Freezing issue on stability master production scheduling for supplier network: Decision making view

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Abstract. In the daily operation, there are frequently changes in customer order requirement which will induce instability of the MPS. Moreover, the frequently adjustment of MPS can induce fluctuation of production and increasing of inventory cost as well as decreasing service level of customer. Most of studies about instability of MPS use freezing method and rolling procedure to adjust MPS periodically. Freezing is the proportion of planning horizon being frozen, whereas rolling procedure is a method replanning periodically of MPS using newly updated demand data. This study is focused on interval freezing length as an issue of decision making. In supply chain, a manufacturer is supported by suppliers to supply material requirement. Since a manufacturer plan production schedule on MPS the freezing interval is determined that will be informed to suppliers which supply the material requirement. In previous research, the freezing interval is decided by manufacturer as necessary decision maker. This decision must be followed by suppliers though it is not beneficial for them. It can be concluded that this condition is no win-win situation. Hence, this research proposes that suppliers will be involved as decision maker besides a manufacturer so the interval freezing is decided by two-side decision maker.

1 Introduction

In uncertain environment, master production scheduling often differs from actual demand. This is happened due to rolling effect and uncertain demand caused by forecast error [1]. Rolling schedule is replanning periodically the MPS depend on replanning interval, frozen interval and forecast window [2]. The MPS changes will have consequences to requirement of material planning (MRP) significantly called system nervousness [3]. MRP nervousness is defined as the significantly changes of MRP due to little changes on MPS [4]. The impact of MRP changes can increase inventory cost and disrupt production activity.

To maintain a stable of MPS is used freezing method that freezes some portion of horizon planning [3]. The portion of freezing can be using either interval freezing or order freezing of the MPS horizon planning. The MPS schedule in frozen interval is fixed whereas the uncertainty of demand as long as frozen interval would be anticipated by safety stock [2]. The variance of MPS planning and actual demand in frozen interval would be a newly data that determines the replanning of MPS for the next period schedule.

In the supply chain system, there are two types decision making namely hierarchical planning system and heterarchical planning system [5]. Hierarchical planning system or hierarchical coordination represent centralized decision making that is achieved by top-level of an organization decision process. Moreover, in order to organize and control the various operation processes the coordination of these activities is a common way in one hand. Conversely, heterarchical approach or decentralized decision making considers an agreement based on consensus between all parties involved in supply chain with different objectives, measures and rules. This approach is called collaborative planning which refers decision making process in decentralized perspective [6]. A decentralized approach will not guarantee global optimum solution. In addition, a decentralized approach can reduce complexity and flexibility of decision making [7].

The frameworks of the relationship between a manufacturer and suppliers are classified into transactional, strategic and collaborative relationship [8]. Moreover, suppliers included in collaboration relationship are strategic supplier. Collaboration proposes the better cooperation of supply chain members to achieve win-win situation in a long term relationship. In addition, collaboration refers coordination of all participants in the relationship to solve some problems together [9]. The other definition of collaboration is a relationship of independence participants to reach more successful [10]. Collaborative advantages is not only the individual partner but also the whole partnership in supply chain structure [6]. The benefits of collaboration are less characteristic variance of component, communication more effective and simple, fewer

document, short lead time, low carrying cost, fixed schedule, low inventory level, faster design changes, and stability of price [11]. Based on stage of production process, there are two stages of collaboration consist of product development and production [8]. Due to this research discuss about production planning of MPS this study focuses on production stage.

2 Previous research

Most of researches solve stability Master Production Scheduling using freezing method can be classified into determining freezing parameters by simulation, freezing variables by mathematic model and planning-replanning model. Some researches determine freezing parameter using simulation for single and multi-level of product [3,4]. Meanwhile, mathematical model to find optimal freezing variables in uncertainty environment are develop to single level of product in single and multi-echelon of supply chain structure [2,10,13]. All of these studies were using rolling schedule planning.

