DESCRIPTION AND EVALUATION OF SERU PRODUCTION SYSTEM WITH S-F SCHEME

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Abstract
A seru production system is a new manufacturing method developed in Japanese industry. Its essence is removing out traditional assembly conveyor lines and adopting them into mini-assembly units, called seru, a Japanese word for cellular organism. However, until now almost reports about seru production system were from Japan and be not well known in the world. It motivates us to make a comprehensive research to totally investigate seru production system. S-F scheme is a four dimensional paradigm of Substance-structure-form-Function, to show different sides and different features of a thing, qualitatively and quantitatively. We try to use S-F scheme to describe the seru production system, and provide a clustering approach to proof its correctness. Here we collected all the published materials about seru production system, including books, journals, newspapers and websites. 276 factory cases are picked up from the materials. We also select 194 key words from the title of the articles that could be considered to describe the feature of seru production system well. Then a factory-keyword table can be obtained. Clustering those keywords into a S-F scheme based groups then we can describe systematically what be the seru production system, and several insights are proposed.

Keywords:
Seru production system, real case analysis, S-F Scheme, clustering.

1 INTRODUCTION
A seru production system is a new manufacturing method developed in Japanese industry. Its essence is removing out traditional assembly conveyor lines and adopting them into mini-assembly units, called seru, a Japanese word for cellular organism. A detailed introduction to seru production system and its managerial mechanism can be found in [1], [2], [3], [4], [5]. In Japan, many successful stories of seru production system were reported in the literature ([6], [7], [8], [9]). However, it can be observed that those reports were from Japan and be not well known in the world because they were written in Japanese. It motivates us to make a comprehensive research to totally investigate Japanese seru production system. In this paper, first the consideration and method for surveying data about seru production system be discussed in detail. Then the collection’s results are reported. Several discussions are presented based on the results from the collected data. We also provide a clustering analysis based on a S-F scheme to describe systematically what be the seru production system.

The paper is organized as follows. Background and several related researches are presented in Section 2. The consideration and method of how to survey the data of seru production system are discussed in Section 3. In Section 4, we show the results and discuss the feature of seru production system from the selected data. Finally, several remarks are concluded in Section 5.

2 BACKGROUND
Generally, market, technology, labour and corporate organization underwent substantial transformations since the emergence and early diffusion of the Fordist paradigm in the beginning of the 20th century. However, further developments and adaptations brought about variant systems better suited to the new business and competition circumstances contributing to prevent the obsolescence of this approach. The evolutionary emergence of derivatives such as automated transfer-lines, mixed-model production lines, and robotized flexible assembly lines are nowadays common applications in many industrialized economies, has contributed to sustain the efficacy of the strategy of splitting the process and building production lines in which parts and products are transported by means of belt conveyors. However, as consumption patterns become increasingly sophisticated and manufacturers strive to improve their competitiveness not only offering quality products at competitive costs, but also by providing broader mix of products and keeping it attractive by launching new products in succession, the turbulence of the markets has intensified. This fluctuating nature alternative production system supposed to enable them operations more responsively under such circumstances [10]. Since the 1990s, Japanese manufacturers were faced with a decreased market demand and increased product variations. To survive in such an extremely tough business environment, the traditional high-volume conveyor assembly line was no longer fulfilled. Speedy adjustments were needed to handle transitions in product models and demands. A company’s competitiveness was becoming dependent on whether or not it can respond to these transitions. In such an environment, there was a trend in Japanese industries toward converting conveyor assembly lines to more flexible manufacturing system, seru.

In a seminal field study on the trend of shifting from conveyor line production to seru [11], the initiatives taken in the electronics industries by firms like NEC Nagano, Yamagata Casio, Olympus, Pioneer and Santronics have been reported. Similar conversion cases in plants dedicated to assembly of printers, digital cameras, digital video cameras, and module parts for digital electric equipment also have been reported [12]. It has been claimed that many manufacturing managers in Japanese companies seem now to realize that the advantages of the conveyor lines no more pay off the adoption of this type of production system design. Since the 1990s, Japanese companies have been actively introduced seru production systems, which handle small-lot multi-kind production more efficiently than the belt conveyor assembly line with the resultant advantages of a marked improvement in productivity, reduction on capital investment, shortened lead times, saving of manufacturing work space, improvement in product quality, and so on.
On the other hand, as for the physical configuration of serus, quite often they are designed in resemblance of the U-shaped lines, which are notably developed from 1960s on as a means to build streamlined flow (by a layout configuration that assures a more rational materials flow than the functional layout), enable one-piece-flow, reduce work-in-process inventory, and nature work in small groups as well as workers’ multi-functionality. Naturally a question is could we say that seru is different to the traditional cellular manufacturing? Several researchers made comparative studies and listed up a lot of differences of seru and cellular manufacturing, to try to proof that seru is a new production system (for example see [6], [7], [8], [9]). However, it seems not so successful, because many similar technologies are used in both seru and cellular manufacturing system.

