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Application of Digital Visualization in Traditional Manufacturing Transformation

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At present, when traditional industries process a large amount of data and key data are combined with specific technologies and management skills, a lot of manpower is required for data processing or decision-making work analysis. However, within the background of information technology, sensing components and various decision-making calculations are mature, and a manufacturing system that uses a large amount of advanced sensor software of the graphical user interface (GUI) and hardware systems of, for example, photoelectric, registration mark, color and luminescence, pick-to-light, and temperature vibration sensors can become more and more intelligent and capable of replacing some human expertise. Intelligent manufacturing is expected to improve the efficiency of the whole production process, provide timely production technology, complete the production schedule, control the accuracy of the delivery date, and devise effective countermeasures in accordance with market changes at any time. Therefore, a digital transformation system solution is proposed for enterprise problems or the development of bottlenecks, so that the digital level of the entire industry operation can be improved. Therefore, it is expected that Microsoft's Power Business Intelligence (PBI) can be utilized to visualize and present the data imported from Excel, allowing the production data to be transformed into easily readable charts. This enables the real-time monitoring of on-site information, ensures the proper material coordination, and achieves Just-In-Time (JIT) production. By adopting this approach, enterprises can easily implement intelligent manufacturing, improve work efficiency, reduce the cost of acquiring visualization systems, and enable managers to have real-time insights into the current operational status of the company. This reduces the need for substantial investment in funds and manpower, allowing companies to allocate resources in accordance with their needs and accelerate the transformation into the era of smart manufacturing.

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1. Introduction

With the expansion of the business scale of enterprises, the disadvantages of enterprise management are gradually being revealed and found to somewhat affect the healthy development speed of enterprises. Therefore, in the development of enterprises, enterprise data have been accumulated over a long time. Will these data become complicated at the execution level? Such complicated old data and the ever-increasing amount of new data may cause low-level managers to develop inefficient and low-quality working methods, making it impossible for corporate decision-makers to quickly obtain effective data and information for the development of the company. Therefore, enterprises need visual management to improve the level of on-site management, cultivate autonomous employees, optimize the on-site working environment, and prevent or eliminate various hidden dangers. This is the development trend of modern enterprise management. Small- and medium-sized enterprises are the main force of Taiwan's manufacturing industry, and the accumulation of past experience has spanned a long time and delved deeply, with immeasurable amounts of data and information having been amassed. However, most companies still do not collect big data, and cannot immediately aggregate and analyze statistics from various sources of data. As a result, they cannot control the progress of on-site operations in real time, resulting in problems such as production shortages, shutdowns, wasteful waiting time, and delays in delivery, owing to the lack of real-time and effective information feedback. [1–3]

Data visualization is a simple and fast way to express complex information with a large amount of data. In this form, it is easier to understand complex meanings. The advantage of visualization is the expression of the desired information graphically in the shortest time. On the other hand, factory operations are carried out sequentially using production machines. It is necessary for field operators to operate the machines to identify key bottlenecks. This not only wastes time and manpower, but also prevents the ability to understand and handle the subsequent production performance, output, control of quality, and manufacturing issues. Therefore, many companies expect to achieve smart manufacturing and software system coordination by introducing a variety of packaged software systems. At the same time, a visualization application that can display information in real time allows the overall production process to be effectively grasped in a timely manner.[4] Therefore, current data visualization is a way of expressing complex information with a large amount of data quickly and easily. It is no longer merely the expression of digital data, and it enables us to quickly understand complex meanings. Therefore, it would be effective to transform the massive amount of available data into a visible form and to express the desired information graphically in the shortest time possible. The resulting improvement in the decision-making response would greatly increase the operation efficiency of a company.

