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Information processing structures and decision making delays in MRP and JIT

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ABSTRACT

Prior literature has asserted that higher supply chain visibility, concerned with better information flow and determining more accurate demand levels within the supply chain at a given time, improves decision-making efficiency. Decision-making efficiency denoted by decision-making delay is in turn dependent on the information processing structure. Different production control systems have different information processing structures. This paper considers the relations between the production control system (MRP and JIT) and the organization structure of information processing that determines the decision making delay. We compare MRP and JIT across different information processing structures and decision efficiency, and find that JIT is suitable for small lot size and large variety production and MRP for large lot size and small variety production. In addition, an optimized organization structure of information processing will surely reduce the decision making delay.

1. Introduction

The resource-based view (RBV) asserts that the competitive advantage of a firm owes to the application of valuable resources (Wernerfelt, 1984). Nowadays a world-class sustainable manufacturing also aims to conserve resources (Dubey et al., 2015). Resource based theorists have conceptualized Supply chain visibility, concerned with information flow and demand levels within the supply chain at a given time, as a capability that may reduce the negative impacts of a supply chain disruption (Christopher and Lee, 2004; Barratt and Oke, 2007; Jüttner and Maklan, 2011; Brandon-Jones et al., 2014), which further influences performance or lead to sustained competitive advantage (Newbert, 2007; Wu et al., 2006).

Supply chain visibility are often associated with supply chain information sharing (Barratt andOke, 2007). In supply chain, more information can be integrated by information sharing (Prajogo and Olhager, 2012; Wong et al., 2015). Many studies have shown that the information sharing could improve the performance of supply chain (Brandon-Jones et al., 2014; Wu et al., 2014). The information sharing can be realized by more closed relationship of buyer and supplier (Narasimhan and Nair, 2005; Yang et al., 2016) with revenue sharing contract (Zhang and Chen, 2013), RFID technology (Nativi and Lee, 2012). Especially, the information system is very important to information sharing (Qrunfleh and Tarafdar, 2014). ERP is a common information system for information sharing (Kelle and Akbulut, 2005). In order to emphasize the collaboration in supply chain, ERP even evolve to ERPII (Koh et al., 2008). Now big data analytics within world-class sustainable manufacturing can obtain superior performance (Dubey et al., 2016). In recent years, big data collected by RFID or Barcode becomes a new research direction in service and supply chain management (SCM), it can provide more information for enterprises to make more accurate decision-making. However, this information is disorganized, so how to deal with the data in production operations is the key problem faced by the business and scholars and they have developed various methods and models to solve the problem. Opresnik and Taisch (2015) report a strategy called the big data strategy in servitization based on the servitization in manufacturing. Tan et al. (2015) develop an analytic infrastructure for enterprises to obtain competitive advantage in big data by deduction graph technique. Wamba et al. (2015) propose an interpretive framework based on the definition of perspectives and the applications of big data to help firms to realize the role of big data. Zhong et al. (2015) seeks a holistic big data approach to excavate frequent trajectory from massive RFID-enabled shop-floor logistic data. Zhang et al. (2015) builds a dynamical

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optimization model for shop-floor material handling utilized the manufacturing data. Dutta and Bose (2015) develop a novel framework for firms to implement Big Data projects successfully. Akter et al. (2016) proposes a BDAC (big data analytics capability) model based on influence of survey data on corporate performance and Wang et al. (2016) provide the SCA (supply chain analytics) maturity framework based on big data. Roy et al. (2011) study the cost estimating model in the automotive industry to obtain the data and information requirements.

In a fast changing market, an expedited decision making process is as important as decision accuracy. In other words, a delayed accurate decision might just be as wrong as an inaccurate one. The traditional information sharing literature has although contributed to decision accuracy, yet it often neglects decision efficiency denoted by decision making delay in information processing. A decision making process is an information processing procedure. The time to process information determines the decision making efficiency. Galbraith (1973, 1977) observed PCS as an organization that processes information. The diversification and frequent changing of market demand make the transmission as well as processing of information in PCSs increasingly important. To make decision accurate and fast, from the master production schedule (MPS) to the occasional production adjustment aroused by market change, it needs prompt, efficient and comprehensive information.

In order to do so, firms are trying their best to acquire information faster and faster. Information and communication technologies provide firms with advanced tools such as RFID to locate every product. RFID are playing an important technical role in helping firms promptly acquire a mass amount of information, which is big data, to make accurate decision. Fosso Wamba et al. (2016) develops a conceptual model and find that the intention of small and midsized enterprises to adopt RFID technology is mainly related to RFID's relative advantage and compatibility, the firm's size and location. In this constantly changing global market, however, prompt acquisition of comprehensive information is far from achieving operational excellence. Firms need to quickly make decisions to satisfy frequent-changing customer demand. The process of making decisions is essentially a procedure of information processing.

Radner (1993) found that the time to make decisions was related to the organization structure of information processing as well as the amount of information. The time to make decision is called the delay of decision making. Therefore, there are two ways to reduce the delay of decision making: (1) reducing the amount of information, and (2) restructuring the information processing organization. Bertschek and Kaiser (2004) focused on the effects of organization-restructuring on productivity from the perspective of micro econometric evidence.

