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An Investigation into Refining Accuracy of Business Quote Estimation by Digitalization in Small and Medium Manufacturing Enterprises in Japan

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Abstract. Many of Japan's small and medium manufacturing enterprises (SMMEs) are referred to as "subcontractors", meaning that they are contracted by certain prime contractors to process parts or manufacture a portion of their output. These SMMEs are in a difficult business situation because they have little bargaining power with prime contractors and unable to raise the fees charged to them. Under these circumstances, Digital Transformation (DX) for business sustainability is attracting attention. In this paper, we analyzed each of process leading to the creation of new value, focusing on factors such as human resources, data, business functions, and inter-business information linkage in four companies that are advanced in the use of DX. As a result, we found that all the cases had one thing in common: they were all working to improve the accuracy of their estimates. Based on these results, we will discuss how the DX process should be implemented for many SMMEs with weak price negotiation capabilities.

Keywords: DX, G-RD, Price negotiation capabilities.

1 Introduction

Many of Japan's SMMEs are referred to as "subcontractors", meaning that they are contracted by certain prime contractors to process parts or manufacture part of their work. SMMEs have weak bargaining power against prime contractors, and despite the recent rise in consumer purchase prices due to inflation and the COVID-19 pandemic, they are unable to raise the fees charged to prime contractors and subsequently have been exposed to adverse changing business conditions [1]. Under these circumstances, DX for business sustainability is attracting attention. Some SMMEs have reported advanced cases in which they are not only improving internal efficiency and utilizing data by introducing new digital technologies such as the Internet of Things (IoT), but also creating new value including new business development [2]. Conversely, many SMMEs have only been able to progress as far as developing visual representations of manufacturing processes, due to discrepancies such as lack of management understanding of IoT, on-site resistance from staff, and lack of engineers [3].

In this paper, we analyzed each process leading to the creation of new value, focusing on aspects such as human resources, data, business functions, and inter-business information linkage in four advanced companies. As a result, we found that all the cases had one thing in common: they were all working to improve the accuracy of the price estimates for manufacturing jobs they gave to prime contractors. Based on these results, we will discuss how the DX implementation process should be approached for many SMMEs with weak price negotiation capabilities.

2 Research Methodology

2.1 Preliminary Research

Regarding research on DX and IoT utilization in SMMEs, Kondo [2] introduced a business model that moves from demand to supply as a competitive strategy business model for IoT utilization. However, he did not describe the acquisition of resources as being up to the supply side. Iwamoto [4] introduced a case study of utilizing IoT in SMMEs and pointed out that some of the reasons for the lack of progress in IoT utilization include the lack of IT knowledge in management. The study also made recommendations on how to introduce IoT but did not mention the process of business improvement focused IoT utilization.

2.2 Research Scope

This study analyses examples of DX initiatives in SMMEs, including advanced companies that have succeeded in transforming their business models, and considers the resources and processes required when SMMEs use digital technologies to create new businesses.

2.3 Research Objective

This study focused on SMMEs that are engaged in the piece processing industry. They receive processing fees for processing raw materials owned by other companies (Japan Standard Industrial Classification). This paper surveyed four companies that created new businesses based on the data obtained from DX. Company A is an industrial coating company. Company B is an ultra-precision metal processing company. Company C is a pipe and sheet metal processing company. Company D is a precision parts processing company. The research method consisted of a literature review [1, 4-9] and interviews relating to company practices (March and September 2023), content analysis, the processes of business re-engineering through IT. Also covered within this study was company processes of data accumulation and human resources.

3 Analysis of Company A

3.1 Summary of Company A's Approach

Company A is a small to medium-sized industrial coating company founded in 1973. The president has been concerned about a labor shortage within this industry in recent

years. To address this concern, the company's president began utilizing digital technology to improve the quality of human work. The company's DX progressed in the following order. It started with developing and implementing office management software, followed by the production management software, production management system, technical support system, and then, when development had concluded, selling the system to other companies [9].