Sridharan et. al. [3] discussed to solve instability MPS by determining freezing parameters using simulation for one item or one product. This study checked three parameters of freezing to the MPS stability such as the freezing method, the portion frozen of MPS and horizon planning length of MPS. The result of this research are freezing portion up to 50% reduce cost significantly and a long interval freezing more costly than freezing based on order.

Zhao and Lee [4] continued Sridharan et.al research included multi-level of product to find freezing parameter. The result of this result are the order based freezing method recommended than that of period based, and the increasing of freezing portion can reduce total inventory cost and instability of schedule, contradiction with prior research result.

Lin and Krajewski [2] defined freezing interval, replanning interval and forecast window based on the solution of mathematical model. Freezing interval is frozen period of each planning cycle which no schedule change are allowed. Replanning interval is an interval between two successive replanning of MPS that determines how often the replanning of MPS. This model is focused on single echelon or a manufacturer.

The study evaluated the effect of integration scheduling to reduce negative impact of schedule revision in two echelons supply chain between a manufacturer and suppliers is developed by Krajewski and Wei [12]. In this study stochastic cost model is developed able to analyze the value of scheduling integration by choosing the optimal variables of freezing interval and replanning interval. The model integrates manufacturer and supplier freezing model in two echelon supply chain.

The two echelon supply chain which consider uncertainty environment is also studied by Sundana and Samadhi [13]. Developing Krajewski and Wei research, this study considers safety level as decision variable than that of previous study as parameter model. Therefore the decision variables are freezing interval, replanning interval and safety stock to minimize total cost of system.

3 State of the art

All of the previous researches decide either freezing parameter or freezing interval in hierarchical decision making approach by dominance position member in supply chain. Based on previous researches about instability MPS in uncertainty environment with rolling schedule, they can be classified into one echelon level of supply chain model and two echelons model. For one echelon level the model can be divided to the model which is define the freezing parameters model using simulation and also the model which is determine the freezing decision variables using mathematical model. In two echelons level, the model determines the optimal solution of freezing decision variables using mathematical model.

Dolgui and Prodhon [14] define the technique commonly used to solve uncertainty environment based on recent studies consist of instability in MRP system and demand uncertainty. There are two actions to overcome instability in MRP system namely action on MPS and lot sizing. Meanwhile, the techniques accomplish the problem of demand uncertainty i.e. action on MPS, lot sizing, and safety stock. The state of the art research concerned about instability MPS can be illustrated in Figure 1.
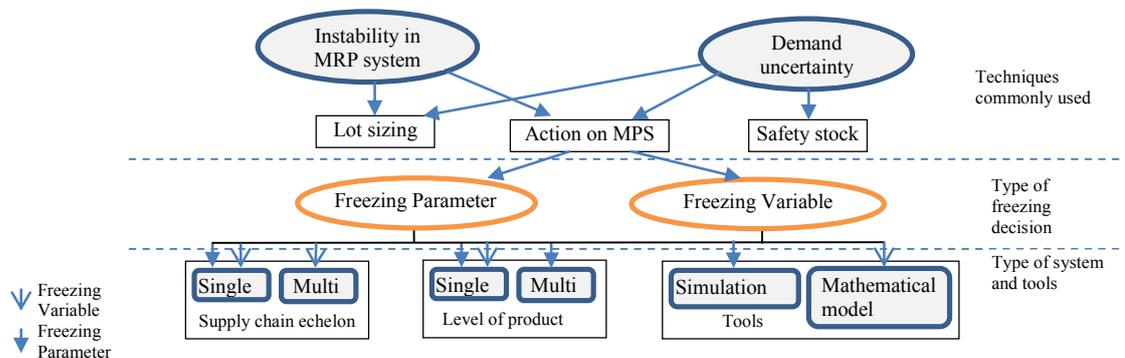