However, most of the visualization software used in the industry is a set of general-purpose functions,[3] which are expensive and take a long time to build. Small- and medium-sized enterprises cannot all apply general-purpose functions of the visualization software to the production line. As a result, the traditional manufacturing industry cannot purchase or use visualization under the condition of limited resources. It is a pity that visualization cannot be

realized. Therefore, if it can be customized or integrated with a company's existing systems [such as Microsoft Power Business Intelligence (PBI)], it can assist the manufacturers based on traditional manufacturing that suffer from insufficient resources and make good use of its flexibility and rapid response characteristics to target the visualization.(5) The problem, combined with the practical needs of the production process, is to reduce the labor burden and cumbersome processes when the system is introduced and to shorten the time consumed for collecting, analyzing, and compiling statistics, thereby turning the enterprise toward smart manufacturing and visualization.(6)

Therefore, the main purpose of this study is to design and implement the functions of real-time system monitoring and data capture, which can assist supervisors to collect on-site operation information, and to present a visual and explicit interface to realize real-time monitoring and systematic management of production lines, integrated with industrial automation products.(7) On the basis of the business behavior of different companies, visualization can help to establish an automated production line with a smart manufacturing process structure, and at the same time, provide a reliable basis for optimizing production scheduling, allowing companies to realize information-based, visual, and real-time on-site management, and to improve the overall on-site manufacturing efficiency. The optimization of manufacturing methods is based on the improvement of on-site work processes, the collection of smart manufacturing machine data, and the use of smart factory detectors, smart input devices, and more sensor parts. The basic-level data are transformed into visual manufacturing information. After the collected Internet of Things (IoT) data is effectively received, the benefits of visual manufacturing information can be monitored in real time. By clear data link analysis and system structure application, effective data can be provided as analysis reference. On the basis of manufacturing management experience, combined with the actual needs of customers, a manufacturing management visualization platform has been developed. The platform is mainly used in production, equipment, and quality management, and provides managers with functions such as production process and manufacturing progress analysis, machine maintenance, real-time reporting of abnormal conditions, failure analysis, and records of use to improve production and management.(8) With the permission of the management personnel, the data can be viewed through a liquid crystal display (LCD) screen to understand the dynamics of the production information. Managers can clearly grasp all production information, which can reflect the actual situation of production capacity and quality in real time, and make full use of the benefits of overall management. At the same time, the management effect can be directly extended to the operation site to achieve smart management with no time difference.

2. Materials and Methods

The main purpose of this research is to design a visualization function to collect and analyze information, so that timely progress information can be provided visually in real-time in order to grasp the overall business and production status, enabling the reduction of various waste, costs, and personnel. In order to achieve the research purpose, we use Microsoft's visualization tool PBI as the core of development. Although small businesses cannot use large-scale enterprise

resource planning (ERP) to collect information on all documents, existing company forms can be used for information cascading by optimizing the internal process operations and defining the time and content of each maintenance form operator. Finally, BI tools are used for the integration of data. In addition to making data into an information situation board for management, additional detailed analysis can be performed, allowing the management to quickly understand and grasp situations and make immediate decisions.[9]

There are currently three data visualization systems: Tableau, Microsoft PBI, and FineReport. Founded in 2003 and made public in 2013, Tableau is the gold standard in data visualization. Therefore, Tableau is suited to medium and large enterprises with sufficient funds and sufficient manpower. Microsoft PBI, a product from 2013, quickly became Tableau's strongest competitor after its appearance and has surpassed it in many ways. PBI is compatible with Microsoft's product suite, such as Azure, SQL, and Office 365, and it is widely adopted in the market. For enterprises already using Microsoft products, it is a popular and accessible choice for getting started. Therefore, PBI has a significant cost advantage compared to Tableau. FineReport by FanRuan is a rare vendor that can rival Tableau and PBI. It was launched in 2006 and has primarily focused on the Chinese market, as well as Japan, Korea, Taiwan, and Southeast Asia. It holds advantages in marketing and promotion, information collection, report printing, openness, localized learning resources, and service support. As a system for creating diagrams and visualizing information, FineReport offers dynamic chart visualizations that provide real-time displays. This allows managers to easily and quickly understand and analyze data and information. With the current digital IoT big data trend, there is extensive collection of data with more information being continuously obtained. The fifth-generation mobile network (5G) has become prominent, and it has developed into a new topic of the future. Information visualization enables enterprises to quickly respond and make the best decisions, thereby enhancing managers' ability to grasp the overall operation of the company through information data. It has become an important challenge in addressing the digital IoT. Therefore, we use PBI as the main system, which is convenient and easy to learn, widely used in the market, and inexpensive to develop and design.[10,11] Affordable BI is available to everyone, since PBI Desktop is provided to users at a low monthly price. BI and analysis capabilities can be provided to everyone in a cost-effective manner. PBI will enable the entire organization to propel the data culture to completion. With PBI, it is easy to build business applications and automate workflows, turning data into insights and actions as shown in Fig. 1.[12]

