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IoT-based framework for agile supply chain in FMCG indus-tries – a solution for (post-)pandemic times

Maria Schianchi[a1]

[a] *Department of economics, University of Rome, Italy*

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ABSTRACT

In recent decades, with the growth of sustainable development, supply chain agility has become very important as a strategy for competitiveness in the business environment, and supply chain stakeholders expect the role of digital developments and efficient tools in these developments in the supply chain to be considered. One of the most important transformational solutions in today's world is the Internet of Things (IoT). It can accelerate activity in the supply chain and create value in the organization. Due to environmental issues and the increasing speed of changes in customer needs in various industries, such as critical industries where agility has a high impact on people's health, these industries have undergone many changes with the emergence of innovation. Therefore, the whole supply chain path requires im-plementing strategies such as agile and green supply chain and achieving smartness. Thus, emerging technologies such as the Internet of Things play a significant role in the agility and greenness of the en-tire path of the supply chain. Given the importance of the FMCG industry and its impact on people's dai-ly lives, this qualitative study aims to provide a framework for agile supply chain sustainability in the FMCG industry and draw possible implications for a post-pandemic period. This framework embedding the IoT into agility in supply chains can effectively guide FMCG companies in using the Internet of Things to streamline the supply chain.

[1] **Corresponding author**
Email Address: mrschnch@gmail.com

1. Introduction

The global competition is made now between supply chains. Value-creation systems are more responsive, durable and reliable in the face of rapid market changes. Supply chain agility is a vital factor that affects the competitiveness of organizations (Al-Zabidi et al. 2021). The concept of agility was introduced following problems with managing multivariant production, complexity of logistics systems and growing environmental challenges and changes(Rimienė and Bernatonytė 2013). The root of agility is agile production, a strategy successfully accepted by manufacturers in many sectors (Nozari et al. 2019). Therefore, companies align with customers and operate efficiently to gain a competitive advantage in a changing business environment (Nozari et al. 2021b). Methods and ideas for improving supply chain performance are designed to coordinate supply and demand. Therefore, they simultaneously reduce costs and increase customer satisfaction (Nozari and Szmelter 2019). Companies face rapid technological change, growing uncertainty and dynamism in markets, reduced product life cycle and increasing market segmentation in the global environment. Therefore, the ability of the organization to adapt quickly to environmental changes and market conditions is essential for their survival (Nozari et al. 2021a). In the FMCG industry the shelf life and expiration date are not very long and these products are in the category of perishable market products, so it seems that supply chain agility for timely and appropriate distribution of goods in this industry is of particular importance. In the absence of agility and speed in timely delivery of goods, results such as low quality, lack of timely presence of the product in the market, etc., will eventually lead to lost sales and customer dissatisfaction. Therefore, it seems necessary to pay attention to supply chain agility and the main factors of its success in this industry (Ghahremani-Nahr et al. 2020). According to studies, the most important factors are the ability of organizations to provide appropriate and rapid response to diverse and unpredictable needs of customers and achieve a competitive advantage, organizational agility and internal processes, agility of suppliers and knowledge of the actual demand (Raut et al. 2021).

Since Internet of Things (IoT) technology is one of the most important sources of big data and provides the possibility of integration and speeding up data transfers in supply chain. Taking into consideration those aspects, the aim of the paper is to answer two research questions:

RQ1: Is it possible to use IoT in the supply chain to successfully introduce and manage agility?

RQ2: Is the IoT an appropriate solution for the post-COVID time?

The new generation of communication technologies, such as the Internet of Things, as well as the set of complementary technologies known as the 4th generation industry, can have a very high impact on the collection and sharing of information, which is one of the fundamental foundations of an agile supply chain. In addition to reducing operating costs, Internet of Things technology can provide better services to customers from the perspective of personalization, responsiveness, agility, innovation, and flexibility. Also, the use of this technology has led to better sharing of information, through which the company can gain a better understanding of the needs of its customers and through interaction and cooperation with them, have a better plan to respond to the needs and favorite services of the customers. According to an extensive survey of experts across a wide range of industries, IoT and related technologies such as automation, big data, artificial intelligence, and self-driving cars will have the greatest impact on global supply chain management. These technologies can be used together to create high operational efficiency, acquire data related to the digital supply chain, and improve supply chains from visibility, agility, and response to customer needs. In most industries, supply chain leaders tend to use IoT technology alongside related technologies such as big data, data analytics, machine learning, and deep learning to transform supply chains into a networked platform with the ability to create value and transform. For these reasons and also due to the growing importance of big data from the Internet of Things technology (especially in the post-Covid era due to the high understanding of the importance of supply chain agility in critical industries), in this article, a conceptual

framework for implementing an agile supply chain based on The Internet of Things and big data are presented. A detailed understanding of this framework can be a valuable guide for the powerful and effective implementation of agile and lean supply chains (with high resilience) in the supply, production and distribution networks of fast-moving consumer goods (FMCG) industries.

