A REVIEW OF INSTABILITY OF PLANNING SYSTEMS IN A MATERIAL REQUIREMENTS PLANNING ENVIRONMENT

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Abstract: Uncertainties in demand and supply lead to disruptions in material planning and frequent plan revisions. A stable schedule is one that does not often change with time as additional requirements data are added to the planning horizon. Besides stability, there are other stability-related concepts to evaluate the sensivity of planning methods e.g., flexibility, robustness and nervousness. Measurement of instability would enable performance comparison of different planning procedures for managing the production plans under a variety of operating conditions.

This paper is a review which examines the previous research on planning stability under different operating conditions, compares stability measuring metrics, and finally it will present strategies to dampen nervousness and decrease instability.

Keywords: *Scheduling Instability, MRP, Nervousness, Planning Horizon*

MALZEME İHTİYAÇ PLANLAMASI ORTAMINDA PLANLAMA SİSTEMLERİNİN KARARSIZLIĞI ÜZERİNE GÖZDEN GEÇİRME

Özet: Malzeme ihtiyaç planlamasında, talepten ve kaynak tedarikinden kaynaklanan bilinmezlikler malzeme planlarında bozulmalara ve planlarının sık sık revize edilmesine neden olur. Stabil bir üretim planı, üretim planına ek ihtiyaçlar girdikçe zamanla sık değişmeyen bir plandır. Stabilitenin yanında, stabilite ile ilgili başka kavramlar da vardır. Örneğin, esneklik (flexibility), robustness (planların kuvveti) ve sinirlilik olgusu (nervousness). Bu faktörlerin ölçümü, üretim planlarının farklı işlem koşullarında yürütülmesi için değişik yöntemlerin performanslarının karşılaştırılmasına olanak verecektir.

Bu bildiride, üretim planlarının kararlılığı üzerine değişik işlem koşullarında yapılan geçmiş çalışmalar, bu çalışmalarda yer alan stabilite ölçüm yöntemleri karşılaştırılmış ve son olarak da üretim planlarındaki sinirliliği (nervousness) azaltan yöntemler gözden geçirilmiştir.

Anahtar Kelimeler: *Üretim Planlama Kararsızlığı, MİP, Sinirlilik*

1. Introduction

In Material Requirements Planning (MRP) environment, material plans are frequently unrealistic due to the existence of different sources of uncertainties. Generally,. uncertainties in demand and supply lead to frequent plan revisions. The ability of a system to respond to these uncertainties is referred to as “flexibility”. In connection with the flexibility, “robustness” is usually considered. It can be defined as the insensitivity of the planning systems when the parameters change in stochastic input data. Frequent adjustments to schedules caused by customer order changes, varying sales forecasts and production plans can lead to increase inventories, production and inventory costs, decrease capacity utilization and a deterioration in customer service levels. This phenomenon in literature is referred to as “nervousness”. In summary there is a close relationship between the terms nervousness and instability and the term “planning instability” must be defined more clearly and should be in such a measurable format that performances of different procedures could be easily compared. For this purpose, the following section presents different measuring metrics.

2. Measurement of Instability

In literature, a systematic discussion of instability measures is found in Sridharan et al. (1988), Kadipasaoglu and Sridharan (1996), Kimms (1998), Kok and Inderfurth (1997), and Heisig (2002).

Sridharan et al. (1988) suggest an alternative measure of instability that includes the weighted average of schedule changes in order quantity per order over subsequent planning cycles, i.e.

$$I_{SBU} = \frac{\sum_{\forall k>1} \sum_{t=M_k}^{M_{k-1}+N-1} \left| Q_t^k - Q^{k-1}{}_t \right| (1-\alpha)\alpha^{t-M_k}}{S} \tag{1.1}$$

Where; t = time period, Q^k_t = scheduled order quantity for period t during planned cycle k, M_k = beginning planning cycle k, N = planning horizon length, S = total number of orders over all planning cycles, and α = a weight parameter (0< α <1). This measure is intended for single-item, single-level situations, but the components at lower levels must also be considered. In addition, the instability measure is not normalized between maximum stability and maximum instability. Furthermore, it is biased because number of orders depends on the cost structure of the item, and on the ratio between the setup cost and the holding cost.

Kadipasaoglu and Sridharan (1996) have extended the previous instability measure I_{SBU} in (1.1) and eliminated some shortcomings of it by adding a weight parameter β to assign decreasing weights to the changes in subsequent levels of the product structure.

$$I_{KS} = \sum_{\forall k>1} \sum_{j=0}^{m} \left[\sum_{i=1}^{n_j} \sum_{t=m_k}^{M_{k-1}+N-1} \left| Q_{ijt}^k - Q_{ijt}^{k-1} \right| (1-\alpha)\alpha^{t-M_k} \right] (1-\beta)\beta^j , \tag{1.2}$$

Contrary to I_{SBU}, this measure does not divide the total instability by the number of planned orders over all planning periods. Therefore, the bias is avoided, but it is still not standardized between a minimum and maximum value of nervousness.

