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Real-time recovering strategies on personnel scheduling in the retail industry

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ABSTRACT

Retailers must frequently deal with alterations in planned customer service levels due to unexpected demand variations or unscheduled employee absences. Although personnel scheduling techniques have been extensively studied and successfully applied, previous treatments of scheduling adjustments in response to demand and employee contingencies have not systematically considered all of the relevant issues. After presenting a mathematical specification of the problem, this study develops various algorithms that search for the best adjustments among all available contingency recovery resources, including transfers of multiskilled employees between different store areas. The proposed formulations also permit interaction between the user/decision maker and the affected employees. The underlying objective is to maximize profits, favoring solutions with fewer schedule modifications in order to minimize worker dissatisfaction. Due to the complexity of the basic model, the problem is divided and simplified using two greedy heuristics. Both algorithms can be implemented with real-world size problems and reach good solutions within minutes. Multiskilled employees prove to be an important reserve capacity for recovery of service levels in the face of unexpected variations. Empirical results using real data from a Chilean chain retailer show that in the worst scenario, the proposed model's schedule adjustments reduced lost profits due to unexpected variations by 18%.

1. Introduction

The retail trade is highly labor-intensive as well as extremely competitive (Nissen & Günther, 2010). Businesses in the rapidly growing industry face both predictable phenomena such as demand seasonality and unpredictable ones like demand uncertainty and unscheduled personnel absences. Unlike other sectors of the economy where demand is regular and predictable, retailers must deal with demand volumes that may vary dramatically over the course of a single day or the days of the week (Cuevas, Ferrer, Klapp, & Muñoz, 2016). In this scenario, and given the often complex labor law restrictions on working hours in the industry, planning shift schedules to efficiently meet the requirements of customer demand is no easy task. The goal of retail firms is to minimize labor costs while maintaining the best possible customer service levels, but even those with sophisticated workforce planning systems may find themselves confronted at different moments of the week with overstaffing or understaffing problems (Henao, Muñoz, & Ferrer, 2015). Overstaffing in this context refers to periods when there is an excess of employees on duty (and often idle) for a given desired level of customer service while understaffing denotes periods when employee requirements exceeds on-duty personnel. In latter case, the staffing imbalance can be propagated across successive periods. Thus, poor management of these issues may result in significant sales revenue losses, deterioration in customer service and a negative impact on a firm's business reputation (Kabak, Ülengin, Aktas, Önsel, & Topcu, 2008).

Personnel scheduling is traditionally a static process in that the scheduling decisions are all made at the start of the planning horizon, the assumption being that they cannot be adapted dynamically to address the stochasticity inherent in supply and demand. The process of planning a given day, week or month usually begins several weeks beforehand on the basis of demand forecasts. In some cases, it is executed by sophisticated shift-assignment systems that optimally allocate available personnel according to demand requirements. However, in the days and weeks following definition of the assignments, decision-makers will inevitably be confronted with a series of new and unpredictable events that force them to make adjustments.

In Bard and Wan (2005), the authors suggest a hierarchical three-phase approach to schedule adjustment. In the first phase, employees are assigned to daily shift and days-off patterns over a short-term

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planning horizon, typically a single week. In the second phase, new information is added to the weekly scheduling process on predictable events such as scheduled personnel absences (e.g., medical leave, holidays, resignations) and expected average demand increases (e.g., sales promotions, introduction of new products). The third phase, and the one that will concern us here, concerns the real-time adjustments (i.e., day to day) in personnel scheduling in response to the occurrence of events more difficult to predict.

Contingencies arising at the last minute that affect the quality of employee workforce planning may originate in demand and/or staffing level factors. In the case of demand, variations may occur due to internal events such as marketing campaigns, unanticipated public events or other eventualities such as the weather. As regards staffing, levels may be altered if an employee for any reason cannot work the assigned hours or because of new recovery resources that were not included in the plan. An example of a recovery resource is overtime. In either case, to ensure a day's shift scheduling requirements are met in the face of an unexpected occurrence, recovery resources must be applied once demand and actual personnel availability are known so that the contingency can be mitigated at minimum cost. The recovery resources most widely used by service industry companies are the following:

