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INDUSTRY 4.0 AND LOGISTICS 4.0 – INTELLIGENT DESIGNS IN FMCG LOGISTICS

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Abstract: In these times Industry 4.0 and Logistics 4.0 has become a quite popular and trending topic amongst companies. There are market leaders who have the best knowledge and resources to use the relevant tools and technologies in their daily operation, and there are small players who has limited capabilities or only able to follow these – in all of the cases it is inevitable to get to know and utilize these technics to keep and increase competitiveness. Researches and studies have a very important role to explore these opportunities and what is more to transfer the knowledge to the participants has no access at first hand. It is specifically valid for sectors like food industry and FMCG segment where we can face with falling competition and increasing pressure caused by the higher expectations but in parallel several innovative solutions as well. This gave the reason for me to take a deep look into this case and summarize recent developments.
Keywords: Industry 4.0, Logistics 4.0, FMCG sector, Intelligent logistics

1. RELATIONS OF INDUSTRY 4.0 AND LOGISTICS 4.0

In order to identify the relevant professional literature and research results first we need to clarify the basic definitions, processes and tendencies [1]. Prior to the currently processing Industry 4.0 we can mention three important milestones in history leading to the current situation. It started with the invention of the power loom in 1784. As the next steps there were multiple water and steam-powered production equipment implemented. The beginning of the Second Industrial Revolution can be linked to the first conveyor belt used in manufacturing industry – it happened in 1870 in Cincinatti in a slaughterhouse. After this mass production with usage of electrical energy started up and led to the Third Industrial Revolution in 1970. This was the point when stored program control in manufacturing (SPS-Speicherprogrammierbare Steuerung) spreaded. The continued automation in production and development in electronics and information technology (IT) delivered the current status of digitization which is defined as the Fourth Industrial Revolution. This changes current manufacturing methodologies and processes in basics with automation and information technologies [2].

1.1. Industry 4.0, digitization and the relevant technologies

Based on the definition of Nagy, Oláh, Erdei, Máté & Popp (2018) Industry 4.0 helps the transparency of the processes, integrates the value and supply chain of the company to raise customer value creation to a completely new level. It happens with utilizing the opportunities given by digitization [1].

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According to Weber & Kauffmann (2011) digitization is when we convert physical or analogue products to digital version. Projecting it to business life it mostly means development of tasks, functions, datasets and models which are able to produce an output helping to have a valuable competitive advantage – with applying some of the digital technologies [3].

Actually, it is a completely new direction of the industrial developments, meaning the connection of the processes as well as the machines (M2M – Machine to Machine). With the help of these the focus shifts from mass production to the more and more popular customized manufacturing. To be able to manage that smoothly digitization of the entire production and supply chain is a basic requirement. On the top of these trends – which are even a more significant circumstance – organizational changes of the companies are also significant. There are more complex and integrated structures and this is the real, quality change for the future [4].

Industry 4.0 has several new technical solutions (Figure 1.), we can segregate the relevant technologies to three basic segments according to below [5]:

- Cloud computing: real-time storage of big datasets to support analytics and decision-making processes,
- Cyber-physical systems (CPS): communication of the so called "smart" devices during the manufacturing process – with the help of sensors
- "Intelligent factory" solutions: in fact this means the intelligent network of humans and machines with the usage of cyber-physical systems and IoT (Internet of Things) devices.