3. Results

First, the data and items displayed by each unit must be understood. Obtain the data collected by the user unit every day, and ensure that the data provided are correct. Classify the data provided by each unit to analyze and display the desired information. Then, we enter the visual dashboard and report module pre-built by the management supervisor to identify the problem from the visual information. We can also obtain the state of progress and the production schedule that the unit requires through the online management page. As a result, the operation of the company can be effectively managed, and at the same time, a reliable basis for improving the

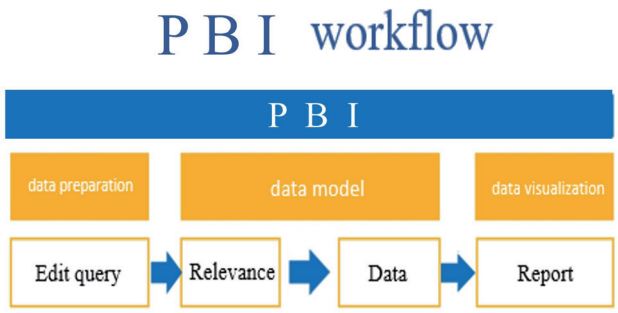

Fig. 1. (Color online) Practical application of PBI data analysis and visualization.

manufacturing process can be acquired so that the company can realize information collection, visualization, and real-time control of the production line, and improve the production efficiency of the factory site. PBI is an operating program provided by Microsoft for free, so it can be installed on Windows OS. PBI provides various functions and technologies that can be used for layout planning, data collection and classification, analysis, and output of the required information and results.[13] This software includes loading/querying from data; thus we can design associations and build models for data sets, then design and develop visual reports desired by relevant personnel, and finally publish the report results and the data for relevant personnel for analysis and judgment. Therefore, in the stand-alone version of the PBI software, most of the work of the data analysis process can be completed. Therefore, in this study, we analyzed and categorized the data based on four aspects: procurement of materials, factory working hours, machine progress, and overdue accounts. The process involved data connection, data cleaning/transformation, establishing relationships/analysis, and designing visualized reports. The content of the report was continuously adjusted and revised in response to market changes, as illustrated in Fig. 2.[14]

Also, the company's existing machine production management worksheet in Excel was used to import data. After generating a file that can be previewed on the right side of the display, confirm whether the draft data were successfully imported. After adding the text management header file, we used the card function to upload the required date, number of orders, number of customers, and number of machines into the text management header file, labeled the columns of the draft data as "material stocking percentage" and "assembly completion rate", and loaded them into the bar graph to create the visual information of the machine production progress, as shown in Fig. 3. Next, we used the text card and stacked histogram functions to add the visualization of working hours management, as shown in Fig. 4. we establish a visual diagram of overdue accounts management, as shown in Fig. 5.

After the final category order number, customer name, machine name, estimated delivery date and other information have been imported into the text management header file, all personnel can grasp the real-time progress status and detect whether there is any abnormality from the on-site display. After the above process, the four items of production machine progress, purchased materials, factory working hours, and overdue accounts are finalized and classified

