Decision model for planning material supply channels in construction

Piotr Jaśkowski\textsuperscript{a}, Anna Sobotka\textsuperscript{b}, Agata Czarnigowska\textsuperscript{a,⁎}

\textsuperscript{a} Lublin University of Technology, Nadbystrzycka 40, Lublin 20-618, Poland
\textsuperscript{b} AGH University of Science and Technology, Al. Mickiewicza 30, Krakow 30-059, Poland

A R T I C L E   I N F O

Keywords:
Construction
Dynamic supplier selection problem
Mixed integer linear programming
Supply chains
Fuzzy numbers

A B S T R A C T

Material supply-related decisions strongly affect economic performance of construction projects. To facilitate planning, the authors put forward a mixed integer linear programming model for optimizing supplies of materials or components that are consumed irregularly. The model’s objective function is minimizing the total inventory management cost. As material prices change over time and cannot be predicted with certainty, they are expressed as fuzzy values with triangular membership functions. The planning horizon is divided into units of time to allow for seasonal changes and scope variations that affect consumption of materials. The model enables the user to determine economic order quantities for consecutive periods of construction works and to select most economical supply channels of a particular material/component. The model allows for material/component substitution. Substitutes may differ in level of prefabrication and thus in costs of on-site processing. To solve the problem the fuzzy model is converted into a three-objective linear program with crisp coefficients. An example illustrates benefits of using the proposed approach in reducing the total inventory cost.

1. Introduction

The researchers and practitioners keep arguing over specific features of construction supply chains compared with the supply system in the production environment [1–3], and trying to elicit guidelines for their efficient management. These guidelines draw upon experience of the manufacturing industry [4,5] or, on the contrary, build upon the assumption of independent and rational evolution of each industry, with management ideas not being directly transferable between them [6–8].

Among construction supply chain activities, material/component procurement is one of the most demanding tasks [9]. Materials are consumed in large quantities and, obviously, need to be delivered to a “random” location (selected where the built facility is required, not where materials are available or easily transportable). The share of material-related costs, though project-, and country-specific, may be as high as 40 to 70% of the total hard cost of construction [10–12]. Therefore, the search for economies often focuses on managing materials in most effective way [13]. Efficient material logistics is considered a key determinant of project success. This is especially true in construction, with its tough competition, adversarial relationships, and traditionally low profit margins [9,14,15].

Mathematical models constructed to facilitate supply decisions are expected to allow for the real-life complexity and dynamics. Therefore, the authors put forward an Economic Order Quantity model (with its origins in manufacturing industry [16]) to minimize total inventory management cost. Though the method is classic (linear programming), the model’s originality lies in adopting a unique set of constraints deemed typical for construction projects. To account for erratic material price fluctuations observed recently – so uncertainty of prices – the authors use fuzzy logic, and analyze a number of scenarios of future price development.

The purpose of the model is to facilitate finding a rational supply plan for construction materials or components that are consumed in large quantities, irregularly (according to the schedule of works), and for a time long enough to prevent the suppliers from guaranteeing fixed prices.

The model is meant to account for constraints related with the source’s production capacity and availability of means of transport. This implies modelling effects of intermediate storing or contracting a number of suppliers to provide the same type of material. As opportunity purchases at lower prices may be justified, storage facilities need to be arranged and encompassed by the model.

Another assumption is that the model is to allow for material substitution. Substitution, understood as replacing one type of material or component with another with no detriment to quality or function of the final product, may be a result of material shortages or searching for economies (including make or buy decisions). The benefits of substitution are referred to in the literature, such as increasing flexibility of agile supply networks operating in competitive markets [17]. Enabling
the contractor to propose alternative technical solutions that can equally perform the required functions of the specified items is encouraged by public procurement legislation (e.g. EU Directive on Public Procurement, 2014/24/EU article 74, US Federal Acquisition Regulation 11.104) to avoid favoritism and corruption and promote innovation. Substitution may be also welcome due to sustainability reasons [18–20].

The remainder of the paper is organized as follows: Section 2 reviews literature related to supplier selection problem. Section 3 defines the problem and proposes its mixed integer linear formulation. Section 4 presents details on the model formulation. Section 5 discusses the scheduling, and that prices may fluctuate. If materials are required in large quantities over some time, the problem of changing supplier capacities may be worth considering together with the possibility of using substitutes or delivering the same material from more than one source at a time. Many models that allow for all or some of these aspects were presented in the literature [29–33].

A mixed integer non-linear formulation of dynamic supplier selection problem can be found, among others, in [29], where the authors expressed the estimates as fuzzy sets. This was due to difficulties in using purely statistical methods that rely on price records. In the authors’ opinion, fluctuations of construction material prices, though carefully observed and recorded by both national statistical...
دریافت فوری
متن کامل مقاله
امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات