moen, K. (2017). *Dagligvarehandelen 2017*. Retrieved from https://www.virke.no/tjenester/rapporter-analyse/rapporter/dagligvarehandelen-2017/

Lee, C. (2017). A GA-based optimisation model for big data analytics supporting anticipatory shipping in Retail 4.0. *International Journal of Production Research, 55*(2), 593-605.

Lee, J., Bagheri, B., & Kao, H.-A. (2015). A cyber-physical systems architecture for industry 4.0-based manufacturing systems. *Manufacturing Letters, 3*, 18-23.

Mühlbacher, C., Gspandl, S., Reip, M., & Steinbauer, G. (2017). *Estimation of the Traversal Time for a Fleet of Industrial Transport Robots.* Paper presented at the International Conference on Robotics in Alpe-Adria Danube Region.

Nielsen Holdings PLC. (2016). *Think smaller for big growth: How to thrive in the new retail landscape*. Retrieved from http://www.nielsen.com/lb/en/insights/reports/2016/think-smaller-for-big-growth-how-to-thrive-in-the-new-retail-landscape.html

Nukala, R., Panduru, K., Shields, A., Riordan, D., Doody, P., & Walsh, J. (2016). *Internet of Things: A review from 'Farm to Fork'.* Paper presented at the Signals and Systems Conference (ISSC), 2016 27th Irish.

Papert, M., & Pflaum, A. (2017). Development of an Ecosystem Model for the Realization of Internet of Things (IoT) Services in Supply Chain Management. *Electronic Markets, 27*(2), 175-189.

Rese, A., Baier, D., Geyer-Schulz, A., & Schreiber, S. (2017). How augmented reality apps are accepted by consumers: A comparative analysis using scales and opinions. *Technological Forecasting and Social Change, 124*, 306-319.

Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. *Boston Consulting Group, 9*.

Stolze, H. J., Mollenkopf, D. A., & Flint, D. J. (2016). What is the Right Supply Chain for Your Shopper? Exploring the Shopper Service Ecosystem. *Journal of business logistics, 37*(2), 185-197.

Stoyanov, T., et al. (2016). No more heavy lifting: Robotic solutions to the container unloading problem. *IEEE Robotics & Automation Magazine, 23*(4), 94-106.

Walton, B., Petrovici, D., & Fearne, A. (2017). Factors Impacting the Success of new Product Development in the UK Grocery Retail Industry: An Empirical Examination of Product Innovation Performance. In *The Customer is NOT Always Right? Marketing Orientationsin a Dynamic Business World* (pp. 182-185): Springer.

Wang, G., Gunasekaran, A., Ngai, E. W., & Papadopoulos, T. (2016). Big data analytics in logistics and supply chain management: Certain investigations for research and applications. *International Journal of Production Economics, 176*, 98-110.

Willems, K., Smolders, A., Brengman, M., Luyten, K., & Schöning, J. (2016). The path-to-purchase is paved with digital opportunities: An inventory of shopper-oriented retail technologies. *Technological Forecasting and Social Change*.