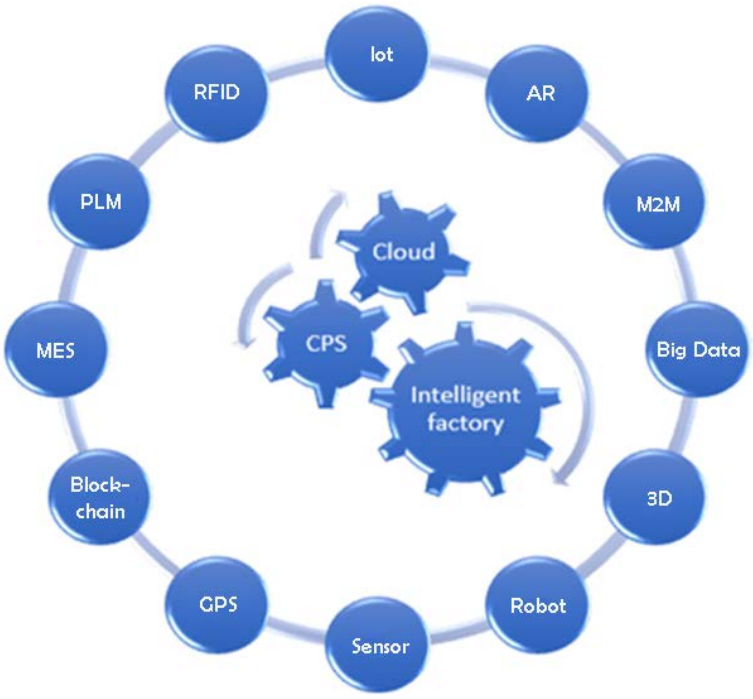

Figure 1. Most important tools and technologies of Industry 4.0

Hereinafter the most important process supporting solutions are listed:

- **Internet of Things** (IoT): actually the process describes the network of physical objects embedded with sensors, softwares or other technologies for the purpose of connecting and exchanging data with other devices and systems – through the Internet. The output of these networks supports the decision making process and helps determining the correct steps of intervention in case of need. With the help of it processes can achieve a great level of efficiency increase and parallelly cost-out – let's just think over the case of preventing an unplanned outage due to machine shutdown with the usage of sensors or eliminating some waste of resources from the system. To have an efficient process it is inevitable to be able to determine what is the exact source of information and how we are able to step in and implement any change remotely. Because of this two-way communication amongst the system elements is a basic need [6, 7].
- **Big Data**: in fact it is a term means the large volume of unstructured data that is collected during the daily operation with the help of the relevant tools. After the phases of measurement (data mining) and collection, the valuable step of the entire process is the proper usage of these datasets: with certain mathematical and artificial intelligence (AI) methodologies we can discover correlations that help to make transparent and optimized the process completely or partially. For maximized efficiency we need to ensure digitization of the processes, storage of the datasets and having the necessary resources – hardware, software and human – for the analyzation [8].
- **Digital twin**: although the concept itself has appeared in 2002, industrial implementation happened only later, with the spreading of IoT technologies. The tool in fact is the way of virtual modelling of a product or a process. During this we are able to connect physical and virtual dimensions and analyse, simulate or monitor the real physical system. This is a great and effective support in failure detection or process improvement.
- **Cyber-Physical System** (CPS): describes handling in one unit the informatics, mechanical, electronic elements and the software with utilizing one certain infrastructure – usually the Internet. Mostly it supported with sensors that collect data from the environment and helps decision making and intervention processes. A more and more widely available example of it is the connection of traffic elements and ensuring a safer and more efficient daily transport.
- **Cloud Computing**: it is a general term for any system that involves delivering hosted services over the internet. With these systems we are able to utilize these informatic resources – data, processes, services and models – in a decentralized, customized way. Programs are not running on the local devices anymore but operating remotely and able to support, change and optimize any of our operation steps.
- **Machine-to-machine communication** (M2M): it is a direct way of communication between devices using any communication channel – without human intervention. With the help of this process manufacturing or operation can easily be optimized or any necessary interruption implemented. Figure 2. shows a very simple way of introduction of this process.