Combined with Radner's view, Stein (2002) explored how well different organization structures performed in terms of generating information about investment projects and allocating capital to these projects, and found that different information types resulted in different organization structures: decentralized approach or large hierarchies. Ricardo and Wouter (2008) compared centralized and decentralized coordination when managers were privately informed and communicate strategically, and showed that a higher need for coordination improved horizontal communication but worsened vertical communication.

In this paper, we take the decision making delay as the measurement of operational efficiency in a PCS: the less decision making delay, the better efficiency. Much more attention has been paid to economic efficiency. However, there has been little literature discussing how organization structures influence the operational efficiency in different PCSs. Segerstedt (1996, 2006) provides a full understanding of MRP decision making. They address the two dimensions of production control: quantities and timing. Gong et al. (2014) had studied the amount of position information by information entropy in different production control system, and concluded that the production control system with smallest amount of information spends the least amount of time decision.

We will focus our research on how the production control system determines the decision making delay in MRP and JIT. The paper proceeds as follows. The two conventional production control systems are presented in Section 2. Section 3 develops two information processing organizations of MRP and JIT and compares their decision making delays. A general model is given to compare the decision efficiency between MRP and JIT. Section 4 makes the tradeoff on the decision making delays and accuracy. A management implication is in Section 5. Section 6 presents the conclusions.

2. Information processing organizations and delays of MRP and JIT for a single product

2.1. Information processing organizations view

For the decision maker or top manager who is in charge of the PCS and wants to know how many complete products can be provided on-time to satisfy purchase-orders, he/she probably needs to use a hierarchal information processing structure organized by a group of managers and operators considering the limited capacity of individuals for information processing. An efficient organization structure of information processing would play a positive strategic role in reducing the decision making delay. In this part, we will use the hierarchies developed in Radner (1993) to shape information processing organizations of different production control systems.

Radner (1993) regarded a firm as a computer and put some concepts of computer science into the definition of the "special computer": the managers and operators engaged in information processing were called the processors; each processor had an in-box, a register and a clock; decision making time was measured in cycles; in one cycle, a processor could take one item from its in-box and added it to its register; the number of units of elapsed time (measured in cycles) between the entry of information and the output of the final decisions was the delay.

The basic construct that Radner (1993) used to represent decentralized information processing was that of a (programmed) hierarchical network of individual processors. Roughly speaking, a hierarchy of processors would be defined as an inverted tree in which the processors were partitioned into levels. There was a single processor at the top of the hierarchy, and, except for the top one, every processor "reported to" exactly one processor directly above it. One processor was the immediate superior of another if there was a direct link pointing upward from the second to the first. The levels were ranked, and if one processor was above another, it was also at a higher level. Fig. 1 illustrates a hierarchical network. The procedure begins with each first-level processor adding its 5 items into its register. After 5 cycles, each first-level processor sends its sum to its immediate superior at the second level. Each second-level processor then takes two cycles to add its two items and send its new sum to its immediate third-level processor. In the following two cycles, either third-level processor add its two items and send its new sum to the top processor. At the end

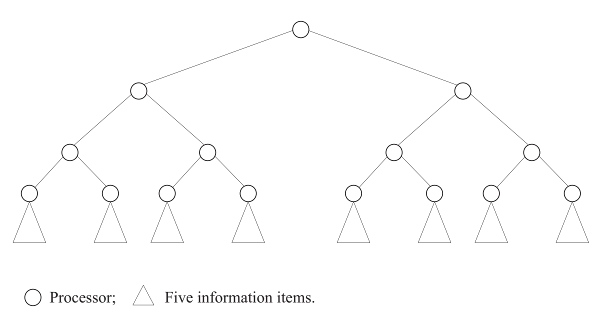

Fig. 1. A hierarchical network with 15 processors, 40 items, and delay 11.

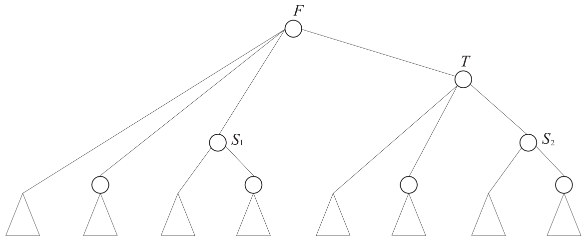

Fig. 2. A hierarchical network with 8 processors, 40 items, and delay 8.

of 11 cycles the top processor puts out the grand total of the 40 items; thus the delay is 11.

In Fig. 1, only processors at the same level can achieve parallel processing. Whether or not processors belonging to different levels can process information in parallel makes a difference to the decision making delay. Allowing for parallel processing among different levels reduces the decision making delay to process information. Fig. 2 illustrates that all of the processors are processing information in parallel during the first 5 cycles.

The procedure begins with each processor adding its 5 items into its register. After 5 cycles, each of the four first-level processors sends its sum to its immediate superior. Each processor except the first-level processors takes one cycle to add its item from the first-level processor to its register. Then processor S_1 sends its new sum to the top processor F, and S_2 sends its new sum to the third-level processor T. In the next cycle, processor F adds its received item to its register, and processor T adds its item from S_2 to its register and sends the new sum to F. F spends the last cycle adding the item to its register. At the end of 8 cycles, the single fourth-level processor F puts out the grand total of the 40 items; thus the delay is 8.