3.2 Human Resources Overview

The company's DX has been a top-down operation led by the president. The president had experienced work within an ICT vendor company as a Systems Engineer (SE). He and another newly hired SE handled the system development. However, there was some resistance to the utilization of digital technology amongst the staff members on site. To address this, the administrative staff, which were the first to be introduced to the new digital system, relayed their experiences to other employees, telling them that utilizing it would make their work more efficient. When introducing the production management system to the worksite, the president personally explained the system to the workers until they understood the necessity of the system and became proactive in its introduction. This shows the importance of IT literacy in management, recruiting advocates of the system within the company, and gaining the ascent of the worksite staff for the introduction of DX in SMMEs.

3.3 IT Related Business Improvement and Effectiveness

(1) Simplification of Work Slip Preparation Work

In the past, a schematic was used to prepare job slips, which is work intensive and often necessitated starting work before the slips were completed. Also, when multiple orders were received from the same customer, they were combined on the same slip. Subsequently, using the new office management software, handwritten sketches were scanned and stored as data on one work slip. This eliminated the need to make similar sketches repeatedly. And by reducing the time required to create work slips, design and documentation processes flow together, helping to predict time to completion.

(2) Improving Accuracy of Delivery Date Estimates

In the past, the processing time of individual parts varied widely, and the delivery date estimate for work had to be based on the experience of staff. To refine this process in the new system, the company used production management software to collect and analyze data on customers, types of machining, and working hours. From the work time data, it became possible to derive the time required for each process, enabling the creation of highly accurate process plans and a somewhat accurate delivery date estimate. In addition, the order value for each processing method was clarified by comparing the likely profits of a job with the work time required.

(3) Maintenance of Master Data

A production management system developed in-house was used to input a set of Bill of Materials (BOM) data, production and process control data, and detailed coating data. By properly managing coating data, work standardization, and progress monitoring, productivity improvement and quality improved. In addition, the linkage with the design BOM enabled efficient ordering of materials. Compiling a history of estimates has enabled an accurate understanding of the gap between estimates and actual costs.

(4) Centralized Management of Equipment Operating Status

Data on the operating status of machines was collected using self-developed devices and cameras, and the operating status was made visible on a single screen. This data was used for quality control and work order design, and thus production efficiency was improved. The data on equipment condition and coating also made preventive maintenance possible. Currently, the company is selling an equipment monitoring system that packages this expertise for use by other company.

4 Analysis of Other Examples

4.1 Company B

Company B is an ultra-precision metalworking company founded in 1964. Because of the company's high-mix, low-volume production, there was little information on which to base estimates. And the company had to rely on “Kan, Keiken and Dokyo” which means experience, intuition, and nerve. In order to make estimates based on data, the president herself attended a programming school and deepened her understanding of IT. Then, in cooperation with an outside vendor, she built a production management system. More than 10,000 parts and design drawings were registered in the production control system, and the necessary information was organized at the design stage. In addition, the system enabled the collection of work time data using tablets and process control to grasp lead times and calculate man-hours. As a result, it became possible to grasp the data on which estimates are based.

4.2 Company C

Company C is a pipe and sheet metal fabrication company founded in 1952. The company uses a cell production system, with one person performing all work for each production job. As a result, the time required to complete a product and the quality of the product varied depending on the skill of each worker. To improve this process, the president, who is knowledgeable about IT, and a newly hired SE developed a production management system. The system collects data for each worker, including attendance, production orders, warehouse inventory control, process defect management, production performance management, quality control, and status analysis. Lead time and cost per product were clarified, leading to improved delivery estimation operations.

4.3 Company D

Company D is a manufacturer of machined precision parts established in 1981. The company competes to offer the lowest bid to clients for each production job. Therefore, bids require a thorough knowledge of market prices and price fluctuations at different times of the year, and the company tends to use “Donburi kanjo” which means to go with a “gut instinct” to make estimates. The president wanted to automate and control the estimates process, so he developed a system to support estimates through an industry-academia collaboration. This system made it possible to automatically create estimates from drawings based on the data accumulation. The standardization of the

estimates system has succeeded in reducing workloads. Currently, this estimates support system is being marketed to other companies.

