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Pharmaceutical supply chain network design under uncertainty

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Abstract—**In this paper, a novel mixed integer programming (MILP) model for pharmaceutical supply chain network design (PSCND) is developed. The proposed model contains four-echelons, in which some important decisions such as licensing a drug manufacturer for manufacturing a new drug and opening of distribution centers as strategic decisions alongside with product flows in each period as tactical decisions are made. Since a supply chain network design (SCND) problem deals with great degree of uncertainty, an efficient possibilistic programming approach is used to handle epistemic uncertainty of imprecise parameters. Finally, some numerical examples and sensitivity analyses on critical parameters are provided.**

Keywords-pharmaceutical supply chain; Supply chain network design; uncertainty; location-allocation; Fuzzy

I. Introduction

Pharmaceutical industry, which is considered as an immense global industry, can be defined as a complex of processes, operations and organizations involved in the discovery, development and manufacture of medications and drugs [1].

In 2009, this industry consumes approximately 10% of annual healthcare expenditures in the United States and about $600 billion globally [2]. Although application of sophisticated technologies in order to improve both the quantity and the quality of associated products in these supply chains is observed [3, 4], however it can be seen that many pharmaceutical companies are significantly far from effectively satisfying market demands in a systematic manner. Thus, these pharmaceutical drug supply chains are much ready for applying efficient optimization techniques [1, 5, 6].

Challenges and different methodologies in pharmaceutical supply chains have been widely surveyed by Papageorgiou [5] and Laínez et al. [7]. Rosseti et al. [8] focused on identification and examination of the major forces in the pharmaceutical supply chain which may change the way biopharmaceutical medications are purchased, distributed, and sold throughout the chains. Jetly et al. [9] developed a multi-agent simulation of the pharmaceutical supply chains and for validation of the model, one thousand replications, each lasting the equivalent of 39 years, have been used. Sousa et al. [10] presented a mixed-integer linear programming (MILP) model for allocation-distribution structure of a pharmaceutical supply chain with considering the maximization of the company's net profit value as the objective function. They have applied Lagrangean decomposition alongside heuristic methods for sequentially optimizing the frames of products. Susarla and Karimi [11] proposed a MILP model for multi-period enterprise-wide planning which integrates procurement, production, and distribution with the effects of tax differentials, material shelf-lives, inventory holding costs, and waste treatment. Rotstein et al. [12] presented an optimization based approach to selecting both a product development and introduction strategy, and a capacity planning and investment strategy for pharmaceutical supply chain with considering the demand to be dependent on the clinical outcomes. Levis and Papageorgiou [13] presented mixed-integer linear programming (MILP) model for long-term, multi-site capacity planning under uncertainty in the pharmaceutical industry with considering the trading structure of the company. Gatica et al. [14] presented a MILP model for formulation of multi-stage, multi-period stochastic optimization problem for pharmaceutical inventory system. A performance measure for including risk and potential returns