Note that each processor is processing items from its in-box in a serial fashion, whereas processors at the same level are doing their work in parallel. Generally speaking, for a given number of items, increasing the amount of parallel processing (and decreasing the amount of sequential processing) leads to a decrease in delay and an increase in the number of processors. Let Z denote the number of individual processors in the hierarchical network. Given the amount of information, $\overline{N}$, a hierarchical network is efficient if it is impossible to decrease the delay, D, without increasing the number of processors, Z, and vice versa.

2.2. Information processing organization structures in MRP and JIT

Generally, the front-line operators first get the decentralized information about products, and the information must be transmitted to the decision maker or top manager who is in charge of the PCS to make centralized decisions. The decision making delay has much to do with the time for information transmission; to reduce the delay means to reduce the transmission time. Technical tools are important, but we are also in need of helpful operating strategies. Successful operating strategies, for example, Ford's assembly line, can largely enhance productive efficiency.

Upward information transmission can be regarded as a feedback. Besides receiving and adding information delivered from lower levels and transmitting the gathered information to its superior, a processor receives necessary information to perform his/her job or solving problems. The hierarchy of the product structure implies the organization structure of information processing: the complete product concerns the top processor; the more superior processors are involved in the management of the more integrated subassemblies, components, and parts. In the following discussion of this section, we will compare the different structures of IPOs in MRP and JIT for explicit comparison of decision making delays.

MRP is a planning technique and JIT is an execution tool (Lee, 1993). Flapper et al. (1991) developed a three-step framework to embed JIT into MRP. The JIT benefits can be outlined. Ho and Chang (2001) integrated MRP and JIT to address the multi-stage, production-inventory system problem. A key difference between MRP and JIT is the extent to which planned-order-releases are used. MRP schedules the release of work based on demand, while JIT authorizes the release of work based on system status (Hopp and Spearman, 1996). However, the outputs of the two production control systems are the same-timed requirements (i.e. release and due dates, and quantities) for materials, labor and equipment resources. Either MRP or JIT organizes production planning into a hierarchy of long-, medium- and short- range decisions. The decisions differ somewhat because the systems have different objectives (Benton and Shin, 1998). Miltenburg (2001) analyses the computational requirements of widely used algorithms for production planning problems in MRP and JIT, and emphasizes time is the computational resource of interest and the measure of it is computational complexity.

In the present paper we shall consider that the decision is an adjusted prediction regarding how many complete products can be provided timely to satisfy purchase-orders. Each processor at a higher level modifies his/her records based on the components' status information transmitted from its immediate inferior(s) or subordinate(s). Under the condition of identical amounts of information, first-level processors' jobs can be omitted in comparing decision making time delays in MRP-type IPO and JIT-type IPO.

Production planning that essentially can be seen as information processing in MRP and JIT is multi-level, which refers to the bill-of-material (BOM) nature of the items that are being produced. End products are built from Stage III, which are built from Stage II, etc. The MRP and JIT production planning systems are depicted in Fig. 3. Either develops a long-range, aggregate production plan (APP) to ensure that sufficient capacity is available to manufacture product families in quantities appropriate for long-range forecasts. The second level in the planning process disaggregates the aggregate production plan among the end-products in the product families. This is called developing a master production schedule (MPS), and it will include setting a final assembly schedule (Stage IV) when JIT is used. The next level is a detailed material plan for all items. Production is triggered by the material plan when MRP is used, and by 'pull signals' (e.g. Kanban). The aggregate production plan problem does not depend on whether MRP or JIT is used. JIT requires the MPS to be steady and then calculates a steady final assembly schedule to ensure that: (1) the subsequent material plan is feasible; and (2) the JIT mechanism for identifying wastes and making improvements can operate as smoothly as possible (Monden, 1993). Compared to MRP, JIT has almost no difficulty with the material plan. Companies that use JIT follow a principle of 'simplify first' and then plan and execute. Consequently, there is no need for a manufacturing execution system.

As we know, MRP uses planned-order-releases for all items. JIT uses them only for end-products and some purchased items (e.g. commodities which are purchased periodically in large quantities to obtain discounts or better freight rates). All other items are controlled with KANBAN. Miltenburg (2001) considers a simple example to illustrate the difference. When MRP is used, item A along with its components, B, C, D, E and F are produced in response to planned-order-releases. When JIT is used, A, E and F are controlled by planned-order-releases. B, C and D are controlled by KANBAN signals from A and so are dropped from the BOM for the purpose of computing a material plan. This is done by making B, C and D 'phantom' items (Vollmann et al., 2005). So the multi-level BOM in MRP becomes a two-level BOM in JIT and the total number of items in the material plan is $N^{\mathrm{JIT}}=3 < N^{\mathrm{MRP}}=6$. See Fig. 4.