The structure of the paper was subordinated to this purpose. The first part presents the literature about agile supply chains and agility itself – e.g. key success factors, methods for its optimization and evaluation. This part is followed by description of the research approach. The final outcome of the research is a framework for an agile supply chain management system in an environment based on the Internet of Things, intelligent agents and business intelligence capabilities. The final section discusses and includes those findings.

2. Literature Review

In the following sections of this research, the literature in the development of agile supply chain and the role of information technology and IoT organization's agility. Theoretical background will help draw the basics for creating agility using IoT.

2.1. Agile supply chain

In today's dynamic business environment, using an agile supply chain is considered a key strategic move to align with market instability, manage competitive pressure, and strengthen organizational and operational performance. The agile supply chain is one of the types of a supply chain that looks at flexibility and focuses on responding to unpredictable changes in the market and taking advantage of these changes through fast delivery and flexibility in the volume and type of product (Sharma et al. 2021). For this purpose, it uses new technologies and tools such as advanced information technologies such as electronic data interchange (EDI) and virtual companies. This model also has significant people and inter-organizational relationships (Mastos et al. 2020). The special focus of this approach is on issues related to knowledge systems and employee empowerment generally building a systematic approach that integrates business, increases innovation in the organization and creates virtual organizations based on customer needs (Abideen and Mohamad 2021). Agility enables institutions to succeed in an environment full of continuous and unpredictable change. This is a new and post-mass system for producing and distributing products and services. Therefore, in order to achieve agility, an organization must implement a continuous evaluation of employee performance and the value of its products and services, respond to constant changes in the needs of its customers, be a learner, have high information content, be ready to respond to sudden changes and events, use advanced technologies and take advantage of new opportunities that increase profitability and productivity (Chhetri et al. 2021).

With the development of global supply chains and their increasing complexity, fundamental changes in the management of supply chains have become essential. Researchers have suggested the use of agile supply chain as a strategic solution in response to the ever-changing needs of customers (and therefore customization of production), shorter product life cycle, productivity improvement, product diversity management, development of flexible and dynamic capabilities, as well as global challenges such as the coronavirus epidemic(Um 2017a, b; Shashi et al. 2020; Jindal et al. 2021; Karmaker et al. 2021; Nandi et al. 2021). The most important reasons for using an agile approach in the supply chain are reducing costs, improving productivity and increasing service speed. (Shashi et al., 2020).

To sum up, the agile supply chain is today a determining factor in maintaining competitiveness in a turbulent economic environment (Sangari et al. 2015). Following the coronavirus epidemic, many businesses faced inadequate patterns in their production, consumption, and supply chain processes. Therefore, in order to overcome these problems, they must consider the three characteristics: localization, agility and digitalization in their supply chain (Nandi et al. 2021). In times of disruption, supply chain agility enhances the visibility

of networks, including the production and distribution network, and thus protects the entire chain against the changing needs of the market (Karmaker et al. 2021).

Such a supply chain can adapt to unexpected events, respond appropriately to system disruptors, and retain itself by maintaining operations' integrity at an appropriate level of relevance and control over structure and performance. For this purpose, the use of smart technologies in supply chains has become prevalent. Intelligent technologies make it possible to monitor the entire product path from production to delivery remotely. Increasing inventory control accuracy increases the agility of a supply chain and speeds up the information flow process(Al-Talib et al. 2020). Agility makes the supply chain highly information-driven, thus providing a deeper understanding of lower-level capabilities (Hazen et al. 2017).

Intelligent systems play a very important role in supply chain agility by providing the ability to share information throughout the supply chain (Kim and Chai 2017).

The identification of market needs is not based on past information and retrospective estimates. Rather, the it is received in a completely up-to-date manner and based on them, supply chain planning and management is done. Therefore, feedback from customers is done instantly and through this, the market's future needs are estimated. Increased volume, communication tools, and real-time information have provided the basis for large-scale data analysis in agile supply chain management. Therefore, companies can adjust their policies and suggestions based on customers' behaviour (Richey et al. 2016; Shashi et al. 2020). Big data analysis in the supply chain can increase the return on investment by 15 to 20 percent, improve competitiveness, reduce risks and significantly increase the ability to monitor activities. Through implementing the concept of a data-driven supply chain, organizations can gain competitive advantage and manage market volatility (Raut et al. 2021).

Agile supply chain places great emphasis on digitization. Research in the agile supply chain field shows a direct relationship between investing in new technologies and agility in organizations. Many researchers have studied supply chain agility drivers (Umar et al. 2020). These drivers include e.g. the availability of technological infrastructure and resources, and the integration of information technologies (Al-Talib et al. 2020). access to hardware, software, human capital, systems and processes. In examining the necessary prerequisites in terms of organizational capabilities to achieve agility in the supply chain, researchers have studied methodologies, frameworks, exchange standards, flexibility measurements and the development of tools for agile supply chain (Kalaboukas et al. 2021). New technologies can also play a key role in selecting business partners, as these technologies can enhance an organization's benchmarking capabilities and thus make the best choices (Shashi et al. 2020). Also, the new generation of communication technologies such as the Internet of Things and a set of complementary technologies known as the Industry 4.0 can have a very high impact on data collection and sharing, which is one of the foundations of agility in the agile supply chain.

