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A review of mathematical models for supporting the order promising process under Lack of Homogeneity in Product and other sources of uncertainty ☆

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ABSTRACT

This paper presents a review of mathematical programming models for supporting the order promising process (OPP) under Lack of Homogeneity in Product (LHP) conditions and uncertainty in a modelling approach. LHP appears in productive processes with raw materials, which directly stem from nature and/or production processes with operations that confer heterogeneity to the characteristics of the outputs obtained, even when the inputs used are homogenous. LHP has a direct impact on the company's service level, mainly when the customer needs to be served with homogeneous units of the same product. LHP leads to inherent sources of uncertainty due to the natural physical characteristics of the supply chain. This research aims to determine the way that LHP, and uncertainties related either to LHP or different variables that confer more realistic conditions to OPP, have been modelled in different LHP sectors, or others affected by uncertainty. This result may provide the opportunity to transfer knowledge among them and to identify gaps for further research. Accordingly, and in order to set the basis for future research into the OPP topic, for cases affected by LHP and for uncertainties inherent to LHP conditions, or due to other possible uncertain variables, this research needs to consider both mathematical model types: (i) mathematical programming models of the OPP that consider some LHP characteristic and (ii) mathematical programming models of the OPP that consider any type of uncertainty in the modelling approach. We propose a taxonomy approach to classify and analyse the literature based on the main characteristics of its environment, order promising approach, customer order characteristics, modelling characteristics, and LHP and uncertainty modelling. The main finding of this research was that research into OPP modelling, combined with LHP characteristics and uncertainty, are lacking. We provide some starting points for further research in this field.

1. Introduction

Customer satisfaction can lead to customer loyalty, which is one of the factors needed to guarantee the sustainability of any business (Okongwu, Lauras, Dupont, & Humez, 2011). The order promising process (OPP) has made significant advances in making processes of supply, production, storage and delivery more efficient in order to better attend demand requirements with high standards of service level and customer satisfaction. According to Alemany, Alarcón, Oltra, and Lario (2013), the OPP refers to a set of business activities triggered to provide a response to customer order requests.

Although much research on OPP has been done, there are sectors that present particular common characteristics that have a great impact on the OPP and have not yet been sufficiently investigated. Some examples of these sectors are agri-food, ceramic, wood and reverse logistics, among others. They are all characterised to present the so-called Lack of Homogeneity in Product (LHP), defined as lack of uniformity in the products required by customers (Alarcon, Alemany, Lario, & Oltra, 2011). LHP appears in production processes with raw materials that directly derive from nature and/or production processes with operations that confer heterogeneity to the characteristics of the outputs obtained, even when the inputs used are homogeneous (Alemany, Alarcón, et al., 2013). The results are units of the same finished good (FG) in a lot with some attributes that are relevant for customers which can differ.

LHP may become a considerable problem when customers acquire several units of a given product and require product

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homogeneity to use, present, arrange or consume them together to avoid functional or esthetical problems. One slight difference in a part is easily seen in certain products like parquet strips, leatherwear, floor tiles or pearl necklaces (Alarcon et al., 2011). LHP supply chains are forced to classify items into different homogeneous subsets (subtypes) based on certain criteria for the purpose of meeting the customer homogeneity requirement. However, the homogeneous quantities (subtypes) that will be available to customers are not known until they have been manufactured and classified (Boza, Alemany, Alarcón, & Cuenca, 2013). For instance, in the ceramics sector, units in a production lot of the same tile model (FG) can differ in quality (aspect), tone (degree of colour) and calibre (thickness). As customers require uniformity as regards these attributes in their orders to ensure uniform esthetical appearance, ceramic companies inspect each production lot and classify it into homogeneous sublots (subtypes) based on the different combinations of attributes to comply with customer requirements. Fig. 1 shows a general schema of the appearance and effect of LHP on production processes.

According to Mundi and Alemany (2013), LHP leads to inherent sources of uncertainty due to the natural physical characteristics of the supply chain. Three possible causes are identified: (1) intrinsic product characteristics caused by lack of homogeneity in raw materials and the dynamic state of some LHP items (subtypes); for example, the perishability factor; (2) the technological characteristics of the process caused by the existence of LHP activities and LHP factors (e.g. humidity, temperature, etc.) and (3) logistic actors' characteristics due to, for instance, consumer eating habits (customers' preferences in required subtypes). The above inherent sources of uncertainty can be associated with supply chain uncertainty stages according to (Peidro, Mula, Poler, & Verdegay, 2009): (1) supply uncertainty, (2) process uncertainty and (3) demand uncertainty.

