Post-epidemic era—
The Opportunity of smart manufacturing & digital transformation for food industry.

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1. Impact of the post epidemic era

In 2020, the outbreak of COVID-19 around the world has caused great damage to the global economy. Most industries are unable to continue production due to laborer shortage, work stoppages, and eventually resulting bankruptcy. Taiwan has great effort on epidemic prevention, with only few people infected. The output value of the food and beverage industries are quite stable, on the contrary, the epidemic has prompted our food industries due to shifting & increasing demand of the domestic market. Most of the growth were contributed of product types such as ready-to-eat food (canned foods), refrigerated & frozen foods, and health supplements. At the same time, it accelerated ready-to-eat and various online shopping with the integration of take-out service. In order to manage the impact of epidemic, most manufacturers have extended diversified business models, for example, from packaged foods to catering, and vice versa due to increasing demand of food ordering and delivery services. The epidemic restricts social distancing of people by avoiding public spaces and generally limiting their movement. People tend to buy things via e-commerce platforms or community livestream instead of physical shopping. E-commerce are completely blended into our life because uncertain epidemic increases the feeling of unsafety and the impulse buying for self-satisfaction. The impact of the epidemic on the global food supply chains is that panic triggers rapid & large demand on the strategic stockpile industries. The sudden increase in consumer demand overload the orders to food manufacturers and raw material suppliers that creates more & more challenges on food supply chain, flexible production, and employee dispatch. Not only the border control suspension, but also city lockdowns and transportation restrictions affect the food logistics. The epidemic affects shipping schedule, trucks loading process and transportation efficiency that resulting in a global shortage of containers and twice freight costs. The sickness halted the laborer from production and hindered high labor-intensive food industry. Thus, the resumption date of workers cannot be expected and heavily disrupt the supply chains. (FIRDI ITIS, 2021 Food Industry Yearbook)

2. The opportunity

In the past few years, the novel technologies and cross-domain application rapidly change the shape of global industrial ecology. For example, the need for the vaccine accelerated the integration of biology and kinds of intelligent platforms. AI, 3D printing, blockchain, microbes Group and other innovations continuously cooperate with food industry and even renovate

the way it works with artificial intelligence algorithms. Some evolution such as AI links with the Internet of Things and become AIoT, or the application of AR and blockchain expanded to factory management such as logistic or maintenance. This cross-domain technology involves process and quality digitalization, parameter/IO standardization, and on-site status livestreaming that leds the same way as other industries towards industry 4.0. However, the failure to fully integration with innovative tools came from the conservative mind of older generations when facing unknown technologies and uncertain environment changes. We cannot only rely on the ability of SI' s tools such as IIoT to data mining or machine connection, we should develop complete solution that can maximize its value. However, the global epidemic has forced people to accelerate the pace of digital transformation that requires immediate actions instead of a slogan. Solutions are categorized as follows:

a. Unmanned factory: How to reduce labor or remote monitoring by automation to maintain a certain degree of enterprises productivity. Filling and packaging machine, for example, many of them have integrated with bottle conveyer and capping modules. Most of the flexible production applied intelligent secondary packaging technology in the final stage such as cardboard packaging, basket carrier, shrink wrap or other quality inspection modules. By 2021, it has been predicted that the global market of packaging robot will reach 10% of compound annual growth rate. Innovative technology integration has dramatically changed the rules of the game. Others improve or modify the key process equipment, or simply add an automated collaboration platform with quality inspection module such as real-time data collection and visualization - SCADA, which increases product throughput and thereby obtain a greater ROI. The introduction of flexible production technology requires a full process inspection and confirmation of the necessity. To reduce the unnecessary waste and increase the output value. To maintain the flexibility of multiple production lines in the factory by using mobile working stations line and optimizing these combinations. To avoid waste and improve the quality of system production. Most pharmaceutical factories or nearly aseptic filling lines usually produce few for a single package, but takes orders of different bottle types or filling volume. Considering the limited area of the plant and hygiene risk, system integration manufacturers try to integrate clean rooms with the six-axis robotic arm that simulates different processes to become a multi-functional filling system. For example, the AST GENiSYS® R filling system meet aseptic processing standards such as environmental monitoring and electronic batch record reports, and the robotic arm module that can perform different packages conversion within half an hour due to well-integrated with filling weight control modules, bag opening modules, sealing modules, etc. It can easily handle various package sizes and types. The modular system is designed for flexible production based on market demands and orders. The technique requires correct motion matching and synchronization for multiple sets of robotic arms. Mass production requires stabilized flow and accurate filling volume when designing the modular system. Therefore, the Fillomatic Global (FG) Industries designed Robofiller with a robotic arm for dynamic intermittent filling and also equipped with ten filling valves, with an output of up to 200 bottles per minute and can be synchronized with the arm of GENiSYS® R. It can be quickly installed on the linear conveyor belt with positioning,

