Smooth Priorities for Make-to-Stock Inventory Control

Carlos F. Bispo*

In the context of periodic review inventory control for capacitated machines and multiple products, we address the problem of dynamically allocating the available capacity for the competing products, assuming a capacitated multi-echelon base-stock policy. Each product has to undergo several operations on different machines, and each machine is able to process a different set of operations. Products may have different flow patterns through the machines, including re-entrant flows, that is, some products may have to visit the same machine more than once, to undergo different operations on each visit.

The model builds on [2], where they considered single product flow lines, and builds on [1], where they addressed re-entrant flow lines producing multiple products In both cases, the authors adopted multi-echelon capacitated base-stock policies to control such systems. They used Infinitesimal Perturbation Analysis to compute the optimal parameters for the policies.

To deal with the fact that multiple products compete for the same resources at any period, [1] proposed three dynamic capacity allocation rules, named the *Linear Scaling Rule*, the *Priority Rule*, and the *Equalize Shortfall Rule*. The experimental studies conducted show that the LSR and the ESR achieve very good and similar performance results. However, there are cases where the PR is the best way to dynamically allocate capacity. The problem with this last rule is the fact that it is not easy to determine the appropriate priority list, since this is a combinatorial problem. The data presented in [1] only provides some dominance results which, while reducing the set of choices, do not allow a complete determination of the right priority order.

On the other hand, production decisions generated either by the PR and the ESR are not smooth as functions of the multi-echelon base-stock variables for sufficiently general systems with re-entrant flows and where different operations use different amounts of the available capacity – *non uniform loads*. This fact implies that optimization procedures based on IPA are not applicable, since the technique relies on smoothness to validate the permutation between the expectation and the derivation operators. This problem is not present for the LSR. However, when the systems are re-entrant the performances achieved by this rule can be disastrous, due to a lack of appropriate bounding of new products into the system, given that raw-material is assumed to be infinite.

In this paper we propose a two phase LSR, termed *Smooth Priority Rule*, where the combinatorial problem of determining the right priority list is converted into a smooth and continuous non-linear programming problem, for which the IPA is valid. In each phase of the SPR only a fraction of the feasible – constrained by feeding inventory – shortfall per product is allowed to be considered to be satisfied on the current period. The total feasible shortfall per product is considered in both phases, but the fraction entering the first phase is a control parameter subject to optimization. This way, we also expect to address the lack of bounding for new products present in the LSR.

The experimental results obtained so far show that it is possible to improve upon the performance of strict priorities. That is, for cases where the optimal priority list is known and also achieves the best performance of the above mentioned three rules, we have achieved better performances with the SPR. Given the fact that it is a variant of the LSR, SPR is also structurally ensured to be no worse than the LSR.

*Instituto de Sistemas e Robótica – Instituto Superior Técnico, Av. Rovisco Pais, 1049-001 Lisboa, Portugal, cfb@isr.ist.utl.pt

References

[1] Carlos F. Bispo and Sridhar Tayur. Managing Simple Re-entrant Flow Lines I: Theoretical Foundation and Experimental Results. *To appear in the IIE Transactions*, 2001.

[2] Paul Glasserman and Sridhar Tayur. Sensitivity Analysis for Base-Stock Levels in Multi-Echelon Production-Inventory Systems. *Management Science*, 41(2):263–281, February 1995.