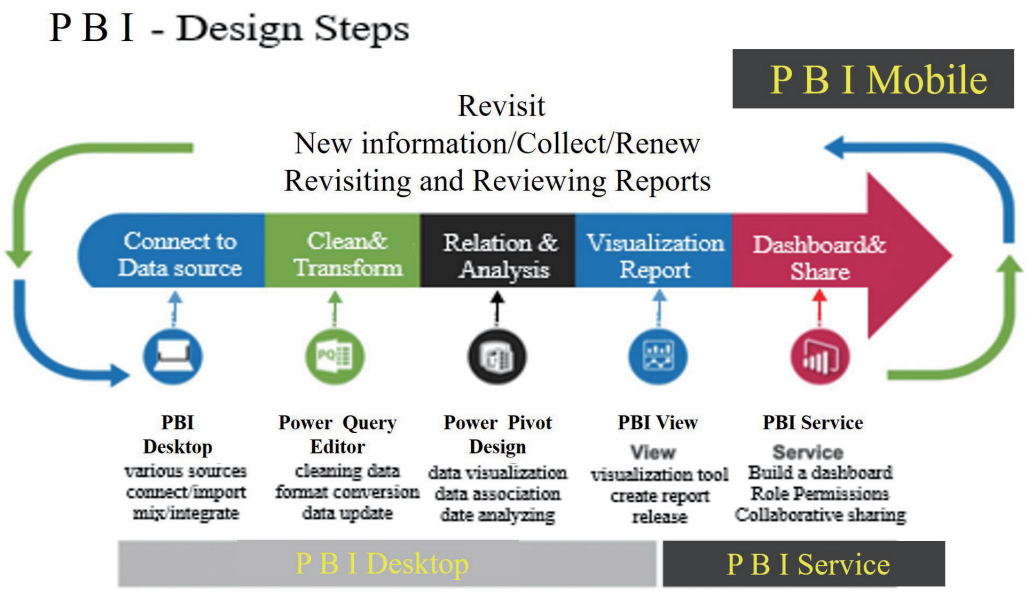

Fig. 2. (Color online) PBI design steps.

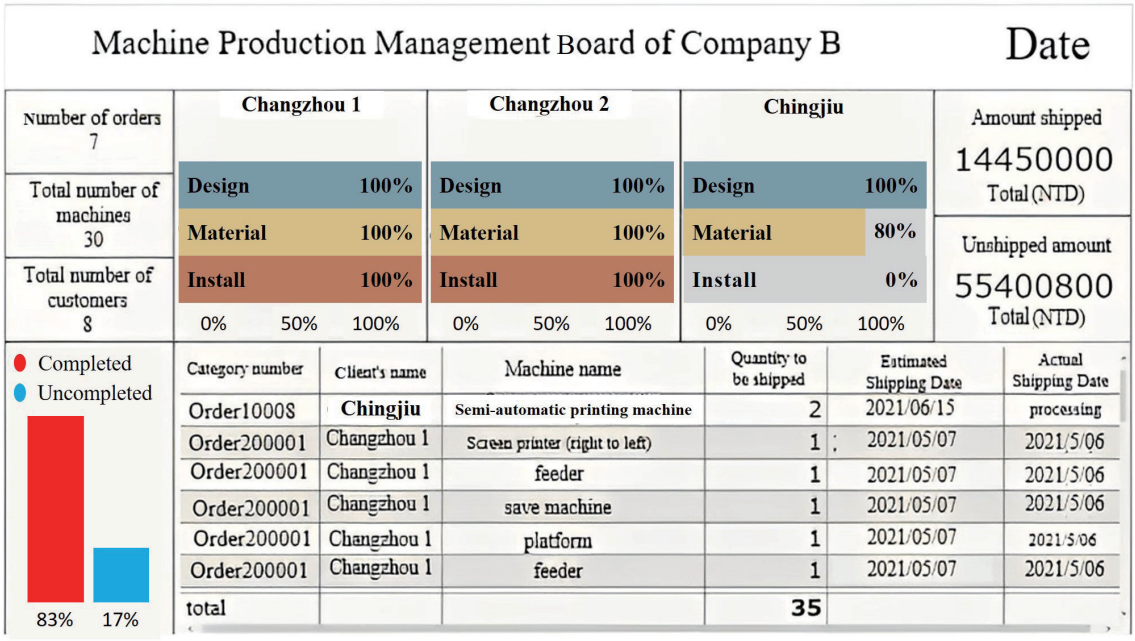

Fig. 3. (Color online) Created visualization of management of production.

and connected to data, converted into a unified format, established and analyzed, and the required information is identified. After the visual display of each unit, the operation and management board is compiled to allow the supervisors of each unit to submit reports on key projects and items that should be reviewed and improved, so as to shorten meeting times and improve efficiency. The integrated design of the visualized information is shown in Fig. 6.