conveying, cleaning, and packaging functions according to customer requirements that increase flexibility and shorten delivery time (RoboSys is a complete packaging line).

To reduce the people movements, some focuses on the design of pipelines and pumps to transport most of the material, however, it may involve system cleaning and application restrictions. If the automatic guided vehicle (AGV) is used to transport materials, it can increase the flexibility of the production line, improve the quality, and eliminate the waste. The AGV are capable of large and bulk materials, but the site environment must be considered wisely. In addition, to combine with the function of data collection and analysis using mobile devices, not only the required personnel for operations and management can be greatly reduced, but also transmission wires can be abandoned by using wireless transmission – Wi-Fi. The factory information such as production bottlenecks, machine status and shortage alarm can be feeback quickly. In terms of data collection, a mobile cell can be used instead of a scanner to track stock. Through mobile data analysis, manufacturing department managers can distinguish and solve on-site problems without re-entering the factory. The key to the excellent performance of AGV is to accurately locate its position within the factory production area and navigate the route effectively. There are two ways to positioning the AGV: relative and absolute positioning. The absolute positioning is to use the optical method or pre-drawing the track on the map with coordinate system established on the factory floor. In the relative positioning method, a reference point inside the factory must be established for AGV cloud computing. Using tape to control AGV is to lay the tape track and it is easy to install, expand, and low cost due to self-adhesive properties. AGV often integrate with sensing elements to detect the object around and avoid it by programming alternative route or stop moving. However, the disadvantage is that the tape is not suitable for a factory since its floor maybe always humid and easily fall off. If the only purpose of that area is AGV transportation, it will not allow the other things or persons to enter during production and occupy large space inevitably. The optical navigation uses brightly colored tape as an alternative, and the sensor can easily identify the tape path with contrast to the floor color. In recent years, AGV have developed laser detection and ranging technology (Light Detection and Ranging, LiDAR) which has been widely used in auto-driving cars. LiDAR sensors receive laser pulses reflected by surrounding objects and walls, which are used to construct a three-dimensional map of the environment and update it instantly. There is no need to fix the route, and it will recompute when encountering obstacles. It is suitable for factories with complex environments and easily applied in different sites. Tetra Pak packaging production line uses AGV to transport straws and paper rolls.

b. Lower risks of manufacturing supply chain: The development and manufacturing of a product usually apply the PDM. PLM system that includes product design, feasibility evaluation, R&D design, production planning, manufacturing, assembly, and maintenance in its project management model is gradually changing shape. The introduction of PLM has become an indispensable part in enterprise competition. The Kirin Group (Brewery) of Japan create a high-precision and efficient management system for product information that integrates market trends, formula and raw material information, and visualization system of product information that manages about

1,000 products by using NEC’ s Obbligato II PLM. The information also allows internal personnel to share, which further enhances the food safety (NEC, 2009). The PLM solution can optimize seven key capabilities: improve project and document management, specification management, supplier management, formula and raw material management, packaging and labelling management, compliance and product quality management, and data integration capabilities (Oracle, 2008). Among them, the supplier management refers to that many companies cannot track supply chain completely. It is difficult to innovate products and optimize management. PLM enables companies to establish a unified supply chain network, manage suppliers and procurement records from the beginning, and maintain all supply chains with its visibility and traceability.