Figure 2. M2M communication process

- **Augmented Reality** (AR): describes an interactive experience of a real-world environment where objects are enhanced by computer-generated perceptual information, many of the cases across multiple sensory modalities, visual, auditory, haptic, somatosensory, etc. It is the mixture of real and virtual objects in real environment, real time and with 3D extraction.
- **Mobile technologies**: supporting digital data transfer – as an example: usage of the Internet.
- **Blockchain technology**: it is any electronic diary containing all the information and transaction related to the product or the process – in chronological sequence. This helps to make transparent the entire procedure for all the roles and elements of it.
- **Radio Frequency Identification** (RFID): radio-frequency identification uses electromagnetic fields to automatically identify and track tags attached to objects. It is pretty similar to bar codes, the only difference is that reading happens with radio-frequency instead of optical devices.
- **Digital camera technology**: comparing to the analogue equipment it is able to shoot sharper and more rich-in-detail images.
- **Global Positioning System** (GPS): a global navigation system operating 24/7 with the help of satellites (GNSS), which was developed and operated by the United States Department of Defence – primarily for military purposes.
- **I4Log**: it is an informatics module, that helps production line data collection, analyzation and decision making support in areas like quality control, maintenance or warehouse management.
- **Collaborative robot** (cobot): these are robots intended for direct human robot interaction within a shared space or where humans and robots are in closed collaboration. Due to the development level of these devices humans are not in danger in any time [9].
- **Manufacturing Execution System** (MES): it is a production controlling system, which ensures the connected, transparent management of manufacturing, logistics and quality control areas – also enables any participants of the process to intervene in case of need.
- **Complex and intelligent sensors**: in case of complex sensors we are able to serve multiple perception dimensions due to the several elementary sensors in the process, while intelligent sensors enable us to cover functions like communication or sign-evaluation.
- **PLM application**: the application developed by Siemens supports the simulation and optimization of the manufacturing and logistics processes with modelling of all the levels of the entire production and factory.

In addition to the above there are multiple other applications and designs supporting the intelligent logistic flow. These are:

- 3D printing, scanning,
- customized machines for automation,
- robot technologies,
- multi-purpose, multi-functional manufacturing lines,
- artificial intelligence solutions,
- mobile equipment,
- application integration,
- VR application in process simulation, analysis or evaluation,
- cloud computing in logistic processes,
- automated and autonomous vehicles in wider range of the operation.

To support the processes above info-communication technologies (ICT) ensure the collection, storage and process of data and information, also secure the flow on certain channels - like through Internet. These are like the above mentioned virtual reality, Big Data usage, cloud computing or the IoT technologies.

1.2. Intelligent logistics

With Industry 4.0 there are new opportunities opening up in intelligent logistics process development.

Logistics 4.0 helps companies achieve, keep or maximize the desired competitive advantages with managing the entire supply chain. Related to these trends there are already multiple tools, processes and best practices not only at the market leaders but in the smaller companies' practices as well.

Actually, talking about intelligent logistics we mean tools, systems or designs that are capable for the flexible management of the external impacts and environment, even react whenever it is necessary. This allows them to realize significant cost saving and optimization in their operation – considering the decreased reaction time and increased efficiency, utilization and optimization of the resources [10].

The most popular and widely-used intelligent logistics designs are the followings in these days (IJEMS, 2019):

- *Intelligent identification and measurement tools* to monitor the parameters of the external environment.
- *Intelligent technical equipment* that are able to sign i.e. the failure or the waste of a certain resource – with usage of sensors.
- *Intelligent quality control* i.e. barcode reading in product identification, quality checking.
- *Intelligent material handling equipment* these are automated tools or vehicles perceiving and considering environmental conditions.
- *Intelligent warehouse* designs are capable to control order and stock management tasks with sensors and further "smart" tools in storage places.
- *Intelligent logistics systems*, the level of automation in these solutions are the consequence of multiple factors combined achieving the highest possible collaboration and communication of humans and machines in logistic processes.

2. I4.0 AND DIGITIZATION IN FOOD INDUSTRY

Although matter of Industry 4.0 has a great popularity and interest in the sectors of electronic and machinery, it impacts food industry and the related other segments as well. Increasing population has a significant impact and higher requirements in terms of effectiveness and food safety which is amplified by globalization. Beside the continuous increase in quantitative demand, quality requirements are also has a significant fluctuation and higher pressure: rising standard of living changes the structure of the product mix, increases the energy demand and environmental burdensome. Adaptation to these new challenges might be best – rather only – way for companies, in which opportunities of digitization is a great support.

Taking into account the domestic trends we can state as the main sectors of Hungarian food industry – giving the 2% of GDP – the following: meat industry, fruit-vegetable and dairy processing and pasta production based on the analysis of Kürthy and co-authors (2016).