Figure 1. State of the art research on instability of MPS

Table 1. Previous researches concern on instability of MPS using freezing issue

Paper	Type of system	Freezing parameters	Freezing variables	Research Result
Sridharan et. el. [3]	Single level of product, single echelon	Freezing method, portion of MPS frozen, planning horizon length		Order based is more preferable than period based, more portion of MPS frozen make MPS stable, too longer horizon planning length induce instability of MPS
Zhao and Lee [4]	Multi levels of product, single echelon	Freezing method, portion of MPS frozen, planning horizon length		The selection of freezing parameter is not influenced by product structure, cost parameter and lot sizing rule
Lin and Krajewski [2]	Single level of product, single echelon		Freezing interval, replanning interval, forecast window	The model can used estimated the expected cost by any combination of freezing variable
Krajeswki and Wei [12]	Single level of product, multi echelon		Freezing interval, replanning interval	Schedule integration can reduce total system cost, supplier with higher inventory cost and longer lead time may not get benefit from the integration
Wei and Krajewski [17]	Single level of product, multi echelon		Freezing interval, replanning interval	Increasing forecast effectiveness can reduce total system cost
Tang and Grubbstrom [15]	Single level of product, single echelon		Freezing interval, replanning interval	A model to find freezing variables
Vargas and Metters [16]	Single level of product, single echelon	Freezing method, portion of MPS frozen, planning horizon length		An optimal algorithm to solve stochastic MPS problems
Sundana and Samadhi [13]	Single level of product, multi echelon		Freezing interval, replanning interval, safety stock	Safety factor is optimized by considering shortage cost and limit of inventory space can result cost saving

4 Conclusion and the future research

From decision making perspective, all of the research concern on uncertainty demand solved by freezing method use hierarchical decision making [18]. In supply chain system, there are many parties involved in the system that it is common the dominance position member decide MPS planning which must be followed by all of the members. In uncertainty demand, the manufacturer must have flexibilities to respond customer requirement changing by replanning MPS. The changes of MPS effect some adjustments on MRP that leads reschedule cost of supplier excluded production cost. However, suppliers have no an authority decide their production planning to achieve satisfaction profit by giving a feedback about the planning. To obtain win-win situation, the members of supply chain should have equal right to respond the decision making about MPS planning. So the decision about MPS and freezing can be viewed from two side decision making perspective or decentralized decision making.

Decentralized decision making enable suppliers give a recommendation to manufacturer about the production schedule planning which profitable for them or arrange the counter proposal. Hence, the agreement about production schedule between manufacturer and suppliers should be in win-win situation that is needed negotiation. Negotiation is a tool to solve a complex situation caused the supply chain members have individual interest respectively which are conflicting. Negotiation enable each party make own decision production planning which will be communicated to the others in supply chain.

Previous researches concern about production planning negotiation between manufacturer and suppliers generally can group based on the negotiation decision maker. This grouping is summarized in Figure 2. The new issue is used in this research to accommodate negotiation to solve problem in an instability MPS that is freezing issue. This research will combine freezing method and negotiation of production planning which is a novelty of this research. The roadmap of this research is divided consist of three steps. Firstly, we develop coordination model between a manufacturer and a supplier then determine negotiation model between a manufacturer and two suppliers. Finally, we will construct architecture negotiation model which support negotiation automatically. The research roadmap and the research position in negotiation of production planning area are illustrated in Figure 3 and Table 2.

This research proposes an approach to solve instability of MPS from two-side decision maker in production planning problem between manufacturer and supplier. This gives equal rights for participants to make

decision that satisfied them than that of one-side decision making. The one-side decision making is dominated by a participant having dominant position to decide profitable production planning which ignore the other party interests.

The previous researches about instability MPS uses hierarchical approach for decide production planning and freezing parameter by manufacturer. This decision perhaps not fair for supplier because the changes of MPS only gives beneficial effect for manufacturer than that of supplier so two-side decision making is propose to improve this condition. In supply chain system the increasing profit obtained by a party can affect the increasing expense for the others.