In the research conducted by Zimon et al. (2019), a sustainable supply chain management implementation framework was presented based on a literature review while categorizing the practices adopted by companies and industries. This research provided new insights into the design of an implementation model and It provides scalable, reactive, collaborative, and dynamic models for implementing sustainable and agile supply chains. Katoch (2022) explores the role of the Internet of Things (IoT) in supply chain management and logistics through an extensive literature review. In this study, several insights about the important aspects of the Internet of Things in supply chain management and logistics are presented through bibliometric analysis. Aliahmadi et al. (2022) also presented a conceptual model for a lean-agile logistics system in the pharmaceutical industry. Nozari and Ghahremani-Nahar (2022) also investigated the effects of blockchain technology and the Internet of Things on the flexibility and agility of supply chains and identified and classified the effective factors.

2.2. IoT-based agility

IoT technology offers new opportunities for risk reduction and complexity management. Also, by using this technology, businesses that deal with physical goods can increase transparency and flexibility throughout their supply chain. A resilient supply chain can adapt to unexpected events and respond appropriately to system disruptors while maintaining the integrity of operations at an appropriate level of relevance and control over structure and performance (Patel et al. 2020). Two essential features of communication with each other and the necessary control throughout a supply chain in the event of a disruption using the capabilities of IoT technology are well responsive. Intelligent technologies make it possible to remotely monitor the entire product path from production to delivery to the customer. Through real-time connection to the network, interactions and visibility can be created as a forward-looking process in the system and a set of simulations (e.g. in the control tower systems) (Trzuskawska-Grzesińska 2017). The information collected through the sensors in a real-time control and monitoring system enables intelligent control in the supply chain (Gawade 2021). This leads to increase in security throughout the supply chain. Also, the upgraded product and service management system allows to monitor resources instantly and in real time. Increasing inventory control accuracy increases the agility of a supply chain and speeds up the information flow process (Bouhannana and Elkorchi 2020). Therefore, IoT technology promises to form a smart, stable, resilient and agile supply chain, as a result of which the error rate in the supply chain is reduced and allows very strong big data-based analyses. IoT technology makes the supply chain resilient, stable, and agile in terms of observability, flexibility, interactivity, and supply chain control (Al-Talib et al. 2020). This led to better information sharing (Baudin 2016). This technology creates a network of physical objects that are digitally connected, through which these objects are identified, monitored and interact with each other. These interactions can be at the intra-corporate level or by running away from the company and its suppliers. This level of interaction allows the company to have accurate and timely planning and control and coordinate processes in its supply chain by creating agility, visibility, observability and information sharing (Frazzon et al. 2019). Emphasizing the Internet of Things technology in the supply chain, Swain et al. (2021) implemented a custom-based sensor node, gateway, and hand-held device for real-time transmission of agricultural data to a cloud server. The results of this study showed that localization algorithms based on They are more reliable and scalable on the combined range for deployment in the field of agriculture, which can increase the growth of agility in these vital industries.

According to an extensive survey of experts in various industries, IoT and related technologies such as automation, big data, artificial intelligence and automotive vehicles will have the most significant impact on supply chain management globally(Ozdogru 2019). . In most industries, supply chain leaders tend to use IoT technology alongside related technologies such as big data, data analytics, machine learning, and deep learning to turn the supply chain into a network platform. Some recent research on the effects of the Internet of Things on supply chain agility is shown in Table 1.

Table 1. Supply Chain Research and Information Technology – literature review result

Paper	Agile supply chain	Internet of Things	Big data	Framework/ Model
(Raut et al. 2021)	*	-	*	-
(Al-Talib et al. 2020)	*	*	-	-

(Abdel-Basset et al. 2018)	*	*	-	*
(Lou et al. 2011)	*	*	-	-
(Zhu et al. 2021)	*	*	-	*
(Selvakumar and Jayashree 2020)	*	*	-	-
(Raji et al. 2021)	*	*	-	-
(Raji and Rossi 2019)	*	*	-	-
This study	*	*	*	*