In this paper, we will build-up the information processing structures based on the two different BOMs. The hierarchy of the product structures shown in Fig. 4 implies the organization structures of information processing: the complete product A concerns the top processor; the inferior processors are involved in the management of

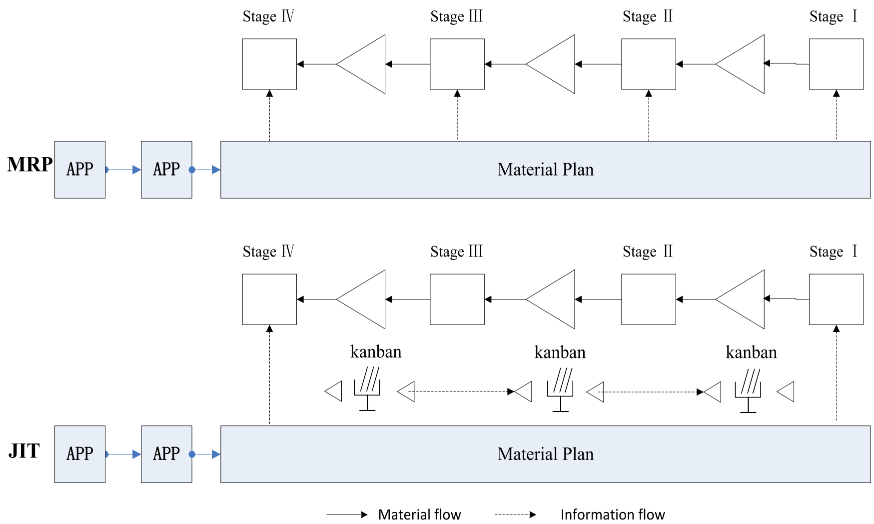

Fig. 3. Production planning systems.

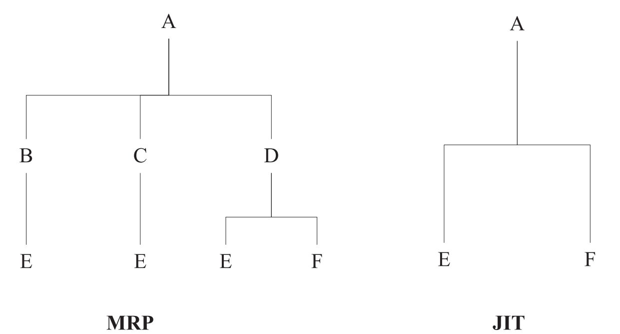

Fig. 4. Bills-of-material in MRP and JIT.

Table 1
Processing Schedule in MRP-type IPO.

Cycle	Working processor (s)	Source processor (s)
1st	B	E1
	C	E2
	D	E3
2nd	A	B
	D	F
3rd	A	C
4th	A	D

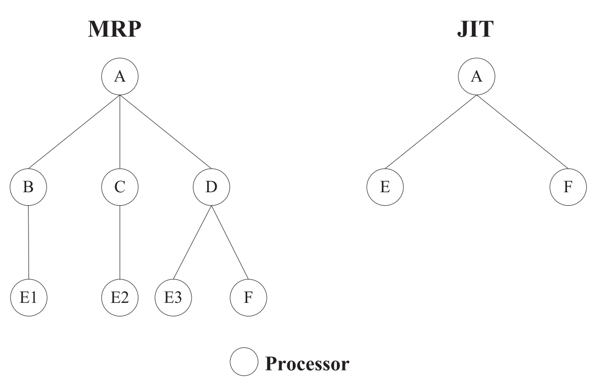

Fig. 5. Information processing organizations of MRP and JIT.

the less integrated components, B, C, and D; the first-level processors, i.e., the front-line operators deal with the items E and F. Fig. 5 shows the structures of MRP's and JIT's information processing organizations. The processors in Fig. 5 are the counterparts of the nodes in the bills-of-material in Fig. 4.

2.3. Decision making delays in MRP and JIT

Each processor except the top one must report to its closest immediate superior at the next higher level. The information processing is similar to the procedure described in Fig. 1. In the first cycle, processors B, C, and D (they are called working processors) are adding the item transmitted from processors E1, E2, and E3 (they are called source processors) to their registers, respectively, etc. At the end of the fourth cycle, processor A puts out the integrated information of the final items. Table 1 shows the processing schedule. In the same way, the information processing in JIT-type IPO takes up two cycles.

For a better understanding of the difference between the information processing in MRP and JIT, here we provide a detailed example of a complete product X. Fig. 6 shows the original product structure.

To produce the complete X, we have two different choices: the MRP production control system or the JIT production control system. The structures of information processing organizations in MRP and JIT are different. Fig. 7 illustrates the structure of IPO in MRP derived from the original product structure with five-cycle decision making delay (the processing schedule is shown in Table 2). While the structure of the information processing organization in MRP is in accordance with the product structure shown in Fig. 6, the simplified BOM makes the structure of the information processing organization in JIT simpler: (1) JIT uses planned-order-releases only for end-products and purchased items at the bottom of BOM(all other items are controlled with KANBAN), and (2) the same purchased items at the bottom of BOM can be shared. In Fig. 6, either item NO. 2 or item NO.7 is part B, and they can be shared in either BOM or the information processing organization of JIT. Fig. 8 illustrates the structure of IPO in JIT derived from the simplified product structure with four-cycle decision making delay.