Moreover, it should be pointed that seru production system is not suitable to be used in all kinds of manufacturers. In some environments where the conventional assembly line outperformed assembly cells in a plant that assembles television sets had been reported [13]. The environments occurred when conversion also results in an increase in task time or other loss of efficiency in the assembly cells. For example, the performance of the assembly cells used in Volvo’s plant was inferior to the more traditional assembly line system [14]. It means that seru or cellular manufacturing system may exist in many configurations and more researches are needed to understand the factors that determine when and where certain configurations are applicable.

Consider seru production system is following those previous innovations in past decade, it cannot be distinguished wholly to other manufacturing methods like as cellular manufacturing, assembly cell, short assembly line. However it totally represents an improved production system and gives its own special characteristics in a whole integration. Therefore a fundamental investigation into Japanese seru production systems to clarify the features of seru production system is very interesting and important. The purpose of this paper is to make an issue table including all of Japanese factories where seru production systems are adopted. You can find any issue and related data about seru from the table. For example, input a keyword like ‘reducing manpower’ into the table then those companies who reported reducing manpower successfully be listed up. And the related information of those companies can be represented. As a useful example, we make a clustering analysis based on a S-F scheme to describe systematically what be the seru production system. We will provide the issue table into a Web site so that a common research platform (benchmark) of seru can be established and used by anyone.

3 METHODS

3.1 Research approach

Fig. 1 shows the consideration of our approach. In step 1 we list up and collect all of published materials from Japanese books, magazines newspaper and websites, also recently published articles in English. Then in step 2 we make a two dimensions data table in where the row shows the issues to represent seru production system, called keywords. And the column shows the reported factories. Keywords are selected subjectively and will be recognised rapidly when a new factory is added into the table. There are maybe a lot of keywords first be picked up however many of them are disappeared in next step. A clustering approach is used in step 3 to group keywords into several concepts, which can describe seru production system in a uniform framework, by using a S-F scheme (a four dimensions description framework that will be introduced in next subsection). We can report this opposite approach of S-F scheme to obtain different groups that show the different features of seru production system. Finally only those keywords can describe seru production system very appropriately should be picked up in the table. And the keywords that be not recognized wildly will be disappeared from the table. At step 4 of Fig.1, we check if there is a new factory should be consider. If there is a new one then add those new keywords and factory into the table, and check them whether or no noticed in listed factories and add 1 for the factory who recognized it and 0 otherwise. It is a hard work because such operation should be repeated every time when a new factory has been added and there are hundreds factories have reported their successful stories. We need to find a more effective method (for example text mining method) to complete the selecting process. Finally at step 5 a database indexed by factories and keywords has been obtained. We can use it to do any kind of study on seru production system.

\[\begin{align*}
1 & \text{Collect published materials from Japanese books, magazines, newspapers and websites} \\
2 & \text{Make a factory-keyword relationship table} \\
3 & \text{Grouping the keywords into different categories which responses a S-F scheme} \\
4 & \text{Is there a new factory?} \\
5 & \text{A database can be made as a research platform to study seru production system}
\end{align*}\]

Figure 1. Research Flow.

3.2 S-F Scheme

S-F scheme is a four dimensions analysis framework of Substance-structure-form-Function, a useful tool to evaluate the behaviours of an organization developed by Korozawa [15]. As shown in Fig. 2 for describing a thing, Substance(S) presents the subject of thing to show what is it and what should it be. For example, it can be used to show the philosophy and the features of seru production system [16]. Structure (s) presents the frame of thing which is decided by our mind. that means we can define seru production by using the systematic concept. For example, seru production system can be recognized as a new system shakes off traditional belt conveye assembly line. However, because structure shows the combinations of elements in a set and frame of thing it has a special characteristic of isomorphism, to say different substances may have same structure. For example, it can be observed that many similarities exist in assembly line, cellular manufacture and seru production system. Form (f) presents most efficient gestalt to achieve our objectives of introducing seru production system, for example to response changing market demand quickly, flexibly and efficiently. Different form may response different objective, so that seru production systems may have several different forms [17]. Finally, Function (F) presents the
operations of seru production system, to say what it does [16]. For example, reduce manpower, space, inventory and leadtime; increase moral of workers and product quality; quickly response to market and so on.

