# Abstract

The Lack of Homogeneity in the Product (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 homogeneous. LHP appears in different sectors such as ceramic tile, horticulture, marble, snacks, among others. LHP becomes a managerial problem when customers require to be served with homogeneous product. Supply chains responsible to provide homogeneous product face the need to include classification activities in their productive processes to obtain sub-lots of homogeneous product. Due to the inherent LHP uncertainty, these homogeneous sub-lots will not be known until the product have been produced and classified. An improper management of the LHP can have a very negative impact on the customers' satisfaction due to inconsistencies in the answer to their requirements and also on the Supply Chain's efficiency.

The Order Promising Process (OPP) appears as a key element for properly managing the LHP in order to ensure the matching of uncertain homogeneous supply with customer order proposals. The OPP refers to the set of business activities that are triggered to provide a response to the orders from customers. These activities are related to the acceptance/rejection decision, and to set delivery dates. For supply chains affected by the LHP, the OPP must consider the homogeneity as another requirement in the answer to the orders. Besides, due to the LHP inherent uncertainty, discrepancies between the real and planned homogeneous quantities might provoke that previously committed orders cannot be served. The Shortage Planning (SP) process intends to find alternatives in order to minimise the negative impact on customers and the supply chain.

Considering LHP in the OPP brings a set of new challenging features to be addressed. The conventional approach of assuming homogeneity in the product for the master production schedule (MPS) and the quantities Available-To-Promise (ATP) derived from it is no longer adequate. Instead, both the MPS and ATP should be handled in terms of homogeneous sub-lots. Since the exact quantity of homogeneous product from the planned lots in the MPS is not exactly known

until the classification activities have been performed, the ATP also inherits this uncertainty, bringing a new level of complexity. Non-homogeneous product cannot be accumulated in order to fulfil future incoming orders. Even more, if the product handled is perishable, the homogeneity management becomes considerably more complex. This is because the state of the product is dynamic with time and related variables to it, like quality, price, etc., could change with time. This situation could bring unexpected wasting costs apart from the shortages already mentioned. The perishability factor is itself another source of uncertainty associated to the LHP.

This dissertation proposes a conceptual framework and different mathematical programming models and tools, in both deterministic and uncertainty environments, in order to support the OPP and SP under LHP's effect. The aim is to provide a reliable commitment with customer orders looking for a high service level not just in the due date and quantity but also in the homogeneity requirements. The modelling of the characteristics inherent to LHP under deterministic context constitutes itself one of the main contribution of this dissertation. Another novelty consists in the inclusion of uncertainty in the definition of homogeneous sub-lots, their quantities and their dynamic state and value. The uncertainty modelling approach proposed is mainly based on the application of fuzzy set theory and possibility theory.

The proposed mathematical models and tools have been validated in real cases of SC, specifically in the ceramic tile sector for non perishables, and in the fruit sector for perishables. The results show a very good performance in terms of the interpretation and adaptability to the LHP's effect in both deterministic and uncertainty environments. The uncertainty models outperform the results of the deterministic ones in terms of objectives and robustness for both, planned and simulations of reality, showing more sensitive conditions to better interpret the real behaviour of the LHP problem, which is also an important objective of this work.