Radner (1993) noted that the efficiency frontier is approximately $ZD \approx \bar{N}$ for large $\bar{N}$, Z, and $\bar{N}/Z$. The equation expresses that there is a trade-off between the delay D and the number of processors Z. This trade-off is a reflection of the trade-off between serial and parallel processing. With fewer processors, there is a lot of serial processing that causes a large delay. Information processing organizations with more processors enable a lot of parallel processing, which reduces the delay. Harris and Raviv (2002) explained organization structure based on optimal coordination of interactions among activities and noted that the optimal design of organizations traded off the costs and benefits of

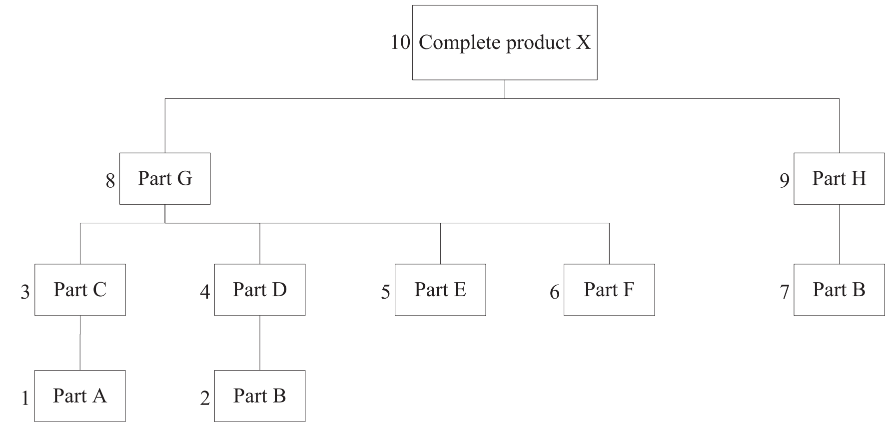

Fig. 6. Original product structure.

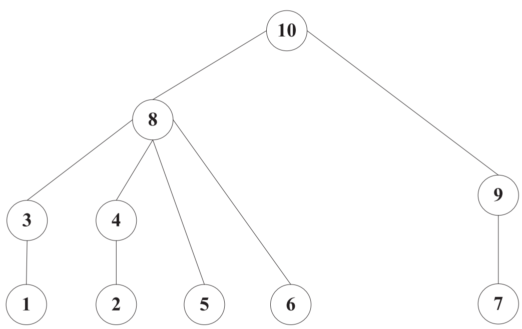

Fig. 7. The structure of the IPO in MRP with 10 processors and delay 5.

Table 2
Processing Schedule in MRP-type IPO.

Cycle	Working processor (s)	Source processor (s)
1st	3	1
	4	2
	8	5
	9	7
2nd	8	6
	10	9
3rd	8	3
4th		4
5th	10	8

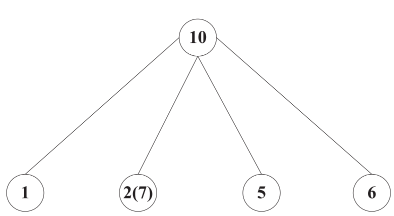

Fig. 8. The structure of the IPO in JIT with 5 processors and delay 4.

various configurations of managers/processors.

Considering the trade-off between the delay D and the number of processors Z, the decision making delays both of MRP and of JIT can be reduced by introducing extra processors into their information processing organizations. Let us introduce a processor numbered 8′ into the information processing organization of MRP shown in Fig. 9 to share the NO. 8 processor's job. Now processors NO. 5 and NO. 6 report to processor NO. 8′ instead of processor NO. 8. The decision making delay is reduced from 5 to 4. Similarly, the decision making delay in JIT's information processing organization shown in Fig. 10 is

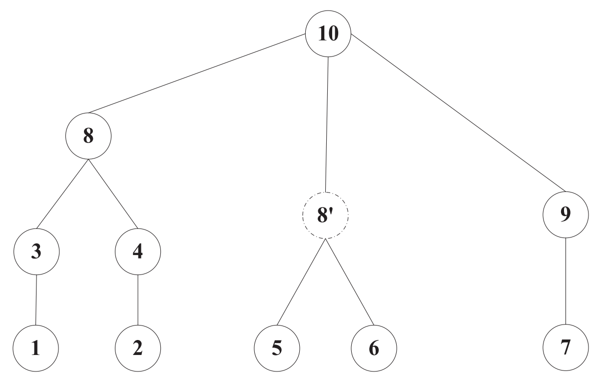

Fig. 9. The improved structure of the IPO in MRP with 11 processors and delay 4.

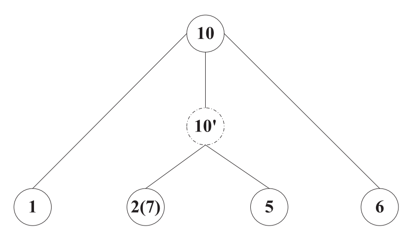

Fig. 10. The improved structure of the IPO in JIT with 6 processors and delay 3.

reduced from 4 to 3 with the help of the processor numbered 10′.

2.4. Products redesign optimize the IPO

Product redesign plans a strong role in reducing the number of part numbers and the number of levels in the BOM. To externalize the product redesign, we assume that there are two models of X: X_1 and X_2. X_1 and X_2 share the part H. Part G for $X_1$is different from that for X_2. With some redesign, the part D became a common part and the part E was common between the two part G models; the methods for part G processing could also be standardized. The product redesign resulted in a streamlined BOM. The number of options from the customer's point of view had been maintained, but the number of parts required had gone down (see Fig. 11).