5 Current Concerns

Fig. 1 summarizes the results of the analysis of the four companies' digital applications.

	IT Related Business Improvement	Effectiveness	Overcoming business discrepancies to DX		
			IT knowledge of management	Utilizing IT personel	Understanding from worksite
A	In-house development of production management system		○		
	Recruitment of new SEs			○	
	Input a set of BOM data, production and process control data, and detailed coating data.	Work standardization, Consistent quality Understanding the gap between estimates and costs			
	The president personally explained the system.	The workers understood the necessity of the system			○
B	The president deepened her understand-ing of IT	The president can now speak with outside vendors as an equal	○		
	The collection of work time data	Grasping the data on which estimates are based			
	Development of production management systems in cooperation with external vendors	More than 10,000 parts and design were registered in the system and they can serch on tablet		○	
	Taught mainly young employees how to use the system.	Eased resistance to DX on site			○
C	Recruitment of new SEs			○	
	In-house development of production management system		○	○	
	Collection of data that varies by personnel (attendance, production orders, warehouse inventory control, etc.)	Lead time and cost per product were clarified, and estimating operations improved			
	Evangelist system	Connecting management and work site			○
D	System construction by industry-academia collaboration		○	○	
	Introduction of NC machine tools	Reduced employees' resistance to DX			○
	Standardization of quotation mechanism	Reducing the burden of estimating work			

Fig. 1. DX measures and effects of the four companies

Fig 1 shows that there are many commonalities between companies. In terms of resources, (1) management understands IT. (2) they are utilizing IT personnel from inside and outside the company, and (3) they have gained the understanding of the worksite, all of which have overcoming business discrepancies in common. In terms of the business improvement process, all four companies have in common that they are aiming to improve their estimate processes.

Specifically, they are proceeding with DX in the following steps.

(1) Reviewing order information and other administrative operations to produce effective IT solutions.
(2) Improvement of worksite operations, such as prediction of processing costs.
(3) Supporting worksite improvement utilization of IT.
(4) Accumulated data utilized for estimate delivery.

Focusing on estimate delivery, functions, databases, and information linkage are expressed using Global Relations Diagram of function and demarcation(G-RD) [10]. as shown in Fig.2.

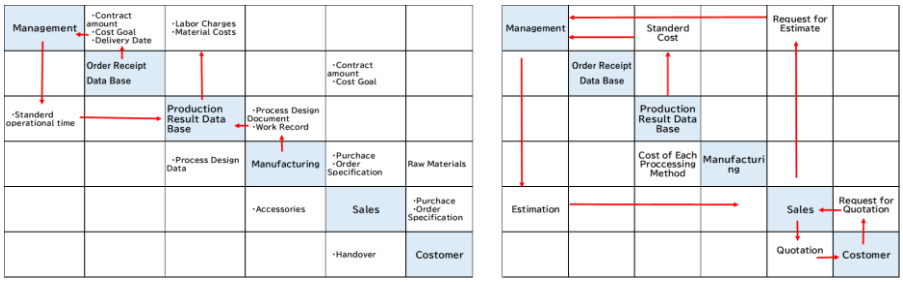

Fig. 2. G-RD of correcting production result data and utilizing that for estimations.

In the lefthand diagram of Fig. 2, it shows the G-RD when the production control software was introduced, and the manufacturing performance data was collected. The target cost calculated from order information and the actual cost based on manufacturing performance have been accumulated, and the difference between them can now be grasped. In the righthand diagram of Fig.2 shows the G-RD that utilizes the manufacturing performance data for estimates. The accumulation of manufacturing performance data has clarified the estimated amount of work for each processing method.

6 Conclusion and Discussion

This paper shows that the pursuit of improving the accuracy of estimates is the first step toward DX, based on a comparison of four advanced case studies. If SMMEs focus their issues on improving the accuracy of their estimates, they will inevitably determine the type of data they want. By improving the accuracy of estimate delivery, SMMEs will be able to negotiate prices based on data. In the future, we will clarify the DX implementation process and necessary items regarding the improvement of estimations accuracy, from the type of data required and data collection such as master data, to analysis and estimate feedback.

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