The main characteristics of the sector are the low wage level, companies with low income and, as a result of these above, the low efficiency – behind the average of the Union. Considering production value it is the third biggest, in terms of employee count it is the leader in Europe's food industry. Since it is the greatest user of the resources it is especially critical and carries a great competitive advantage to examine opportunities of productivity and effectiveness improvements.

2.1. Smart designs in Food Industry

In general food industry is described by continuous, significantly changing trends, especially in terms of product mix and processing requirements – among others, due to the increased popularity of healthy and clean eating [11]. Besides customer demand and requirement fluctuation, there is also a significant pressure from the retail chain claiming continuous price level decrease and in parallel improvement in quality, selection and food safety. Complying with all these requirements digitization and Industry 4.0 can be an effective and long-term support or solution for these market players.

With the help of all above processes -supported by computers and other IT devices and connected into networks – we can execute the efficient, transparent integration of the company value-chain and due to this increased efficiency level.

In fact some achievements of it, like automation or robotization, are available for a while in some certain areas of food industry – i.e. pasta production or dairy processing. Yet there are still segments where the complexity of the processes or the high human labour demand limits the opportunities – these are i.e. meat industry or bakery industry. On all the areas where automation can be implemented or improved these activities resulted to higher efficiency, scrap rate decrease and on long-term quality level increase. Considering it is one of the most valuable articles for humanity inevitable for the future in terms of both material and ethical aspects. Moreover, further positive impact the software-side of this circumstance: collection, analysis and structurization of the datasets, decision-making support activity and official reporting opportunities helps increase further the competitiveness of companies.

In terms of product development there are also multiple areas for involvement under the umbrella of digitization and Industry 4.0 activities. In these times 3D printing has also

become a widely known and spread technic which eases production development, makes packaging more efficient and logistics operations more effective.

Beside all of these above product safety and quality assurance is not a negligible area of the topic either. There are less other segments where product tracking and identification of the whole supply chain – i.e. in case of product recalls – would be more important. In todays, globalized world it has an increased importance. In these aspirations RFID, barcode reading block chain technology or sensors all has a great role – these are specifically considered as basic technics of digitized food industry processes.

In addition to the above there are several other opportunities and tools for the digital improvement of food industry, of course, the most important matter of these projects is the proper balance of the invested resources and the realized efficiency or competitiveness-increase. As in majority of these relevant areas, here is also typical the lack of mature processes, best practices or benchmarking opportunities. This is the reason that many of the smaller market players keep the relevant investments risky and this is why there is a great importance of the proper, complex and comprehensive studies and researches. Having the right information, datasets and good practices is the greatest support for companies has limited access to the latest designs and developments [12, 13].

2.2. Intelligent FMCG logistics

FMCG (Fast Moving Consumer Goods) is a significant piece of the food industry. Articles related to this segment present the typical examples of the necessity of an efficient supply chain process. Since profit margins are low while volumes are significant it is especially key to use capabilities, capacities and all the resources in the most efficient way, parallelly acceptable service level also has to be provided [14, 15].

Product mix has a short shelf life period caused by the increased customer requirements (i.e. for beverages) or the product specifics (like meat, dairy and bakeries). These are typically distributed with lower profit margin but with high income generated due to the huge volumes. There are two basic categories for them: food and non-food products. Latter covers DIY, household, technical devices, toys and sport department's products, while food articles are processed foods, ready-to-serve foods, beverages, bakeries, fresh and frozen foods. The huge market of the sector generates a significant profit (Harward Business Review, 2011). On the international market it is processing amongst the biggest companies (like Coca-Cola, Unilever, Procter&Gamble, Nestle), who has a significant role on domestic ground as well.

