A MULTI-ATTRIBUTE BASED FITRADEOFF TOOL FOR WORKLOAD CONTROL RULES SELECTION

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Abstract
In this paper, we present a decision model based on FITradeoff method for the problem of selecting workload control (WLC) rules in pure make-to-order (MTO) environments. To illustrate the use of the proposed model, a numerical application has been implemented using realistic data of a lady shoes production system.

Keywords: workload control; FITradeoff method; Discrete event simulation.

1. Introduction

WLC is a production planning and control (PPC) concept with three main hierarchical levels (Breithaupt et al., 2002; Fredendall et al. (2010): entry level – accepts or rejects customer orders and determine its due dates; release level – manages the workload of the system; and dispatching level – selects orders from the queue on a work center for processing. In order to support the decisions at each WLC level, a set of rules must be specified. Many different rules have been proposed in the literature (Bergamaschi et al., 1997, Fredendall et al., 2010, Blackstone et al., 1982, and Thürer et al., 2013). Since there are no evidences that a particular WLC rule performs best in all performance attributes under different types of manufacturing systems, identifying the best-fit among due date, job release and dispatching considering multiple conflicting attributes causes challenging WLC rules selection problems.

Only a few research studies have focused on determining the best combination of due date, job release and dispatching rules in job shop environments (see Ragatz and Mabert, 1988, Ahmed and Fisher, 1992, Fredendall et al., 1996, Moreira and Alves, 2009, Lu et al., 2011). However, the models proposed hitherto do not explore the subjective information of the decision-maker (DM) on impacts in the system objectives caused by the use of a specific combination of WLC rules. Although there is a multiple objective nature in this selection problem, not much work done from this perspective (Yoon et al., 2014; Weng et al., 2008).

We propose a multi-attribute value model that combines discrete event simulation (Law, 2015) with FITradeoff method (de Almeida et al., 2016) for evaluating different combinations of WLC rules, in order to obtain the best solution among control levels considering the DM's trade-off judgment on multiple attributes.

2. Basic decision model

The set of alternatives $A = \{a_1, a_2, \ldots a_n\}$ is discrete with n potential planning and control policies faced by the DM. Each a_i is a decision vector $\{d_i; r_i; p_i\}$ with the dimensions associated to different decision levels within the WLC concept, where $d_i \in D; r_i \in R;$ and $p_i \in P$ represent due date, job release and shop dispatching respectively. Based on the method proposed by Law (2015), a discrete event simulation model is built to obtain the performance values $a_i = \{x_{i1}, x_{i2}, \ldots, x_{ij}, \ldots, x_{im}\}$ for m decision attributes $(j = 1, \ldots, m)$. After evaluating statistical significance of the simulation results, the matrix of consequence can be established to represent the mean value x_{ij} of the set of simulation outputs x produced in R replications with the simulation model over j. Given the consequence matrix, one can apply the FITradeoff method for eliciting DM's trade-off judgements in order to obtain a global evaluating for the set A in the context of MAVT.

3. Numerical application

A numerical application has been realized based on realistic data from a Brazilian shoe manufacturing company. The system studied is a pure MTO composed of a due date assignment unit, a job release unit, eight work centers and six queue points. Using Micro Saint Sharp software, a simulation model was built to assess the behavior of this system under the experimental conditions given in Table 1. A full factorial design in the three factors would lead to 18 (3 x 3 x 2) combinations of settings.

Table 1 – Simulated experimental condition.

Decision Level	Acronym	Nome of rule	Reference
Due date	JIS	Job in system	Ahmed and Fisher (1992)
	IWIQ	Imminent work in queue	Thürer et al. (2013)
	JIQ	Job in queue	Ragatz and Mabert (1984)
Job release	IMM	Immediate release	-
	EDD-PA	Earliest due date-Path Aggregation	Fredendall et al. (2010)
	SJPT-PA	Shortest job processing time-Path Aggregation	
Shop Dispatching	FIFO	First In First Out	-
	ODD	Operation due date	Thürer et al. (2014[a])

Table 2 summarizes the simulation results for the Total Cost (T_c), Production quantity (P_q), Flow time $(\bar{F})$ and Tardiness $(\bar{T})$. All WLC rules simulated are measured in hours. Due to unsatisfactory performance, the alternatives JIS-IMM-FIFO, IWIQ-IMM-FIFO and JIQ-IMM-FIFO have been excluded of the consequence matrix.

Table 2 – Performance of manufacturing system under different WLC rules.

a_i	Decision vector			Vector of consequences			
	d_i	r_i	p_i	T_c	P_q	$\bar{F}$	$\bar{T}$
1	JIS	IMM	ODD	39161.54	487172	85.61	2.17
2	JIS	EDD-PA	FIFO	32759.59	477506	95.09	1.22
3	JIS	SJPT-PA	FIFO	34119.25	477414	92.10	3.96
4	JIS	EDD-PA	ODD	35068.70	485824	97.28	1.18
5	JIS	SJPT-PA	ODD	36584.38	477510	92.44	3.43
6	IWIQ	IMM	ODD	35664.28	484550	88.36	1.42
7	IWIQ	EDD-PA	FIFO	38241.48	477908	93.31	1.31
8	IWIQ	SJPT-PA	FIFO	49131.19	477414	92.10	2.23
9	IWIQ	EDD-PA	ODD	44160.91	480194	97.70	1.18
10	IWIQ	SJPT-PA	ODD	48291.06	488308	93.66	2.00
11	JIQ	IMM	ODD	38603.25	483932	87.93	1.46
12	JIQ	EDD-PA	FIFO	40560.83	483632	99.18	1.47
13	JIQ	SJPT-PA	FIFO	46580.93	477414	92.10	2.26
14	JIQ	EDD-PA	ODD	39271.26	475912	91.52	1.42
15	JIQ	SJPT-PA	ODD	46944.36	473718	91.22	2.11

In the first step of the FITradeoff method is to rank the criteria weights (de Almeida *et al.*, 2016). From the DM's preferences, the result obtained was: $K_T > K_{Tc} > K_F > K_{Pq}$. This rank-order is incorporated to a Linear Programing model and given the current level of partial information, the alternatives 2, 4, 6 and 9 were considered potentially optimal. After five questions answered, the new set of potential solutions consists of alternatives 2, 4 and 6. Note that, the consequence space is reduced to the extent that the DM advances in the elicitation process. This is the way by which the FITradeoff method explores the partial information to find for potential optimal alternatives. For this WLC problem, eleven questions were necessary for identifying the alternative 4 as the best compromise solution. Furthermore, the support of graphical visualization at each step may be helpful to reduce the time spent in elicitation process and the cognitive effort from the DM.

4. Final remarks and future research

We present a multi-attribute decision model based on FITradeoff method to identify the best fit between decision levels in WLC concept. The use of FITradeoff allows the DM express his/her trade-off judgements with less cognitive effort. The decision model presented here can be also applied to evaluate any set of WLC rules under various experimental conditions. Furthermore, it is possible to integrate with simulation study others MCDM/A methods, such as those with non-compensatory rationality (de Almeida et al, 2015).

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