Uncertainty in ERP-Controlled Manufacturing Systems

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ABSTRACT

The use of Enterprise Resource Planning (ERP) is becoming increasingly prevalent in many modern manufacturing enterprises. However, knowledge of their performance when perturbed simultaneously by several significant uncertainties is not as widespread as it should have been. This paper presents the developmental and experimental work on modeling uncertainty within an ERP multi-product, multi-level dependent demand manufacturing planning, and scheduling system in a simulation model developed using ARENA/SIMAN. To enumerate how uncertainty affects the performance of an ERP-controlled manufacturing system, the percentages of Finished Products Delivered Late (FPDL) and Parts Delivered Late (PDL) are measured. Sensitivity analysis shows that PDL gives a more accurate effect. Simulation results are analyzed using Analysis of Variance (ANOVA), which identifies four uncertainties; namely, late delivery from suppliers, machine breakdowns, unexpected/urgent changes to machine assignments, and customer design changes, which significantly affect PDL. Some uncertainties are found significantly interactive in two and three ways. They produce either knock-on and/or compound effects, a factor not generally recognized as a criterion for decision-making.

Keywords: enterprise resource planning; manufacturing IS; operations management; production; production planning IS; simulation and modeling of IS

BACKGROUND AND LITERATURE

Modern manufacturing enterprises are facing increasing pressure to improve their responsiveness to market dynamics. Central to this are the issues addressed by manufacturing planning and scheduling systems. Customer expectations for shorter delivery lead-times, greater agility, improved quality, and reduced costs have made the effective application of an appropriate system a significant determinant of survival for many manufacturing enterprises. Within batch manufacturing systems, Material Requirements Planning (MRP), Manufacturing Resource Planning (MRPII), or Enterprise Resource Planning (ERP) is the ideal system for producing work order (Enns, 2001). Since MRP logic is deployed within MRPII and ERP when they are used for planning and scheduling, the Planned Order Release (POR) schedule outputs are identical (Enns, 2001; Koh & Saad, 2002). This research refers to the use of
these systems in batch manufacturing enterprises such as ERP-controlled manufacturing system.

To elaborate the emergence of ERP and how this system is still incapable of tackling uncertainty, let’s discuss the characteristics of this system. In the 1960s, Oliver Wight and Joseph Orlicky introduced MRP (Wight, 1981). It was designed and developed to operate within a stable and predictable batch manufacturing environment; and it was defined as a set of back scheduling techniques that uses Bill of Materials (BOM) data, inventory data and a Master Production Schedule (MPS) to calculate net requirements for materials. MRP run takes place by offsetting parts’ due dates with planned lead-time from the upper to the lower levels in the BOM. Output from the run is a POR schedule, which contains order number, part number, net requirement, release date, and due date for all orders in the MPS. The POR schedule is used to release order to the manufacturing system and execute purchase or manufacture operations.

MRP assumes infinite capacity, as no consideration is given to used and available resources capacity in generating the POR schedule. Both planned purchase and manufacture lead-times are predetermined, which ignores variation in lead-times, for instance, delay resulting from late delivery from suppliers or machine breakdowns. These uncertainties often distort the planned lead-times due to their unpredictability and the stochastic nature in manufacturing environment.

MRP release logic is used in MRPII to generate POR schedule. However, there is a feedback loop in MRPII, which considers used and available resources capacity. However, the feedback loop does not operate in real-time; hence, whenever uncertainty is encountered, it is too late to plan for until the next MRP run. It is arguable that regenerative or net-change rescheduling can be carried out to update the POR schedule, but how frequent should we reschedule? The more frequent that we reschedule, the more nervous will the system become (Ho et al., 1995). Different uncertainty might occur after the POR schedule is updated.

ERP is a more advanced version of MRPII that integrates sales, marketing, human resource, accounting, purchasing, and logistics modules altogether. Nevertheless, when ERP is used within batch manufacturing environments as a planning and scheduling system, the same problems in MRP and MRPII will be encountered. Although detailed analysis can be performed within ERP, for instance, whether to assign three batches of orders using a shared route, provided that the logistics module is integrated, their inabilitys to operate under uncertainty are still overwhelming. For this instance, delay might have already occurred in production, and the affected orders might not be delivered on time.

A considerable amount of research showed many underperformances of ERP-controlled manufacturing systems, ranging from the work by Duchessi et al. (1989), Yusuf and Little (1998), Tinham (1999), and Koh et al. (2002). The main finding from their work is that MRP, MRPII, or ERP is an enabler (planner) rather than optimizer (executer); therefore, under an unperturbed manufacturing environment without the effects of uncertainty, the plan can be executed without revision. Otherwise, the planner has to apply buffering or dampening techniques (e.g., rescheduling or subcontract) in order to tackle the effects of uncertainty. This has led to extensive research to examine techniques to tackle the effects of uncertainty.

A study carried out by Mather (1977) examined changes to MPS and poor vendor performance and recommended removal of uncertainty as a better approach than simply managing it. The results were derived from a planning heuristic and suggested that rescheduling is the main cause of uncertainty, and by tackling the causes of rescheduling, the effects of uncertainty could be reduced significantly. It was identified that most reschedules are not caused by reactions to customer requirements, but resulted from algorithms for calculating lot-sizes and lead-times and from poor execution of manufacturing plans.

Grasso and Taylor (1984) suggested allowing purchased parts to arrive late more frequently than allowing them to arrive early.
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