Considering logistic aspects there is a big importance of packaging. Since during supply chain process it has to stand multiple movements and loadings these products has a lot higher requisition than any others. Beside basic packaging functions – like product protection – there is a significant role of marketing and information requirements and, in parallel, environmental protection is also a primary expectation. Since supply chain has to connect and coordinate several participants it is necessary to have a flexible, well-performing and complex process – this is how the highest service level can be ensured for end users. Another, important specific of the sector is the online presence. Pervious trends raised by the customer requirements for a more comfortable business process were strengthen further caused by the current pandemic situation – there are multiple new players who appeared and could build up their position in present conditions. Beside the increased popularity of the online ordering system of the huge department store chains there were

other players appeared and specified only for the online business practices (i.e. Kifli.hu or Roksh.hu who was named as Smartkosár.hu before). There are also several smaller local shops who introduced or improved their online service in their daily operation.

Since requirements of end users getting higher service providers has to comply with those and ensure smooth supply on multiple channels with continuing costout projects and a permanent level of business service. To be able to meet all these expectations strategic planning is inevitable – with making sure following conditions are kept:

- Real time transparency at all the points of the supply chain.
- Control on all the relevant service and other costs and data – including the transportation and all other expense -, and logistic performance.
- Integration of the certain process and corporate control systems.
- Safe fulfilment practice meeting all the requirements raised.

2.2.1. Industry 4.0 opportunities for digitization and optimization in online fulfilment process. Due to the strong competitiveness and fluctuation on the market FMCG sector is also known about the high level of innovation. In the following the so called „smart" designs and solutions are listed related to the online fulfilment process – the analyzation was made by validation of all the relevant and significant market players to get a comprehensive picture about these days' practices. Purpose of this matrix and the analyzation is to support the 'followers' on the market and point out the right directions for further benchmarking activities.

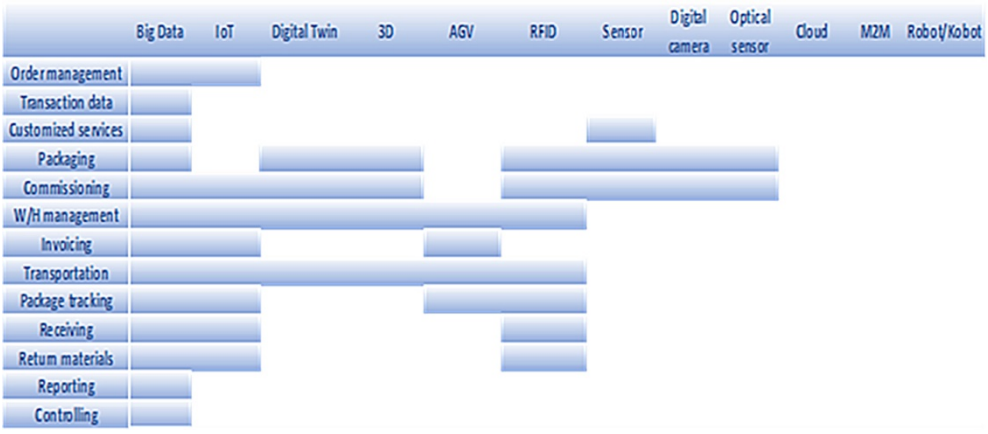

Figure 3. Intelligent logistic solutions in online fulfilment process

Of course, opportunities and developments are continuous and changing dynamically on the market. This is why it is not only a possibility but rather a necessity to follow these trends and monitor the easily implementable steps and tools for the smaller companies. This ensures them to find the proper market segment to supply or the most cost-effective way of business activity.

Since the general trends are leading to the unique and customized products and services, to smaller ordering lots and the online business appearance these smaller businesses has a good chance to find their place on the market beside the giants. The only requirement and chance for this is to find the proper tools and opportunities [16].

As it is clearly visible in the matrix (Figure3.) and also proven by the practical experiences, *Big Data* has a wide range of opportunities for intelligent solutions. Projecting it to the logistic processes in fact this means the collection, analysis and comparison of datasets, and afterwards using them in decision making process or intervention in case of need. Although warehouse-related processes and data output is typically not something can be easily reported, there are a few easily-implementable solutions that can help a lot on daily operation and performance analysis. These are i. e. the fleet- or warehouse management software which are able to report the certain effects, events or losses of the process. With those inputs less optimized warehouse designs or material movement routes can be developed and productivity increased. Besides these there are several areas that can support companies from customer demand forecasting, through inventory management till route planning, marketing, maintenance or labour resource planning. Corporates spend significant amounts on data mining and analysis as these investments has a great turnaround by the end of the day [17, 18].