2.3. Supply chains and COVID-19 pandemic

The recent and unprecedented pandemic situation caused significant supply chains changes, but not all reacted similarly to disruptions (Mchopa et al. 2020). Most of the available sources focus on medical, pharmaceutical or food industries since they seem to be the most volatile for the disruptions because of the specifics of products. What is most important, they usually base on lean-related management strategies because of selling mass products. Therefore, they also were forced to prepare a quick response for the sudden changes(Lapide 2020; Sengupta and Bose 2020). The literature on supply chain management in the time of pandemic usually presents the disruptions like lack of supplies, overload by inventory, disturbed production flows, problems with finding transport or logistics company, decrease of sales volumes and problems with employment (absences, the necessity to reduce the employment) and of course bankruptcies (2020; Gruenwald 2020; Marzantowicz et al. 2020; Oeser and Romano 2020; Vergara et al. 2020; Taqi et al. 2020). The well-known practices that survived the big economic crisis in 2007-2009 had to be reviewed, e.g. just-in-time, just-in-sequence and zer-inventory approach (Weersink et al. 2020; Kovács and Falagara Sigala 2021). Therefore, the decision-makers turned into management concepts based on flexibility to adjust them to the current supply chain needs. Among those, the most significant appeared to be resiliency and agility in supply chains (Rashad and Nedelko 2020; Salama and McGarvey 2021). Since not always the pure agility can be implemented in a full-lean supply chain, the leagile concept became a candidate for future strategies (Rashad and Nedelko 2020). However, to the well-known leanness supply chain coordinators had to add agility.

As mentioned before, agility was not a target strategy for FMCG industries, but the scope of disruptions in the global economy because of the pandemic has forced supply chain leaders to consider it a solution to current problems. Until now, agile management was rather combined with small series production of multivariant products (Borgstro and Hertz 2011). As a result, a paradigm shift took placec(Alkahtani and Abidi 2019), which can also be observed in the scientific space focused on the development of supply chains in the form of the growing popularity of the concept of Supply Chain 4.0 (Frederico et al. 2020).

The FMCG industries, especially food and agriculture-related ones are perceived to be vulnerable for the supply chain changes. In our opinion, this is not true for every kind of final products since many of them have a long shelf life. However, they are necessities without which the population will not survive. Similarly,

for the analogous reasons, medical equipment and more important, medicines define the quality of the population's life. Therefore, supply chains dealing with those two sectors are those that cannot allow for a long disturbance in the flows of materials and finished products.

The pandemic forced supply chains in the mentioned branches to find a way to keep the supplies stable. What is interesting, they are perceived as having a high resilience (Belhadi et al. 2021). The interesting way to evaluate resilience can be by combining the Time-to-Recovery (TTR) and Financial Impact (FI) analysis. The cited study indicated the high importance of big data analysis and industry 4.0 technologies in dealing with the disruptions caused by pandemics (Belhadi et al. 2021) next to the constant cooperation between supply chain members and shared responsibility (Sharma et al. 2020). This was confirmed by a set of studies (Kumar et al. 2020; Pu and Zhong 2020), even for cold chain management (Masudin and Safitri 2020). Resilience through agility, IoT and Industry 4.0 is recognized as possible and optimal in times of pandemic in food- and medical-related research (Polater 2020; Stavropoulos et al. 2020; Ali et al. 2021). Therefore, it is justified to examine those ideas in this study.

3. Research method

This research is based on an extensive research framework. In terms of data collection and analysus, the method of content analysis as well as evaluating the opinions of experts have been used. First, all big data sources in the FMCG industry supply chain were extracted by reviewing the literature and the opinions of experts. Then, by emphasizing the basic features of agile supply chain and based on the 4-step IoT architecture, a framework for agile IoT-based agile supply chain was presented. In this study, among different industries, FMCG industries were selected as a case study due to its high importance and the extent of its significant effects on people's daily lives. Due to the structure of companies and the presence of existing specialists, among the companies in this field, 4 Pharmaceutical companies and 8 food companies in Iran were selected. 14 supply chain experts, as well as those familiar with information technology and the Internet of Things, were interviewed to review the various elements of the framework as well as validation. The study was scheduled for spring 2021, and the main reason for choosing pharmaceutical and food companies was the appropriate access of researchers to these companies. Also, the experts working in these companies had better knowledge of the functions of the Internet of Things. These experts had three characteristics: familiarity with advanced technologies, especially the Internet of Things, experience in the field of information technology and supply chain.

Due to these characteristics, the community of experts in this study in the country is not predetermined. In researches where the statistical sample with the desired characteristics is difficult or scarce, the snowball sampling method is used (Noy 2008). Therefore, in order to identify experts in this field, the snowball method was used. For this purpose, in the first step, three experts in this field were identified and they were asked to introduce other experts in this field who have such characteristics. After three rounds of introducing new experts by previous experts, we repeated the names of those introduced. The network structure of the issue has been achieved through library review and literature review as well as interviews with experts. In this research, a questionnaire has been designed and distributed in order to use the opinions of experts in the fields of dimensions and components affecting the supply chain agility based on the Internet of Things. For this purpose, a questionnaire was used that includes 35 questions, each of which shows the importance of each indicator based on the 5-point Likert scale and sequential variables. The scores of the questionnaire options are from 5 (very high) to 1 (very low). In this questionnaire, the purpose is to assess the impact and importance of the indicators seen on the agile supply chain based on the Internet of Things. The face validity of the content of the questionnaire was reviewed and confirmed by experts. Cronbach's alpha was used to test the reliability of the test. Cronbach's alpha was calculated using SPSS software. Cronbach's alpha value for 35 questions of this questionnaire based on the data obtained from the questionnaire is 0.96. And since it is close to one, it has the necessary reliability.