Moreover, S-F scheme has a nested structure in where an upper element of S-F scheme can divide into an lower S-F scheme. An example was given by [15] is adopted in Fig. 2, Substantial (seru production system) is one element of the upper S-F scheme. It can be divided into a sub S-F scheme, by using the thing (Substance); system (structure); historical gestalt (form) and practice subject (Function). We should give the meanings to describe what the features of seru production system. Then by using this characteristic of S-F scheme, we can induce general principles from those published materials about seru production system. And we are also able to use the defined S-F scheme to check and find what is a defect in the seru production system. That means the S-F scheme can be used to construct seru production system newly (inductively), also can be used to find a defect in a special seru production system (deductively). That is why we try to use S-F scheme to describe and evaluate a seru production system.

<table>
<thead>
<tr>
<th>F(function)</th>
<th>f(Form)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>Flexibility</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S(Substance)</th>
<th>s(Structure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seru Production System</td>
<td>Off Belt Conveyer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F(function)</th>
<th>f(Form)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice subject</td>
<td>Historical gestalt</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S(Substance)</th>
<th>s(Structure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thing</td>
<td>System</td>
</tr>
</tbody>
</table>

Figure 2. The S-F Scheme.

### 3.3 Data collection

There are a lot of successful stories to introduce seru production system into their factories were reported in Japan, through different medias. Several factories were reproted numerously, sometimes as a news and sometimes as a technical report. Our purpuse is to collect the real cases of factories who intruced seru production sysyem into their factories successfully. And to analyze what is and should be seru production system by using those real cases. Until now, there are hundreds publications about seru production system in Japan. Collecting them is not an easy thing. Our collection method is a conventional one. We first collected books about seru production, then checked the references in the books to find the factory real case. If the case is reported in a magazine, then checked the magazine through the past years from 1990s to find other factories. we also checked industry related newspapers and website by using keyword search. Keywords are like ‘seru’, ‘seru production’, ‘yataki production’, ‘ one person complete assembly’, U-shaped line’.

In our research only published materials are collected. That means only successful stories of seru production system are gathered and discussed. On the other hand, questionnaire about seru production system is also a considerable approach. In fact several reports are presented based on their own questionnaires [6] [7] [8], and not only merits but also demerits can be collected by the questionnaire. However, the questionnaire is limited on the questions so that is not appropriate in our research.

### 3.4 Key words selection

Then keywords were selected from those publications, to show what are the features of seru production system. There are hundreds published materials and because there are their own cultures in Japanese companies that leads the same thing may be described in different terms. For example, keyword ‘productivity’ has been mentioned in many factories therefore it should be selected as a key word. Note we do not care how many is productivity increased because they are depended on their own market and production environments. Also it can be considered that productivity may be not a initial keyword because it may be combined by a lot of operational keywords like as lead time, due date; inventory; space and so on. However, how to select a word as a key word is very difficult. We pick up the noun words from the title of the articles and those words which were appeared frequently in literature and recognized being important subjectively.

### 3.5 Make a factory-keyword table

Then we make a two dimensions data table in where the row shows the keywords to represent the characteristics of seru production system, and the column shows the reported factories. The data in the table is a \{1, 0\} variable represents whether is the keyword appropriate in the factory. We scan the publications to find what key words are appeared in or not, and put 1 into the table to show those keywords which reported in the paper. If there is a new factory should be consider to add some new keywords and the factory into the table, then we check it whether or no noticed in the listed factories.

### 3.6 Clustering

Here we used a well-known cluster method to group the keywords by using an index of similarity. Similarity is the frequency of the keyword has been reported to describe seru production system. The more the key word used the more factories, the larger the frequency. Once the similarity coefficients have been calculated for keyword pairs, we can obtain a keyword similarity matrix. Then a clustering algorithm can be used to group the keywords according to the similarity in a descending order starting with the highest value. This procedure continues until all keywords have been combined into one cluster. Note several similarity coefficients and clustering algorithms can be used, and what clusters have meanings is not depended on them, we try to use all the similarity coefficients and clustering algorithms provided by SPSS software to find different feature of seru production system.