Similarly, the structure of the IPO in MRP that corresponds to the redesign product structure is illustrated in Fig. 12. In JIT, the redesign product structure will result in an information processing organization structure as Fig. 13 shows. Here, item NO. 2 and item NO. 7 are shared in the structure of the information processing organization too. To be noted, we could introduce an extra processor to share the job of NO. 10 processor to be the immediate superior of NO. 2 and NO. 6 processors in Fig. 12. With the help of the new processor, the time delay will be

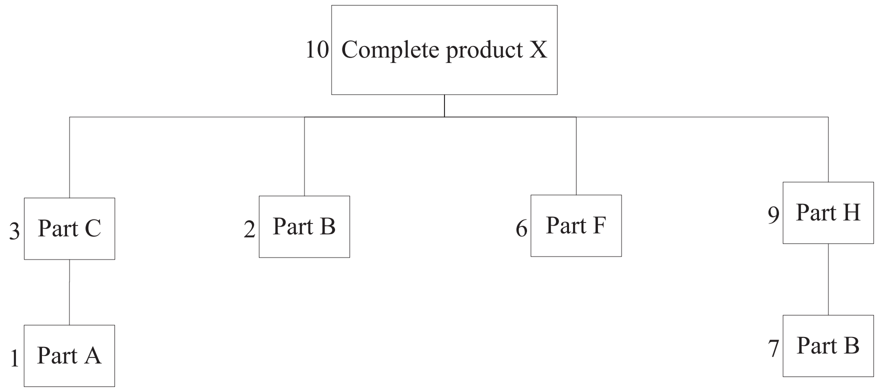

Fig. 11. Redesign product structure.

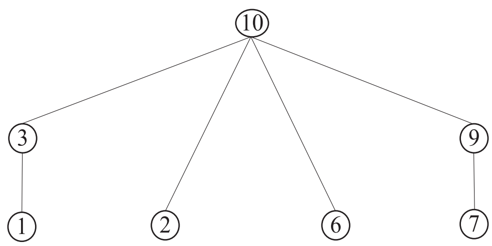

Fig. 12. The structure of the IPO in MRP with 7 processors and delay 4.

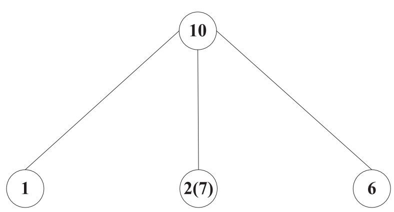

Fig. 13. The structure of the IPO in JIT with 4 processors and delay 3.

reduced from four to three.

By careful comparisons between Fig. 7 and Fig. 12, we will find that not only the decision making delay but also the number of processors has been reduced because of the product redesign: the decision making delay has been reduced by one cycle (from five to four), and the number of processors is cut down by three (from ten to seven). The information processing organization in JIT enjoys the improvement both in time delay and in the number of processors: time delay decreased from four to three, and the number of processors cut down from five to four (see Fig. 8 and Fig. 13). Product redesign benefits both MRP and JIT, and it plays a stronger role in simplifying MRP's information processing organization than in that of JIT. MRP is in eager need of redesigning product structure.

3. The model of decision making delays in MRP and JIT for multi-product

3.1. The estimation of the information items

The number of information items needed to be processed in any PCS has a positive relation to the number of all subassemblies, components, and parts. Specifically, the number of information items, $\overline{N}$ is exponential in the number of all components, N:

$$\overline{N} = aN^b, \tag{1}$$

where $a \geq 1$ and $b \geq 1$. When $b = 1$, $\overline{N} \propto N$.

Suppose that there are x different kinds of complete items needed to be produced. For each kind, the number of components made up of the complete items is $y_i (i = 1, 2, \ldots, x)$. Obviously, the number of all components, N in the PCS will be

$$N = \sum_{i=1}^{x} y_i \, . \tag{2}$$

Furthermore, y_i can be divided into three parts from the perspective of the structure of information processing organizations.

3.2. The comparison of the decision efficiency in MRP and JIT

Generally, for the NO. i items, the number of components in JIT is smaller than that of MRP:

$$y_i^{JIT} \prec y_i^{MRP} \, . \tag{3}$$

In Fig. 4, for example, there are five kinds of components to produce A (they are B, C, D, E, and F) in MRP; while there are only two kinds (E and F) to produce the same item in JIT.

Either MRP or JIT must restrict the quantity of components to simplify information processing to improve the production efficiency. Because $y_i^{JIT} \prec y_i^{MRP}$, JIT could deal with more kinds of finished products at the same time with each kind in small quantity. In contrast, MRP is more suitable to produce few kinds with each kind in large quantity.

Radner (1993) demonstrated that the time delay,D, incurred in making decisions is

$$D = 1 + \log_2 \overline{N}, \tag{4}$$

where $\overline{N}$ is the number of information items. Substitute N for $\overline{N}$ in (4), and we have

$$D = 1 + b \log_2 N + \log_2 a \, . \tag{5}$$

The constant term, $(\log_2 a + 1)$, has a controllable impact on the time delay. The rate of change of the time delay, D, depends strongly on b. Fig. 14 illustrates how the time delay, D, changes with the number of all components, N, when $b = 1$,$b = 2$, and $b = 10$.

A complicated PCS is to export a lot of kinds of finished products, where x is relatively large. The PCS must be operated in a JIT way to reduce the number of all components to limit the decision making delays,D. Similarly, a JIT way is preferred when some finished products are composed of a number of subassemblies (y_i is relatively large). A MRP way can be helpful in a PCS that provides fewer kinds of finished products which are made up of fewer parts. In addition, a smaller b will decrease the sensitivity of the decision making delays,D, to the number of all components, N. Therefore, a smaller b would make it possible for production control systems to be operated in a MRP way which have many kinds of finished goods or a number of components to produce. All the discussions above are illustrated by Fig. 15.