4. Findings

Organizations are currently under pressure from market complexity and fierce competition. In this situation, and due to the significant expansion of the Internet and information networks, companies must move towards the use of software agents (Lou et al. 2011). In this method, agents are responsible for data digging, market research, establishing and managing relationships with colleagues and partners, etc. Therefore, organizations must provide a new platform for collaboration in the supply chain in a dynamic environment and allow partners and components of the supply chain that their software agents can be easily implemented on the computers and information systems of the organization. Intelligent agents and Internet of Things have recently been jointly used in modern agile supply chain management systems to communicate and collaborate extensively with suppliers, manufacturers, distributors, retailers and end customers (Selvakumar and Jayashree 2020).

To examine the dimensions of the impact of the Internet of Things on organizational agility, the agility components in a supply chain must first be considered. An agile supply chain is very sensitive to the market changes, relies on the rapid sharing of information throughout the supply chain, all processes are managed seamlessly, and this is a factor to accelerate activities and avoid errors. The whole network of organizations must act together. As shown in Figure 1, with effective parameters, features are created in the supply chain that are referred to as the main components of the agile supply chain. The initial assumption in this model is the possibility of extensive communication between members of the supply chain and the existence of a technical platform and facilities for real-time information sharing in the supply chain. The components related to this framework are based on a review of the literature and theories of experts.

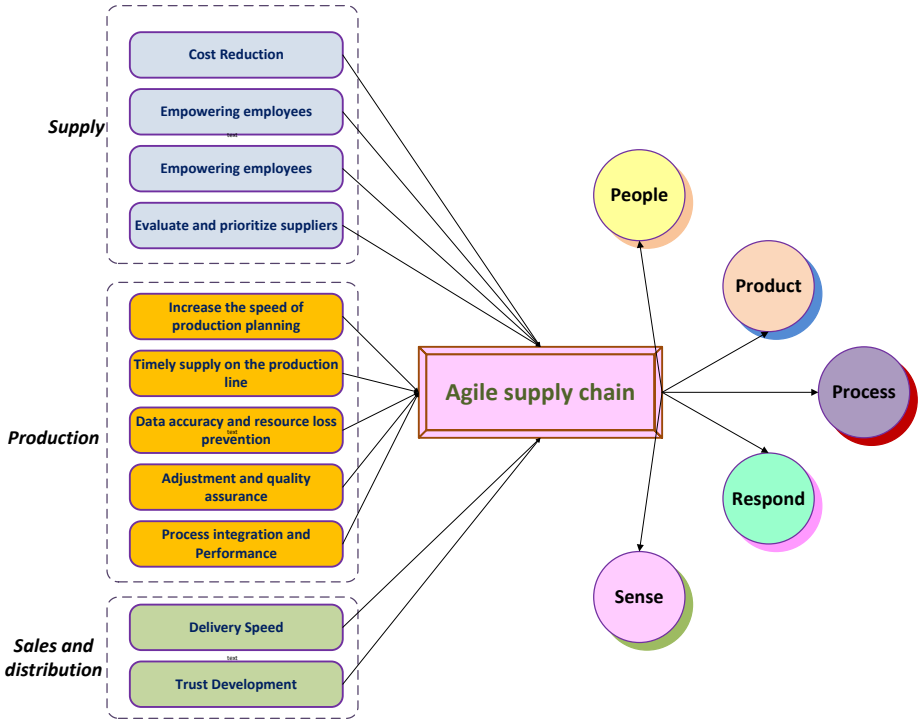

Fig. 1. Characteristics of agile supply chain

Since the Internet of Things is one of the most important sources of large data production, the use of this technology can have a tremendous impact on the organisation's agility. Nevertheless, analyzing existing data to analyze high-volume (and varied) data in real time and generating useful information is not easy. Although many data techniques may help managers generate a great deal of information, they are inefficient because usually in supply chains they are not concentrated in one place. Therefore, it is necessary to create an analytical framework for structures and create different data streams to create a coherent picture of a particular issue to provide a more accurate insight into data analysis (Nozari et al. 2021a). To create a clear picture of the issue in this study, first using field research and review of supply chain literature in pharmaceutical and dairy companies, which are generally in the category of FMCG products, the principles of big data entry in the FMCG industry supply chain are examined. It is estimated that hundreds of billions of dollars per year may be generated using big data analysis in the supply chain. Figure 2 shows the sources of big data input in the supply chain of FMCG companies (Ji et al. 2017).

One of the most significant potential benefits of using big data is to increase ability to deliver and be consistent with customers. Another advantage is that companies can optimize every step of the process from purchase through production to marketing by discovering new insights hidden in the data, and this is the best possible way can pass all the parameters of supply chain agility, and create the ideal agile supply chain.