The obstacles of the supply chain are not only in the manufacturing, the process design, the purchase of equipment parts, and the maintenance are also important parts of the manufacturing supply chain. One of the considerations is how to make a flexible equipment to lowere the risk of missing parts and avoid low production efficiency. For example, standardized communication and interface that also called the “dock architecture” . The main purpose is to create a single I/O connection and let the device more expandable. However, we must consider the overall performance before we configure the correct docking station structure according to the production line requirements. When the devices are assembled with each other without considering the specifications such as communication system, signal reception and transmission, operating speed, the large difference will double the effort to do. For example, Mitsubishi Electric uses the OMAC (Organization for Machine Automation and Control) PackML (Standardized Packaging Machinery Guidelines) template, which complies with the ISA-88 standard (equipment and control module) to construct a filling and packaging platform with package loading modules and filling modules, piston modules, packaging modules, and vertical conveying modules. Due to the unified communication standard and a common control specification platform, it is relatively easy to integrate and modules can be replaced quickly. The second consideration is to avoid the use of dedicated components and customized commercial off-the-shelf (COTS) software. It is worse to become the only customer for special software and hardware provided by a single supplier. Factories usually choose COTS for Manufacturing Execution System (MES) because MES has most of the required functionality. However, considering operation applicability, it still takes a lot of changes for process and personnel. Then, it led to a common conclusion that internal programmer became the only expert of the unique system. By choosing MES that developed from common programming language in the market (such as Oracle or SQL), software engineers will no longer take times to learn new ones. It is the same as the control components which avoid the risk of few stocks for customized design. Commercial standard control components supplier such as well-known manufacturers Siemens & Rockwell can provide kinds of common integrated and expanded parts. For example, the robotic arm can be applied for the secondary packaging such as boxing and stacking. With the product diversity on the market and changes in the retail, the storage system of

beverage factory faces more challenges. A large number of products must be boxed as quick as possible and it led to laborer shortage. Since the robotics technique and related applications become more common in machine tool industry, system integrators have begun to apply robot arms in other industries that does not require high precision to support their labor requirements in warehousing. Most common robotic applications in food industry is carton folding and packaging at docks.

c. Automation (RPA): The status control of warehousing and processing personnel can use the Internet of Things to deploy Bluetooth or RFID connections and other methods and allow the system to link/track materials and production losses. There are many food and beverage factories without the concept of smart manufacturing. Various automated processes and equipment technologies (OT) are different systems and information islands, and their integration obstacles are the complex communication processes involved in cross-systems. The solution is that customized systematic ERP is only the data integration based on IT information. In order to in line with laws and regulations, the comprehensive electronic traceability system already upgraded with information security from raw material supply to the distribution sales. In addition to reducing labor costs, it also increases accuracy and improves data exchange speed. In terms of integration, modules such as energy efficiency, productivity, and production information visualization are mostly used for capital investment operations that can achieve the goals quickly. However, regardless of the level of digitalization, low utilization of data is still the main reason for the lack of effectiveness of digital construction.