In Fig. 15, we divide the two-dimension (x–y_i) space into four quadrants, and apply MRP or JIT to each quadrant: MRP is applied to the quadrant where x and y_i are both small, and JIT is applied to the

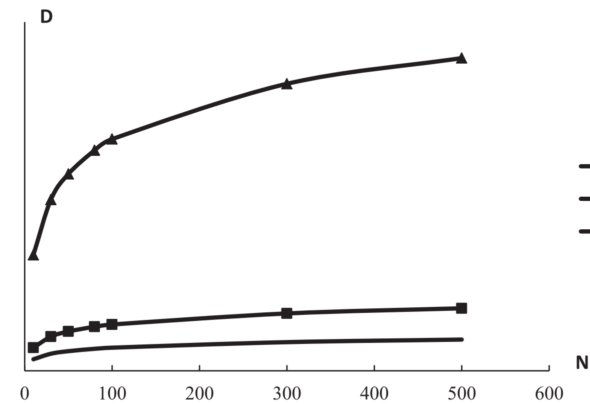

Fig. 14. Information processing organizations of MRP and JIT.

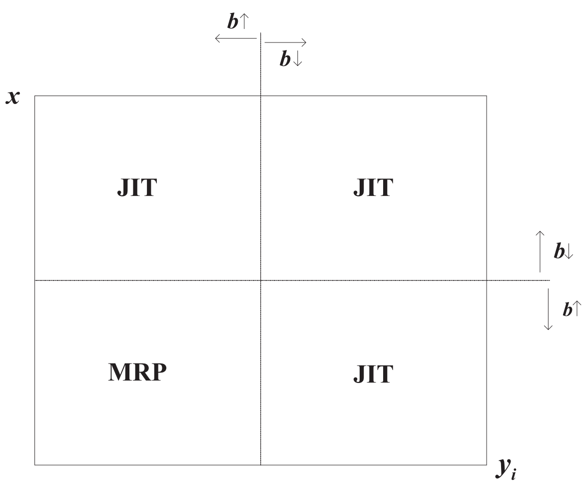

Fig. 15. Information processing organizations of MRP and JIT.

other three quadrants. When there are few kinds of finished goods and a small number of components made up of the finished goods, MRP is a more economic production control system; in contrast, when there are a lot of kinds of finished goods or a large number of components made up of the finished goods, JIT is a preferable choice. In reality, JIT is more suitable for small lot size and MRP for large lot size (Gupta and Snyder, 2009). However, the four quadrants are not immutable, and the power parameter b makes the boundaries between them dynamic. When b increases, the vertical and horizontal dotted lines in Fig. 15 will respectively move left and down to compress the MRP-applied quadrant, and vice versa.

4. The decision making cost analysis

We know that the less information items, the less the time delay. We called this delay cost produced by the time delay. The relation between time delay and the information items can be described by the research of Radner, that is $D = 1 + \log_2 N$。.

The uncertainty is greater when the information items is relatively small, which can lead to inaccurate decision making. The process of decision making can produce an uncertainty cost because of the uncertainty of information, which means there is a reverse relationship between the information items and the uncertainty cost. We define the cost trends to infinite when the information is 0.

From the discussion above, we know that the total cost is constituted by the delay cost and the uncertainty cost, since the information have a compact relationship of the delay cost and the uncertainty. So the function used to describe the relationship of the total cost and the information items is,

$$f(\overline{N}) = \alpha(1 + \log_2 \overline{N}) + \frac{\beta}{\overline{N}},\ \overline{N} > 0,\ \alpha > 0,\ \beta > 0$$

α is the delay cost parameter, β is the uncertainty cost parameter. If the market changes more quickly, the decision making should be faster by processing less information, so the delay cost is larger, that is, the parameter α is bigger. If the accuracy of decision making is more important, it need more information, the uncertainty cost is larger, that is, the parameter β is bigger. We calculate that the minimum value of the total cost is

$$f_{\min} = \alpha(1 + \log_2 \sqrt{\frac{\beta \ln 2}{\alpha}}) + \sqrt{\frac{\alpha\beta}{\ln 2}}\ when\ \overline{N} = \sqrt{\frac{\beta \ln 2}{\alpha}}.$$

Proposition $f(x) = \alpha(1 + +\log_2 x) + \beta/x_{,}\ x > 0,\ \alpha > 0,\ \beta > 0$ is nike function, $f(x)$ gains the minimum value when $x = \sqrt{\beta \ln 2/\alpha}$, and $\exists$ $x_1 \in (0, \sqrt{\beta \ln 2/\alpha})$, $x_2 \in (\sqrt{\beta \ln 2/\alpha}, +\infty)$, $f(x_1) = f(x_2)$.

In Section 4, we have drawn a conclusion that $y^{JIT} \le y^{MRP}$. Suppose that the information items is $\overline{N}_0$ when the cost gains the minimum value, and then $\overline{N}_0 = \sqrt{\beta \ln 2/\alpha}$. When the information items $y^{MRP} < \overline{N}_0$,i.e. $y^{JIT} < y^{MRP} < \overline{N}_0$, we can obtains $f(y^{JIT}) > f(y^{MRP})$. The result reveals that MRP is better than JIT since MRP is with a smaller cost. Obviously, the bigger $\overline{N}_0 = \sqrt{\beta \ln 2/\alpha}$ is, the condition $y^{MRP} < \overline{N}_0$ is satisfied more easily. That is, if the uncertainty cost is big enough, and/or the delay cost is small enough, MRP is more suitable. In other words, MRP is suit for the market which changes slowly and/or needs accurate decision.