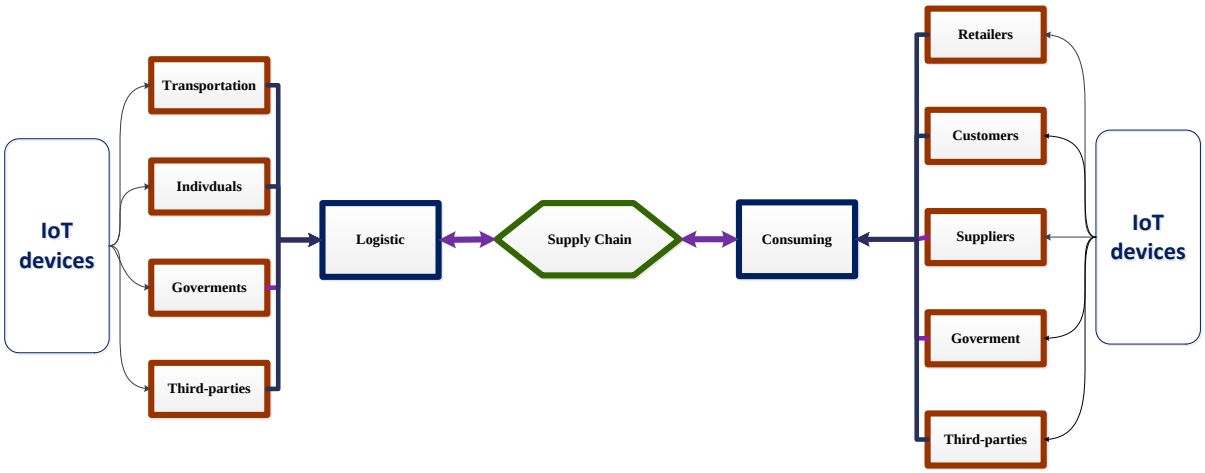

Fig. 2: Big data sources in the FMCG supply chain

In order to implement an agile IoT-based supply chain, it is necessary to align the data entry path with the IoT agility components and then integrate it into a logical framework. To present the real-world solutions in FMCG industries taken into consideration, the framework presented in Figure 3 has been used. As shown in Figure 3, agile supply chain management is based on intelligent systems and chain management agents. Intelligent agents are autonomous entities that can control their behavior and make decisions and act according to their perception of the outside environment to achieve predetermined goals. Intelligent agents do their job without the direct intervention of humans or other agents and have some control over their inner behavior and states. These agents understand their environment and perform actions according to the changes that have occurred in the environment. In addition, by performing activities, they create their desired conditions in the environment. Intelligent agents can communicate with other agents or humans, which can be in the simple case, the transfer of information between agents and in the complex case of negotiation between agents. In multi-factor systems, each agent seeks to increase its interests while working with other agents to achieve their goals. One of the most critical advantages of multi-factor systems is its responsiveness in playing different and multiple roles in a business process in which several software agents act as

representatives of the parties involved in business processes. Multi-factor systems are very suitable for areas where the interaction of several organizations with different goals and information is considered.

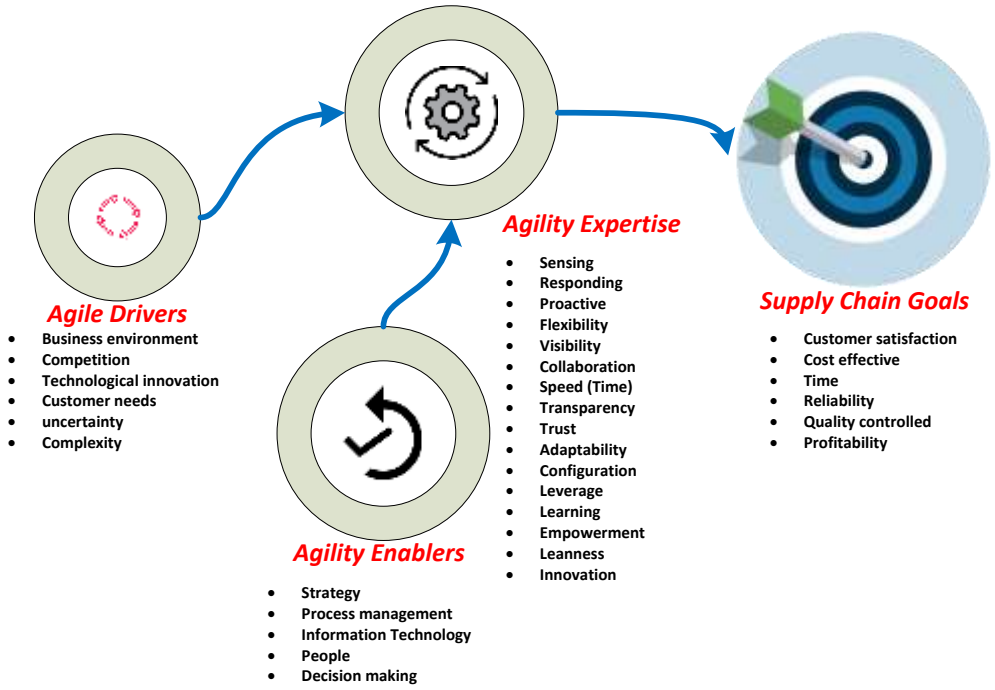

Fig. 3. The agility supply chain framework [5]

