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PRODUCTION POLICY OPTIMIZATION IN MANUFACTURING SYSTEMS WITH LONG-RUN AVERAGE COST BASED ON VANISHING DISCOUNT APPROACH

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ABSTRACT

Production control in failure-prone manufacturing systems is considered. System performance is characterized by either discounted cost (DC), or by long-run average cost (LRAC) over infinite time interval. In the series of theoretical works an approach based on ‘‘vanishing discount’’ was proposed to address the mathematical challenges arising in the problems with LRAC. In our work the vanishing discount is used to constructively define the parameters of an optimal LRAC-based policy from the series of solutions obtained for DC-based policies with decreasing values of discount rate. The rationale here is that for DC-based policy optimization there exist powerful numerical methods, allowing to address the problems arising in real industrial applications. On-the contrary, for LRAC-based policy optimization no such methods exist, to the best of the authors knowledge. Vanishing discount approach was previously used to establishes theoretically the convergence of the DC-based problem to the LRAC-based one, however, any application related issues have not been addressed.

To develop our approach in detail we consider the benchmark problem of policy optimization for one-machine-one-product failure-prone manufacturing system that was solved analytically in the late eighties by Akela and Kumar (AK) for DC-based objective function, and by Bielecki and Kumar (BK) for LRAC-based objective function. In both papers the determined optimal policies were shown to be of critical (hedging) point type and the explicit formulas of similar structure for the hedging levels were obtained.

In our work we prove that the established similarity results in that the LRAC-based hedging level $\boldsymbol{Z_{BK}}$ can be constructively obtained from the DC-based hedging levels $\boldsymbol{Z_{AK}(\gamma)}$ when the discount rate $\boldsymbol{\gamma}$ tends to zero. To make this result useful for real-life applications, we show that $\boldsymbol{Z_{BK}}$ can be calculated by following three steps procedure: (a) compute $\boldsymbol{Z_{AK}(\gamma)}$ for few $(\boldsymbol{k})$ decreasing values of $\boldsymbol{\gamma = \gamma_1, \gamma_2, \ldots \gamma_k}$ (usually k=5 in our numerical experiments), (b) approximate obtained 2D points $(\boldsymbol{\gamma_i}, \boldsymbol{Z_{AK}(\gamma_i)})$ by a smooth function $\mathbf{A}(\boldsymbol{\gamma})$, (c) extrapolate $\boldsymbol{A(\gamma)}$ to the left and calculate $\boldsymbol{A(0)}$ that serves as an approximation to $\boldsymbol{Z_{BK}}$.

As for a benchmark problem $\boldsymbol{Z_{AK}(\gamma)}$ and $\boldsymbol{Z_{BK}}$ available analytically, the obtained approximation can be compared to the exact solution. This verification shows that the proposed procedure is reliable and accurate. To address more general problems, we propose to solve DC-problem numerically for several discount rate values, then apply the procedure described above. This approach potentially allows to solve numerically the LRAC-problems arising in industrial applications.