In a same way, $f(y^{JIT}) < f(y^{MRP})$ when the information items y^{JIT} and y^{MRP} is more than $\overline{N}_0$, namely MRP have more information items than JIT, no matter how smaller JIT's cost is. Obviously, the smaller $\overline{N}_0 = \sqrt{\beta \ln 2/\alpha}$ is, the condition $y^{JIT} > \overline{N}_0$ is satisfied more easily. That is, if the uncertainty cost is small enough, and/or the delay cost is big enough, JIT is more suitable. In other words, JIT suits the market which changes quickly and/or needs less accurate decision.
$f(y^{MRP})$ is MRP's information items corresponding to the minimum value of total cost, When the information items $y^{JIT} < \overline{N}_0$, $y^{MRP} > \overline{N}_0$,the proposition reveals that $\exists \overline{N}_1 \in (\overline{N}_0, +\infty)$,$f(\overline{N}_1) = f(y^{JIT})$. At the same time $f(y^{JIT}) = f(\overline{N}_1) = f(y^{MRP})$ when $y^{MRP} = \overline{N}_1$, however, MRP has greater information items, the better choice is JIT. $f(y^{JIT}) = f(\overline{N}_1) < f(y^{MRP})$ when $y^{MRP} > \overline{N}_1$, so the JIT has an advantage in cost. In this case, MRP produces too many information items. $f(y^{JIT}) = f(\overline{N}_1) > f(y^{MRP})$ when $y^{MRP} < \overline{N}_1$, the result reveals that MRP has an advantage in cost. In this case, MRP does not produce too many information items.

5. Management Implications

Information sharing can make supply chain decision not only more accurate, but also more efficient. It makes supply chain visible. The information processing efficiency can influence the supply chain visibility too. If the information is processed fast, the information can be shared fast. The supply chain can be visible in real time. Information processing organization view is very important in E-era. It is very interesting to see a firm as a computer. Radner (1993) provided an approach to analyze the decision making efficiency by analyzing the information processing. In Radner's view, the decision making efficiency asserts to the information processing organization structure. In this paper, we analyze the product structure (bill of material) and the two production control systems (MRP and JIT) and build the information processing organization structure for a firm to produce a product in a control system. According to the information processing organization structure, we can compute the decision making delays for each product in any production control system. So we apply the information processing organization view into the production decision making.

5.1. Choose the right PCS

The managers can apply this view to choosing the right production control system. MRP has a simple logic based on the BOM naturally. Whereas JIT has a more complicated logic to control the production via Kanban. Unfortunately, MRP needs more information to make decision, so the decision making time delay is longer in MRP than that in JIT for a single product. If the firm produce large enough variety of products, it is better for the firm to choose the JIT control system, because in JIT system, the information processed by the top manager is much less than that in MRP. If the firm produces smaller variety of products and the production quantity is very large, the firm can choose MRP, because the difference of information between JIT and MRP is small. Through cost analysis, it can be concluded that JIT is suitable for the fast changing market and MRP for the slow changing market.

Previous research observed MRP is suitable for the large lot size and small variety production in a slow changing market and JIT for small lot size and large variety in a fast changing market. We verify this view based on decision making efficiency and cost view. Therefore, from both the production efficiency and the decision making efficiency views, JIT is suitable for small lot size and large variety production and MRP for large lot size and small variety production.

5.2. Optimization of product structure

The information processing organization view can not only be used to choose the right production control system, but also to improve and optimize the product structure. If the product structure can be redesigned, the decision making delay can be reduced both in MRP and JIT. The product redesign should be considered in two directions. One is to reduce the items in the bottom in the BOM, so the information can be reduced. The other is to redesign the structure according to the optimized information processing organization. The minimization of the bottom items in the BOM can be reached by modularization that is currently popular among firms. The idea that the product structure should be redesigned to optimize information processing structure is innovative.

5.3. Improve the decision structure

Processing through skipped levels is equivalent to parallel processing among different levels, which would save a lot of time and processors for IPOs to process information. Managers could improve their organization structures of information processing by reporting through skipped levels to reduce decision making delay as well as the number of processors. At some time, decision efficiency can be increased by introducing extra processors into their information processing organizations.

In this paper, we only open a window in the research about decision efficiency. We believe that this is an interesting research direction. In big data era, a firm want to make more accurate decisions, but in an increasingly changing market, decision efficiency is of the same importance.

6. Conclusions

Considering the differences in product structures of MRP and JIT, we make a thorough observation on different hierarchal networks for the transmission of information called the IPOs. Each processor is processing items from its in-box in a serial fashion, and processors at the same level are doing their work in parallel. In the case of identical amounts of information, we examine the separate effect of organization structure of information processing on the decision making delay and find that the structure of the IPO of JIT is superior to that of MRP in terms of both decision making delay and the number of processors. From both the decision making efficiency views and the tradeoff between decision efficiency and cost, JIT is suitable for small lot size and large variety production and MRP for large lot size and small variety production.

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