d. E-commerce model: Many companies have begun to build online stores and integrate with offline stores to accelerate the deployment of e-commerce. The post-epidemic era continues to affect Taiwan' s catering industry, except for the fact that the profits of the current expansion stores are getting lower and high rents and personnel costs are required. Also, people tend to take out or food delivery to avoid contact with people. However, it may be because customers are far from the shop and no services in that area due to distance restrictions on delivery. Since more people are willing to online shopping, the catering service has established a new business model that expands the source of customers such as cloud ordering and nearby services. It is important to know that most food factories operate in a B2B model with restricted manufacturing orientation, while the catering industry operates in a B2C model due to the different flavors and regular customer recipes. For the relationship between them, we should clarify the target market preference analysis, customer preference orientation, product sales with stock control, and correctly introduce the new business model for digital transformation to effectively increase the company' s profits. Some catering companies began to use smart vending machines as a carrier in their implementation strategies, that is, front-end services, while the back-end uses tools to analyze cloud data and perform inventory control. In the beginning of choosing location, the membership system can be used to obtain relevant information or the POS system can accelerate correct

location analysis. It can also be used with common hotspots such as gas stations and rest stations for location evaluation and testing. Inventory information can be obtained from the cloud management system, and the machines can be adjusted immediately from stores and factories.

3. Starting smart manufacturing & digital transformation

Many traditional food factories are mostly conservative, and the process has no complete procedures and digital control or sensor monitoring. It is impossible to make predictions, so companies are often unaware of emergency and no way to solve the situation. In 2017, the government began the project "The introduction Smart machinery into the industry". In 2021, FIRDI continued to promote the "Smart manufacturing in food industry" and develops kinds of strategic solutions for the food sub-industry. FIRDI categorized each successful case and provide consulting on-site to help the food factory to correctly apply the sensor and its control module, collect the processing CCPs in real time, and improve the production efficiency. By using the intelligent inspection module, the product quality can be used to improve process and lower the manpower to increase inspection efficiency or reduce risk of misjudging.

Digital transformation is different from smart manufacturing, it changes or reshape existing business models by combining digital technology. For small manufacturers or medium-sized enterprises, it already takes challenge to introduce the smart manufacturing and retrieve the key data that often referred to food quality. When digital transformation requires the key data mentioned above to help recreate/reshape a new business model, it is quite difficult and out of manufacturer's ability. In response to the trend of global digitalization and the wave of digital transformation, the government start the "The project of assistance for SMEs by using cloud service and digital transformation in food industry" in 2021 to promote the digital transformation.

In terms of planning and promotion, FIRDI also can provide supports for food industry lean production, flexible manufacturing, product customization, service innovation, experience innovation, or international marketing by cooperating with the corresponding associations of the food sub-sector to hold seminars and workshops. FIRDI IT IS team also collect international industry successful case studies to assist manufacturers to turn their minds and take lessons from these cases, and conduct presentations on the promotion of digital transformation for each sub-sector. Through questionnaires, in-depth corporate interviews, data analysis, and expert meetings, FIRDI complete the survey of digital transformation and talents requirements in the food industry. FIRDI also create kinds of courses of digital cross-domain competence for managers and develop a digital transformation evaluation form. Like smart manufacturing, FIRDI also visits the factory on-site and plans a suitable transformation plan based on the digital maturity of the factory to help SMEs find new customers and create new services. Then, to promote their transformation of business model and accelerate the innovation of corporate value.

4. Conclusion

The COVID-19 indeed accelerated the introduction of smart factory or digital transformation. Whether it is smart manufacturing or digital transformation, it is essentially the data mining to improve competitiveness and significantly increase productivity. However, how to effectively use tools is a big challenge. Finding obstacles and gaps are difficult for manufacturers to confirm whether the technology can consistently detect problems in the company or factory. In addition to the above digital integration and data analysis interface consulting services, Food Industry Research and Development Institute (FIRDI) also provides intelligent integration and production function verification services. FIRDI can assist system architecture diagrams revision, equipment and process configurations validation, and intelligent monitoring platform setup with the functional specifications especially the quality monitoring and database analysis for the product transformation or new product formula development. FIRDI can provide sensory evaluation technique, worksheet connection, blending inspection, optimization of process CCPs, inline sterilization value calculation, filling system performance analysis, etc., that help confirm the correctness of the on-site visualization and accelerate the smart manufacturing and digital transformation.

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