Internet of Things (IoT) cannot be bypassed these days either. Although it is used by a smaller portion of the companies – 30% based on the Vodafone's research including 1758 business worldwide – still 95% of them believe investment to these relevant technologies is necessary to increase the productivity of the entire supply chain process. According to logistic and information companies it can increase supply chain effectiveness with 15 % in majority of the market segments. The real leaders of these technologies are the transportation and logistics related businesses. Shall it be humans and machines collaboration in complex assembly operation or the smart vehicles, flying taxis, possibly autonomous cargo ship technologies there are significant future impacts of these connected machines and devices in transportation. Besides this, concept of intelligent warehouse management the material movement without any human control and in parallel with the protection of the articles. A significant support in these processes are the smart devices like digital cameras, smart glasses, sound controlled commissioning technics, material moving lines, forklifts, robots and other vehicles [1, 19, 20].

RFID chip on the packaging of the products are also listed between the intelligent solutions. These are able to distribute information and communicate at every single point of the supply chain. Beside tracking and information sharing it has communication functions as well which really classify this as a 'smart' device. It is able i.e. for communication with the manufacturer to share which are the compatible other articles with the certain product but also can inform end customer about expiring date or other production specifics.

Further requirement of *intelligent packaging* is the identification, and controllability through all the steps of the process – in parallel with cost efficiency and recyclability. Having these smart designs there is a significant role in planning and production of 3D printing technologies. Further advantages of 3D printing is the support of unique designs, stability and weight loss of packaging which result further improvement in efficiency we have not seen before [21].

To make processes transparent and information flow efficient with the client's *digital tracking, visualisation and mobile devices* can also be utilized efficiently. Based on Siemens' survey two-thirds of the relevant companies are going to use artificial intelligence (AI) and data analysis in optimization of their logistic processes in next five years – one-fifth is already doing it. Logistic development cannot stop at the phase of transparent and efficient processes, the next and required level is the so called „proactive logistics", when companies are able to forecast customer demand before the decision has been made at end

users. This increases not only the corporate competitiveness but has also a significant impact on the environment – considering i. e. the more plannable traffic flow, utilizing the off hour transportation opportunities, etc. Connected or autonomous (AGV) logistic vehicles and tools has a significant contribution to the automation of the warehouses, AR/VR solutions are a great support in tracking, while sensors can revolutionize EHS or maintenance processes.

Due to the *automation technologies* today's factory or warehouse is completely different from the ones back to a couple of decades. In these days there are autonomous robots (AMR), high-speed transport lines, cobots and further connected technologies deputies manual material movement. This increases the accuracy, efficiency and also the safety of the entire process and harmonize the production inequalities (shortage or surplus). Besides this can also be a huge help in management of structural labour shortage – supporting employees to deal with the real value-creation and complex activities instead of wasting resources and time on the ones can be managed by machines. AMRs are also able to realize further costout opportunities with saving investments in the warehouse – i.e. magnet lines, wires, forklifts, etc. Considering all of these above their popularity is understandable and utilization of them is recommended. According to latest industrial estimations 79% of FMCG companies are going to use AMRs for their internal logistic process improvements by 2024.

3. SUMMARY

Areas of Industry 4.0 and Logistics have several opportunities for improvement for all the players of the economy. In the globalized and digitized world of these days companies has a lot easier and cost-effective access to this know how. Implementation of the intelligent designs has become a necessity to the basic operation and not a nice-to-have competitive advantage any more. For a smaller company which has limited knowledge and access to these technologies it is inevitable to have a useable information package about them. It is needed to determine their relevant strategy, select the proper tools and ways for development and innovation – considering the right balance of the incremental investments and the expectable efficiency-increase due to that. To support this decision making process familiarizing them and pointing out the ones with the best balance of necessary investment and output is a great support to them. On the top of these it is also important to provide a customised support considering the company's profile and possibilities to avoid some attractive but less relevant expenses for the company.

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