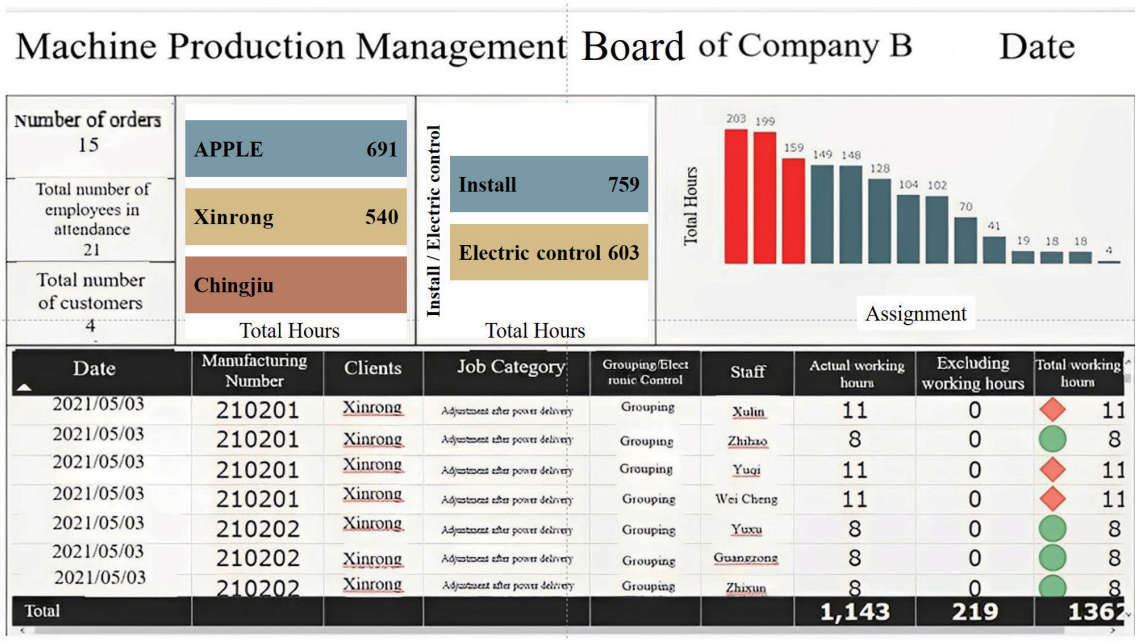

Fig. 4. (Color online) Visualized management of working hours.