LHP inherent uncertainty has a huge impact on the OPP when customer orders that require homogeneity are promised according to uncommitted planned production lots (Master Plan) for which real homogeneous quantities are not known until produced. Due to LHP, inherent uncertainty discrepancies between planned and real homogeneous quantities are usual. This can lead to previously committed orders not being served on time. Therefore, not accomplishing this homogeneity requirement can lead to returns, product and company image deterioration, diminished customer satisfaction, and even loss of customers (Boza et al., 2013). Mundi and Alemany (2013) stress the importance of studying LHP in supply chain modelling problems according to its potential negative effects on the competitiveness of supply chains: (1) LHP leads to fragmented stocks, which can rapidly become obsolete for products with a short life cycle as they cannot be accumulated to be used in the same order given their heterogeneity; (2) uncertainty in the available homogeneous quantities of finished goods (FGs) entails having to produce more than is necessary, which means increasing stocks and (3) the customer service level may prove deficient, even with high stock volumes.

Furthermore, LHP complicates order promising because it increases the volume of information to be managed (different references (subtypes) for the same FG), and other homogeneity requirements-related constraints should be taken into account. In this context, mathematical modelling has proven a powerful tool for the OPP. Thus correct handling of LHP and its inherent uncertainty in order promising modelling is important to reduce and avoid inefficiencies in both order promising itself and previous supply chain processes, like raw materials supply, production, and storage and distribution. Inefficiencies are usually manifested as worse customer service, product waste, delivery time, use of installed production capacity, etc.

Although LHP is present in the supply chains of several sectors (ceramic, marble, tanned hides, leather goods, and horticulture, among others) which suffer the negative effects that derive from inappropriate LHP management, very few models that include LHP or uncertainty aspects have been proposed for the OPP. Even though all these LHP sectors deal with their characteristics as if unique, abstraction can show that some aspects are common to them all. Therefore, a unified study can help to transfer valid solutions from one sector to others and, at the same time, can detect aspects for further research.

According to Meredith (1993), a literature review aims to: first summarise existing research by identifying patterns, themes and issues; second, constitute an initial step in the theory development process. To achieve these objectives, a literature review by sectors was made to analyse to what extent LHP has been considered in mathematical models for the OPP in a deterministic or uncertain context. Given the small number of papers in this field, and as we are aware of the importance of modelling LHP–inherent uncertainty in the OPP, this review was extended to uncertain OPP models. Since the OPP is considered a short-term process, very few models have dealt with uncertainty for the OPP. Yet as explained before, when promising orders do not consider LHP inherent uncertainty can lead to very negative consequences. So this literature review shows that LHP modelling in the OPP is a potential research field that can improve the competitiveness of these supply chains.

The results of this review are:

- LHP inherent characteristics derive from the abstraction of common LHP aspects in different sectors which affect the OPP.
- Definition of a structured framework for reviewing the existing literature on LHP and the uncertainty OPP research area.

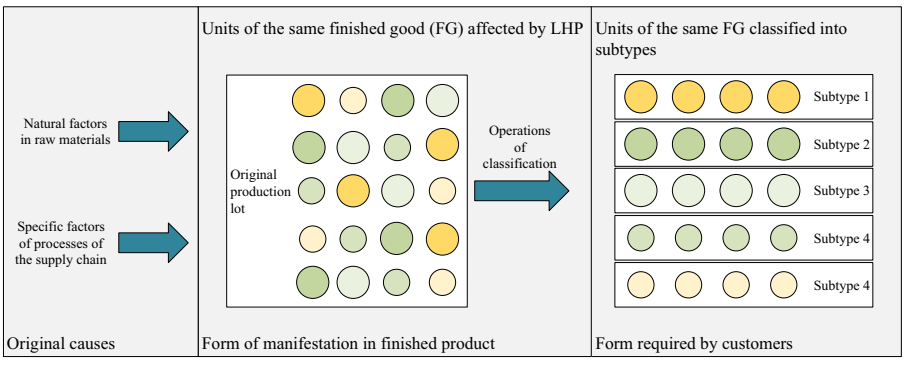

Fig. 1. General schema of the appearance and effect of LHP on production process.