Having said that, supply chain management can be considered an excellent example of multi-agent systems in which software agents act as representatives of different chain components. "Supply chain coordination and integration" with the help of IoT technology tools is a mechanism to increase supply chain efficiency. In this regard, Figure 4 provides a conceptual framework for implementing the IoT-based supply chain with an emphasis on data production resources and IoT tools.

The framework for agile supply chain management is based on the basic principles of data collection, information analysis, access to market knowledge and sharing and disseminating this knowledge throughout the supply chain. As is often the case, the first step in improving supply chain performance and optimizing product production is to examine the data from factors affecting the supply chain. This data can be extracted from information contained in customer relationship management devices, information sensors, RFID and other IoT-based tools that is evident in the framework. The sources of input of big data in the supply chain of FMCG industries, which is shown in Figure 3 and Figure 4, have been obtained by reviewing the literature and the opinions of experts active in the supply chain units of FMCG companies (here exclusively food and pharmaceutical companies). Agile supply chain management in the proposed framework is briefly based on the following principles:

- Extensive and comprehensive communication, close cooperation with partners and suppliers, integration of processes and information based on advanced information and communication technology, sharing of information and banks and information systems of the chain organizations and as a result, complete and accurate knowledge of chain components, position and structure of each other.

Having accurate knowledge and broad insight into agility factors and stimuli such as business environment and structure, customer needs, actual and potential competitors of the organization, general tendencies and tendencies of the society and the direction of the current and future market, social, political and legal factors, technologies related to activities and monitoring and monitoring changes in all of the above parameters and thus having the ability to predict the amount of real demand in the future and be prepared to meet it.