(1) *Overtime:* Involves extending an employee's shift for the day, either by moving up a shift's start time or moving back its end time. This is the most common recovery resource given that it is simple to implement, always available and can be assigned as soon as a staffing deficit appears. On the other hand, overtime is associated with lower productivity, increased stress and other potentially negative consequences of extended shifts.
(2) *Employee call-in:* Refers to employees contracted for a certain minimum guaranteed number of weekly hours but who can be called in for additional shifts. As well as the hourly remuneration, they receive standby pay for being on call during specified hours. The additional shifts must be of a certain minimum length and are subject to a predefined advance notice requirement.
(3) *Temporary employees:* These are employees supplied by an external firm, thus ensuring a certain level of availability. The pros and cons of such an arrangement depend in large measure on the terms of the contract, especially those regarding productivity and availability guarantees (Milner & Pinker, 2001). The main disadvantages are the training, remuneration and administrative costs incurred by the retailer.
(4) *Reallocation of multiskilled employees:* Consists in transferring employees between different store areas or departments, implying that the employees must be multiskilled for each area or department they may be allocated to. This strategy allows shift hours to be dynamically redistributed by making such reallocations for the precise period the contingency lasts without incurring significant labor cost increases. The main cost factors in this resource are the training program and related workforce planning activity. For the service industries and the retail trade in particular, Henao et al. (2015) and Henao, Ferrer, Muñoz, and Vera (2016) showed that total multiskilling is unnecessary. The best cost-effective performance was in fact obtained from a combination of specialized (i.e., employees trained in a single skill) and multiskilled employees, the majority of the latter trained in one additional skill.
(5) *Shift modification and new shift assignment:* A shift modification is defined as a change made to an existing shift while a new shift assignment entails creating a shift for an employee on a scheduled day off. In the latter case it likely also involves the cancellation of some other previously assigned shift. Generally, shift modification is possible if employee acceptance is obtained. The disadvantage of this resource is its lack of flexibility given that it does not allow for small local adjustments, and like employee call-in it is subject to a predefined advance notice requirement.

Various researchers have studied personnel scheduling adjustment processes using recovery resources to mitigate the negative effects of uncertainty (e.g. Bard & Wan, 2005; Pinker & Larson, 2003; Menezes, Kim, & Huang, 2006; Hur, Mabert, & Bretthauer, 2004a; Hur, Mabert, & Bretthauer, 2004b; Orsoni, 2004; Easton & Goodale, 2005). However, they propose make the adjustments automatically and in a single step, with no interaction involving the decision maker and the affected employees. This implicitly assumes that all of the changes suggested will be accepted by both the decision maker and the affected employees. In practice, however, the limited availability of each recovery resource leads inevitably to a sequential decision process. Since the willingness of any given employee to accept a proposed adjustment cannot be known in advance, it is required a sequential decision process that allows interaction between the decision maker and the affected employees.

The present article proposes a contingency control system with interaction based on employee schedule adjustment. Retailers generally define a number of control points for weekly workforce planning depending on their particular needs (e.g., one week beforehand, start of the week, start of the working day). The proposed system is designed to guide the decision maker at each such point in defining the best feasible action plan for recovering as much as possible of the benefits that would otherwise be lost due to a contingency. Additionally, the proposed system also permits an interaction between the user/decision maker and the affected employees. In Section 3, we provide a detailed description of our approach to develop a real-time system for adjusting personnel schedules.

The contribution made by the present study to the personnel scheduling problem consists in the development of a system that provides real-time support for decision makers tasked with determining scheduling adjustments to recover from a contingency once the system have the information about the current demand, staff availability, and the recovery resource alternatives. The proposed solution methodology considers two types of contingency: demand uncertainties and unscheduled personnel absences. Two different methods for addressing an identified contingency are designed. The first one is based on an iterative algorithm that solves a relatively big mixed integer programming model using column generation. The second one incorporates a much more practical approach, evaluating the scheduling adjustment alternatives by performing a local search routine and then greedily applying the most beneficial adjustments. Finally, we present the results of the implementation of both proposed methods for a study case of a Chilean retailer. Experiments are conducted using real-world instances in order to evaluate and compare both methods under various absenteeism scenarios and levels of priority for schedule planning stability. Note that, although contingencies can be attributed to demand variations and/or unplanned personnel absences, in this study case the experiments are conducted only for absenteeism.

2. Review of the literature

There exists an extensive literature on personnel scheduling that addresses various types of problems and solutions with applications to different industries. Thorough surveys of the field may be found in Ernst, Jiang, Krishnamoorthy, Owens, and Sier (2004)a), Ernst, Jiang, Krishnamoorthy, and Sier (2004)b), Alfares (2004) and Van den Bergh, Belien, De Bruecker, Demeulemeester, and De Boeck (2013). It has been shown that solution approaches to the general scheduling problem can be either deterministic or stochastic, in the latter case by incorporating

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