This research uses negotiation approach to decide an agreement about production planning and freezing that can satisfy both manufacturer and supplier. Firstly, we develop coordination model between a manufacturer and supplier to decide production planning and freezing because this step is only needed coordination mechanism without conflict. Furthermore, coordination between a manufacture and two-supplier can generate some conflict that will be solved using negotiation approach. Finally, it is needed to perform negotiation automatically so an architecture using multi agent system is designed to support it.
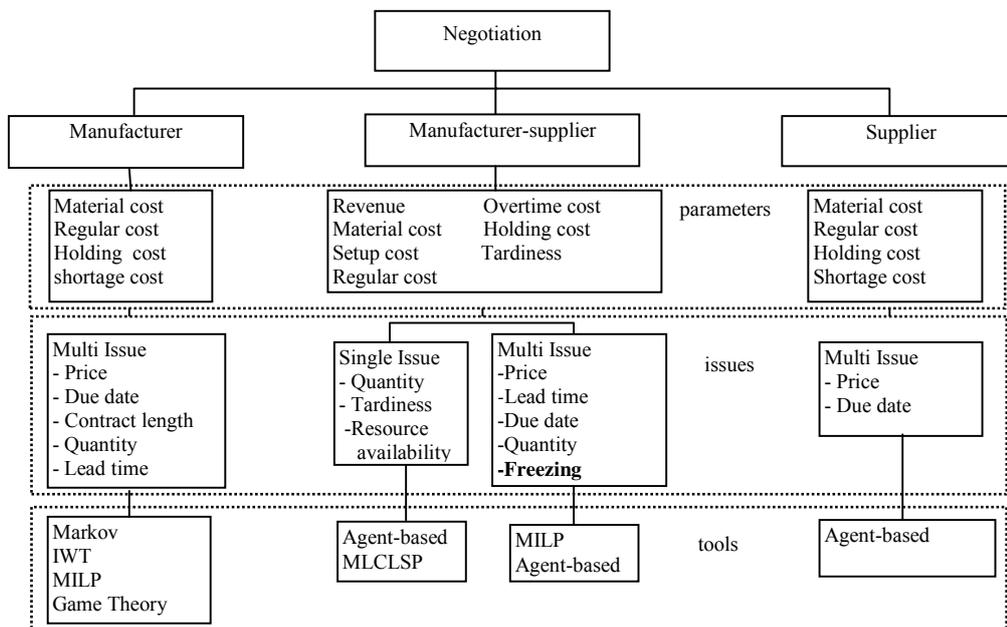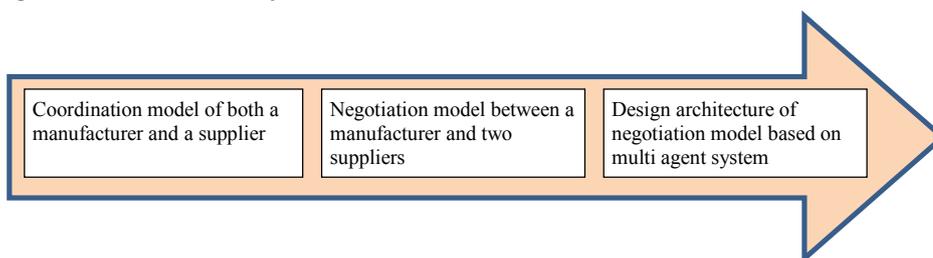

Figure 2. Negotiation research taxonomy

Figure 3. The research roadmap

Table 2. The research position

Paper	Decision Making		Issue	Tools
	One-side	*Two-side*		
Groosman et.al. [19]	√		price, quantity, contract length	Markov
Cakravastia and Nakamura [20]	√		price, due date	Interactive Weighted-Tchebychef
Calosso et.al. [21]		√	price, due date	Mixed Integer Linier Programming
Dudek and Stadtler [7]		√	Production planning	Multi-Level

				Capacitated Lot Sizing Problem
Dudek and Stadtler [22]		√	Production planning	Multi-Level Capacitated Lot Sizing Problem
Argoneto and Renna [23]	√		price, due date	Agent-based
Kim and Cho [24]		√	resource availability	Agent-based
Pan and Choi [25]		√	price, due date	Agent-based
Hernandez et. al. [6]		√	price, quantity	Agent-based
Yu et. al. [27]		√	price, quantity, leadtime	Game theory
This research		√	freezing, production planning	Agent-based

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