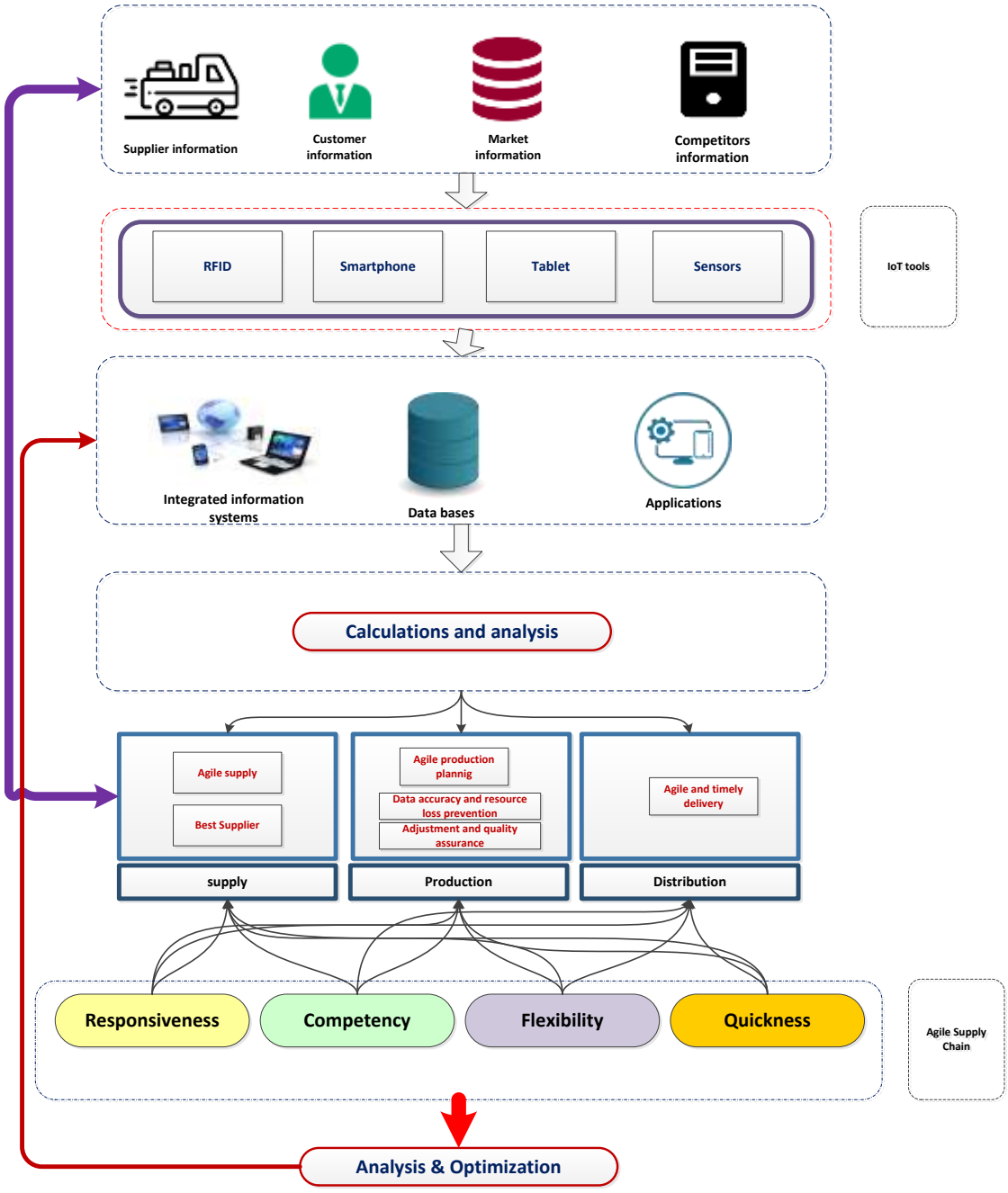

Fig. 4. IoT-based agile supply chain implementation framework

This system is connected to all parts of the supply chain and has all the processes and operations of the chain under its supervision and control. The proposed software framework is also under the control of this section. After predicting the set of forecasting factors, the future situation and the occurrence of changes in each of

the stimuli and the amount of real demand, this system responds by analyzing the forecast and the probability of its occurrence based on information and the current state of the supply chain. Calculates the appropriate and minimum agility required to provide this answer and provides it to the organization and the set of evaluation factors. Then, the process improvement cycle is repeated. Much of the defined framework is closely related to the data that should be included as input to the issues. In this context, using the concept of the Internet of Things as the largest source of big data production has been added. In many cases, the information received from customers and other human data will not be binary, and in this case, the possibility of entering uncertain data in the general state for large volumes of data that have much variety can be challenging and impractical. The use of IoT tools can also be a practical step towards the stability and optimization of the supply chain.

5. Conclusions

Agile supply chain management is a new perspective that helps organizations achieve competitive goals and meet customers' needs in today's highly competitive and volatile market. What is more, in time of COVID-19 pandemic this concept is recognized as the appropriate one even for previously lean logistics systems, as food or pharmaceutical ones, characterized mostly by mass production. This is the beginning of the new way of strategies for FMCG industries caused by sudden supply chains disruption. Of course, achieving an agile supply chain varies according to the nature of the products and the characteristics of the products, and first, the main factors related to the agile supply chain must be identified and the relationship between these factors must be determined. In this study, agile supply chains, the reasons for the need for agility, agility characteristics, agility drivers and enablers and the impact of IoT technologies on supply chain agility were studied. The FMCG industry supply chain is also considered as a case study. These industries are of great importance in people's lives due to the nature of their products, special and unique distribution and consumption. Therefore, supply chain agility is essential in them. Since information flow in this chain is very high and the Internet of Things is one of the most important sources of large data production and can play a key role in supply chain agility. So, in this study, an attempt was made to provide a framework for an agile supply chain based on the Internet of Things. This framework intelligently recognizes the agility needs of the organization and strives to achieve it, and as a result, it will create more competitive advantage for the firm and increase customer satisfaction and expand the organization’s market share. It also provides a clear path from the agility process from data entry to data analysis, evaluation and optimization for further agility, which can be useful for organizations, especially the FMCG industries.

6. Conclusions

Considering today's changing market, timely response to customer needs and demands is considered vital in industry and production. To achieve this, a factor called agility should be increased in the supply chain of factories and productions.

Achieving an agile supply chain is different according to the nature of the products and the characteristics of the products, and first the main factors related to the agile supply chain must be identified and the relationship between these factors determined. Since the flow of information in this chain is very high and the Internet of Things is one of the most important sources Generating big data can play an essential role in the agility of the supply chain, so in this study, an attempt was made to provide a framework for an agile supply chain based on the Internet of Things. This framework intelligently recognizes the agility needs of the organization and strives to achieve it, and as a result, creates a more competitive advantage for the company, increases customer satisfaction, and expands the organization's market share.

Nevertheless, this is only a conceptual framework what is the outcome of this paper and the authors are aware of the limitations of the study. The first one is the method of building the framework – the group of the experts was limited and small. On the other hand, asking the experts in the field about the agility in supply

chain and use of IoT is the best way to get familiar with the practical use of this concept and its implementation. What is more, big data analysis made the results more reliable. Secondly, the results cannot be extrapolated for the whole population of companies in FMCG industries. There were only selected sectors involved (food, pharmaceutical); therefore, the study provides only initial insights into the field. Thirdly, since the pandemic has not ended, the accuracy of agile supply chain management cannot be fully proved. This paper presents only possible ways to deal with the supply chain problems, not a checked and proven solution. Therefore, the future research directions should include the post-pandemic analysis of efficiency of use IoT in agile supply chains to tackle problems caused by supply chain disruptions.

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