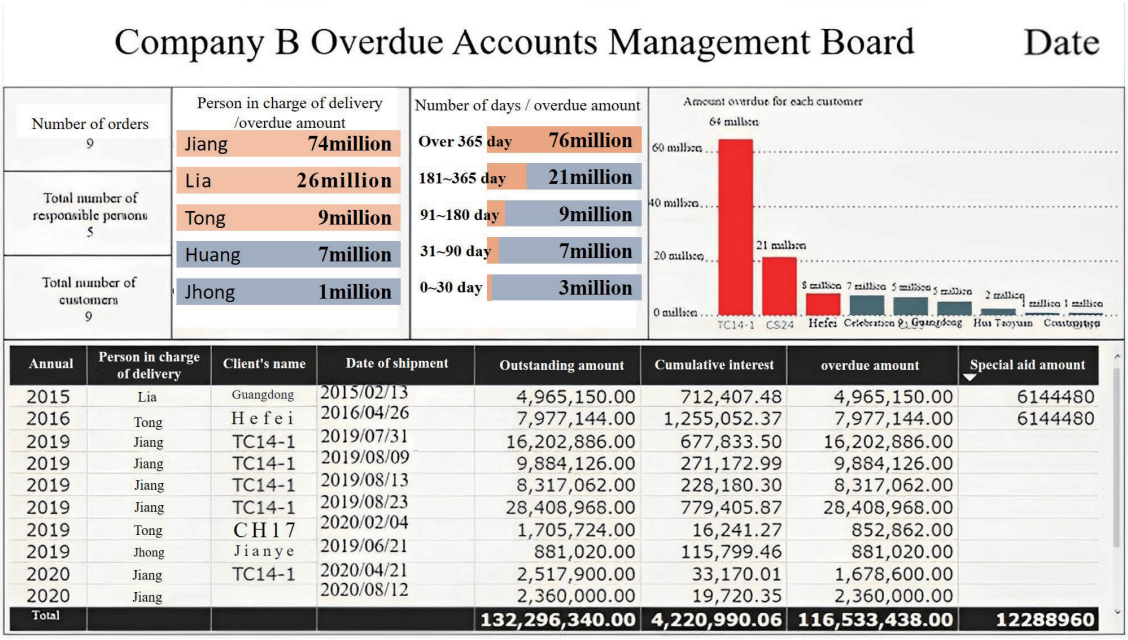

Fig. 5. (Color online) Visualized management of overdue accounts.

There are numerous reports to refer to for on-site manufacturing, but the filling out of those reports requires mostly manual sorting and data input, which cannot be combined with the actual work order. Moreover, the information is for the current day's production that must be completed in the next day or later.[13] Only after manual sorting and input of information can we

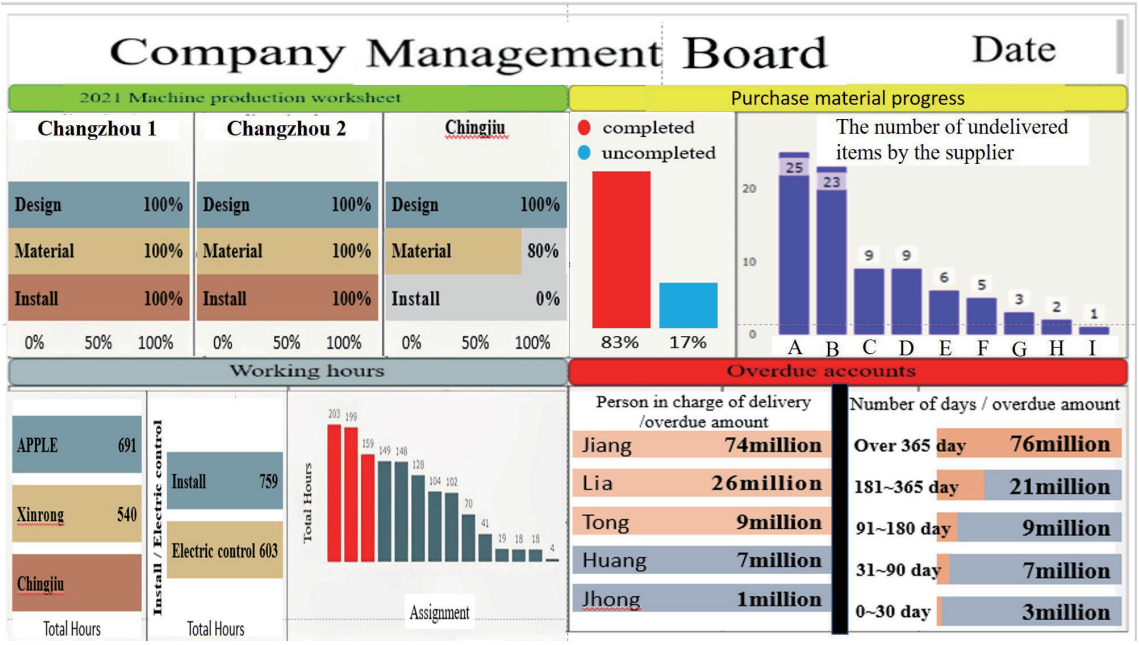

Fig. 6. (Color online) Visualization of overall management.

know the production progress of all the factories. Consequently, mastery of the information seems to be 1 to 2 days behind in actuality. Therefore, determining the required materials is the key factor in overall progress. Accordingly, we start with the control of the incoming materials and make a visual board. The data for daily incoming materials is input and transferred to the office PBI board once the materials are dispatched. Staff can access the information of the desired material without the need to ask for permission. Effective arrangement of the work progress is unhampered, the on-site assembly is improved, and work stoppage due to lack of materials is reduced. In this way, when actually observing the production line, the progress of assembly can be clearly grasped from the daily production situation displayed on the machine progress board. Sales personnel also can instantly grasp whether the delivery will be on time, and feedback the information to the customer. The production staff data, in addition to providing cost statistics, can also be analyzed and improved to reduce waste. Finally, the overdue account items that concern managers are included in the operation management board because they affect the use of the company's overall funds. Thus, managers can directly obtain the desired information from the visual board, control the company's overall operating conditions, and improve the delivery time. The management of delays and shutdowns related to materials is also moving towards smart manufacturing.

