Performance Measurement of the Supply Chain Using Control Engineering Approach

by

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Abstract

A supply chain is an integrated process wherein raw materials are extracted and converted to the final products, and delivered to the customer. To design and analyze an appropriate supply chain we have to evaluate its performance. In practice, performance measurement of the supply chain is complicated due to the influence of different parameters involved in production planning, inventory control, logistics and transportation activities through the chain. On the other hand control theory is a well-known methodology to measure performance of business related problems. In control theory differential equations of a continuous model is derived in time domain and then Laplace transform is used to convert the model to the complex frequency domain or simply s-domain. The converted model is solved and the solution converted back to time domain by invers Laplace transform.

The purpose of this dissertation is to measure performance of the supply chain using frequency response analysis. So control theory approach is used to measure different performance aspects of the supply chain. The IOBPCS model is used as a benchmark to propose an analytical approach for modelling production smoothing constraints. Since production constraints are nonlinear, the extended model which in this research is called Nonlinear IOBPCS (NIOBPCS) is no longer linear and thus nonlinear control theory is applied to measure frequency response for zero target inventory. The results of frequency response show improvement of production performance of the system facing with production smoothing constraints compared with the system without constraints, but deterioration of inventory performance especially if demand has higher amplitudes so amplitude of production signal ideally should be more than production constraints but practically could not be fluctuate appropriately to satisfy the customer demand. Due to lower performance of inventory in zero target inventory condition stock outs is observed during demand peaks, so non-zero target inventory conditions is applied to calculate the amount of safety stock that is necessary to have no stock out in the supply chain.

Furthermore a total performance function is developed based on APIOBPCS which is an extended version of IOBPCS. Frequency response is used to introduce a total performance function encompassing all types of the system costs including production, finished goods holding and shortage, WIP, and ordering costs. The developed total performance function represents aggregate performance of the system in one general function. The results of sensitivity analysis of total performance function indicate a reverse effect of work in process recovery speed compared with finished goods recovery and demand updating rate for different demand frequencies.