### 4 SOME RESULTS AND DISCUSSION

As a undergoing result, Table 1 shows that there are over 1500 published materials have been collected. Those materials cover almost publications on seru production systems in Japan. 276 factories were selected from those materials in where 8 factories of Canon; 6 factories of NEC; 5 factories of Sony; 5 factories of Panasonic and 4 factories of Ricoh were included. It can be observed that almost electronic manufacturers in Japan were adopted their conveyer assembly lines to seru production systems. And great performance improvements were achieved successfully. The trend of those publications in electrical factories is shown in Fig.3, it can be observed that articles of seru were presented from 1992 and reaching a peak in 2004, and constantly presented after then. Consider those successful cases reported in literature are just a part of Japanese manufacturers who adopted seru production systems, we can say it is a trend of that the seru
production systems are often adopted in Japanese manufacturers as an usually used improvement approach. Based on those materials, a comparative study should be taken into account for conventional consideration of seru production system and also those like cellular manufacturing, buffer assembly line and other approach to achieve better performance in their factories. It is one of our future works.

Table 1. All of the published materials in literature.

<table>
<thead>
<tr>
<th>Publication Types</th>
<th>Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journal paper</td>
<td>227</td>
</tr>
<tr>
<td>Companies report</td>
<td>13</td>
</tr>
<tr>
<td>Newspaper</td>
<td>745</td>
</tr>
<tr>
<td>Book</td>
<td>23</td>
</tr>
<tr>
<td>Website</td>
<td>184</td>
</tr>
<tr>
<td>Magazine paper</td>
<td>21</td>
</tr>
<tr>
<td>Cini article</td>
<td>329</td>
</tr>
</tbody>
</table>

Cini: Citation information by NII (National Institute of Information)

There are 196 keywords were picked up from those materials to make a factory-keyword relationship table. It is a big 196*276 table so that several indexes and methods provided by SPSS have not worked on the table. In our experiments 11 indexes and 4 clustering methods can obtain the final results. Then we can get 44 decision trees to describe seru production system with different groups and words. Here we just show a simple example to show how to group those keywords into different categories by a S-F scheme, because the paper limit.

It can be considered that the keywords are mentioned by many factories will have a higher similarities and be grouped into a cluster. Therefore we can use the decision tree to make different clusters that have different meanings. For example, we can describe 'flexibility' as the form of the S-F scheme of seru production system however it may not appear in keywords. It can be considered that the S-F scheme is hierarchical and the upper the class is the more the metaphysical it is. To show the flexibility we can group those keywords as multi-skilled workers; small lot size; changing due date and so on. We can separate those keywords to response the different hierarchical level and different parts of S-F scheme, just like as productivity is the Substance; parallel operation is the structure; layout is the form and multi-skilled worker is the Function. Relieve the distance of the decision tree we can conclude more keywords into several comprehensive groups to describe seru production system in detail. Note the similarity may be changed when a new factory is added so that this procedure will be repeated again, until the final table has been done. In our keyword selecting approach, even all of the evaluation index and clustering method provided in SPSS are discussed, which one is most appropriate for the keyword selection of seru production system should be discussed by a comparison study. How to design and execute the comparative experiments is one of our future works. Also new clustering methods should be studied for achieving the purpose of the platform if the traditional clustering methods cannot achieve it.

5 CONCLUSIONS

In this paper we proposed a novel approach to make a factory-keyword relationship table, to give a comprehensive description of seru production system. We have done several studies on how to evaluate the performance of seru production system (see [2], [17]). Then we found there are many interesting issues in seru production system, not only on productivity but also on such as flexibility; motivation and training; organizational structure; service level and so on. We want to make a platform in which everyone can make his study freely, and compare his results to other researchers. We will open it on network when it has been completed and hope researchers use and improve it in their studies. However, this table is so large that we need to develop a classification method like ABC analysis in inventory control to pick up the words appeared frequently; or a text mining technique to collect the keyword. Those are our future works.

6 ACKNOWLEDGMENTS

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7 REFERENCES