Unahabhokha et al. (2002) use a version of the stability measurement model presented by Sridharan et al. (1988), The measure is:

$$I_U = k \sum \sum W_t \left| Q_{i,t}^{p2} - Q_{i,t}^{p1} \right| / B \tag{1.3}$$

This measure is similar to the measure presented by Sridharan et al. (1988), a multiple factor, *k,* used to amplify the result and weighting factor, W_t, *(Exp(1/t)-1)* is incorporated to represent that the impact of schedule instability is not linear through time, but it includes all the shortcomings mentioned for the (1.1).

Kimms (1998) considers a *T*-period problem on the MPS level which is rolled *n >0* times

$$I_{KI}^j(i) = \frac{\left| Q_j^{\cdot\cdot(i)} - Q_j^{\cdot(i-1)} \right|}{\max\{Q_j^{\cdot\cdot(i)}, 1\}} \tag{1.4}$$

As different from other measures, he uses a different weight parameter (ζ_{jt} = *1/t*) to calculate weighted production quantities and adds a frozen zone in the rolling horizon. This weight parameter can not be varied as Sridharan's parameter α does. In addition only the end item level is considered in this measure and although the differences in quantities are divided by a maximum in the equation, Kimms' measure can take on values greater than 1.

Kok and Inderfurth (1997) treat planning instability under different inventory control rules. They use the measurement concept proposed by Jensen (1993) and measure setup instability and quantity instability as:

$$I_s = 1 - \frac{E\left[\left|\delta(Q_1) - \delta(\hat{Q}_1)\right|\right]}{\max_{\Re, F_D} E\left[\left|\delta(Q_1) - \delta(\hat{Q}_1)\right|\right]}, \quad I_q = 1 - \frac{E\left[\left|Q_1 - \hat{Q}_1\right|\right]}{\max_{\Re, F_D} E\left[\left|Q_1 - \hat{Q}_1\right|\right]}, \tag{1.5}$$

It is clear that both stability measures are normalized, but they are restricted to planned order deviations only referring to the most imminent period in each planning cycle, and describes short-term stability.

Heisig (2002) proposes the modified setup and quantity instability as follows:

$$I_{Hs} = \frac{\sum_{j=1}^{N-1}\sum_{i=j}^{P+j-2}\left|\delta(Q_{t+i}^{t+i-1}) - \delta(Q_{t+i}^{t+i})\right|(1-a)a^{i-j}}{(N-1)\sum_{t=1}^{P-1}(1-a)a^{t-1}}, I_{Hq} = \frac{\sum_{j=1}^{N-1}\sum_{i=j}^{P+j-2}\left|\delta(Q_{t+i}^{t+i-1}) - \delta(Q_{t+i}^{t+i})\right|a^{i-j}}{\Delta q_{\max}} \quad (1.6)$$

The first of these measures is rather similar to the measure presented by Sridharan et al. (1988). The weighted number of periods with changed setups are divided to the weighted total number of periods, and it is normalized between zero and one. In the second, the weighted average percentage of quantity per cycle is divided by the weighted maximum possible amount of changes per planning cycle. However, in this measure the calculation of the maximum quantity is some difficult and requires some additional assumptions.

3. Strategies to Dampen Instability in MRP Systems

Several different strategies have been suggested for dealing with instability in MRP systems in the literature. Blackburn et al. (1986) examined five different strategies: (1) Freezing the schedule within the planning horizon, (2) Lot-for Lot (3) Safety stocks, (4) Forecast beyond planning horizon, (5) Change cost procedure. Among these strategies when measured solely in terms of instability, freezing the schedule within the planning horizon appears to be dominant. Moreover, Vollmann et al (1997) introduces three guidelines reducing instability in MRP plans: (1) Freezing and time fences (2) Selective use of lot-sizing procedures and (3) Using firm planned orders. With regard to the three main decision variables, i.e., total cost, schedule instability and service level, recent studies examine the effect of freezing schedule under different settings. It is observed that increasing the freezing proportion reduces the schedule instability while increasing total cost.

4. Concluding Remarks

In this review, we tried to explain the concepts related uncertainty, i.e., flexibility, robustness and nervouesness, and to identify the need for measuring the instability of planning systems. Using such a measure, performances of different procedures could be easily compared. To compare the metrics, none of the metrics reflects all the properties of instability and each of them has some shortcomings: some of them are not normalized, some are biased. Furthermore, we present several alternative strategies to dampen the instability, one of the most frequently encountered approaches is freezing a portion of the schedule.

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