4. Discussion

The visual display produced by the visualization system in this study has a considerable effect on production line capacity improvement, but there are still many areas that need to be

improved. The results of this study mainly provide some information for senior executives to understand the situation and make decisions quickly, reduce wasted time and cost, and grasp the timing and response to the market. The current changing world trends, the changes in the COVID pandemic situation, and the lack of raw materials can change the development and future progress of enterprises at any time. Unfortunately, funding and the ability of small and medium-sized enterprises (SMEs) are inadequate to develop the described production processes. Therefore, digitization and smart visualization, which can be adjusted to the changing market at any time, are used to improve the situation. Thus also allows SMEs to complete the work even with only small amounts of funds and resources. It is hoped that with these results of visualization, SMEs will be able to devise quick and simple ways to optimize their structure in the transformation process into digital visualization, so as to efficiently lead SMEs toward the era of Industry 4.0.

5. Conclusions

This research was mainly motivated by the fact that, although the performance of traditional industries is the first among peers, it is a pity that the order, production, procurement, and delivery information cannot be grasped and coordinated in a timely manner, resulting in a shortage of materials, shutdowns, delayed delivery, and loss of high profits. Therefore, on the basis of a company's characteristics and operations, on Excel data of the actual work on site is used to create digital visualization boards. From the fixed weekly business meeting held for half a day, the production progress cannot be accurately grasped. Digital visualization boards are optimized so that the management supervisor coming to the site at any time can understand the situation, thus enabling senior executives to make adjustments and decisions in real time, which greatly reduces loss and waste. Then the following can be achieved: (1) increased production capacity, (2) shortened delivery time, (3) improved quality, restructuring of the production process, production of high-quality machines, and maintaining a leading pace in the industry. What kinds of change will be brought about by the introduction of "business visualization?" The answer is visible information and strategy to motivate employees in the following ways. (1) The transparent management direction can attract ambitious job seekers to join the company. (2) Coherence of the awareness and cognition of the problem. (3) Instant grasp of the production status and ability to quickly deal with customer complaints and other dynamics. (4) Transition from post-remedy to proactive management. (5) Thorough implementation of internal control systems and regulations. (6) Fair and impartial evaluation of employees. (7) All staff can face the work from the perspective of the operator. (8) Improved cooperation among employees and departments. (9) Daily stimulation of employees' thinking ability and resilience. Therefore, for the advancement of SMEs, it provides an impetus to keep up with Industry 4.0 and smart manufacturing and to use limited resources effectively to stay in tune with the trend of the times and not be eliminated. Smart operation connects internal and external production, the environment, and operation information; integrates supply chain information; provides management with various operational strategies and operational visualization through big data application and combinations of automated processes, and assists supervisors to make better and

faster decisions. Especially now because of the COVID pandemic, many things have changed. The ways of doing business will also need to be changed and upgraded. When ways of thinking change and the market shifts, retaining old ways of thinking leads to stagnation and decline. In order to judge whether a company is good or bad, we must observe a variety of situations. A good company is able to respond to rapid changes in the market. A crisis is a turning point, and we hope that the current crisis will motivate us to venture beyond our comfort zone. Many companies want to complete the planning of the entire production system all at once and move towards smart manufacturing Industry 4.0, but the high cost of building the system, the long-term establishment of materials, and the need for personnel education, training, and follow-up services have caused these companies to stagnate. Staying as is will result in losing the opportunity to transform to digital. Making good use of existing simple and frequently used systems does not require too much expense, but can improve the company's environment and help senior executives grasp the current situation and take countermeasures in a timely manner, giving rise to hope and enthusiasm for the future. We believe that in the future, and that more SMEs will successfully enter the era of the IoT.

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