Chapter III

Optimal Feedback Production for a Supply Chain

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Abstract

In this chapter, we modeled the dynamics of a supply chain considered by several authors. An infinite-horizon, time-delayed, optimal control problem was thus obtained. By approximating the time interval \([0, \infty]\) by \([0, T_f]\), we obtained an approximated problem \((P(T_f))\) which could be easily solved by the control parameterization method. Moreover, we could show that the objective function of the approximated problem converged to that of the original problem as \(T_f \to \infty\). Several examples have been solved to illustrate the efficiency of our method. In these examples, some important results relating the production rate to demand rate have been developed.
Introduction


In this chapter, we used the model considered by Riddals and Bennet (2002) to develop an optimal control problem. We considered a single echelon supply chain, such as a furniture manufacturer and assumed that orders for furniture were placed continuously. We also assumed that the state variables were the rate of production and the inventory level, which followed the same dynamics as that given by Riddals and Bennet (2002). We further identified the control variables as the management’s magic numbers, $\alpha_i(t)$ and $\alpha_{WIP}(t)$, which were the measures of the importance attached to the inventory level and the amount of work in process. The objective function to be minimized was simply an integral consisting of the sum of all costs (production cost plus storage cost plus shortage cost), possible incorporating future or present value calculations. By minimizing the objective function with respect to $\alpha_i(t)$ and $\alpha_{WIP}(t)$, given some past production parameter and of course the past and future demand, we could compute an optimal open-loop production schedule.

Due to the delay differential equations, it could not be transformed to any canonical form soluble by the package MISER described by Jennings et al. (1990). However, Kaji and Wong (1994), Teo et al. (1984), Wong et al. (1984) and Wong et al. (2001) have established the theoretical framework for solving this time-delayed control problem.

Problem Statement

Let $i(t)$ be the inventory level at time $t$, $p(t)$ be the production rate, $D(t)$ be the demand rate, $\alpha(t)$ be the inventory adjustment parameter and $\alpha_{WIP}(t)$ be the
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