Supply Chain Design and Planning with Product Return: An Optimization Approach

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Abstract
This paper addresses the design and planning of supply chains with product return. A graph approach is used as the modelling methodology. Commonly, the application of graph approaches to the design of supply chains, considers nodes as chain entities and arcs as connections between them. These assumptions are extended in the present work where products may also be associated with both nodes and arcs. A multi-product network formulation is obtained which is further generalised to consider the modelling of time, resulting in a dynamic multi-product network model with product return. This generalisation assumes that any node is a transformation point which allows inbound and outbound products to differ. Considering four different kinds of entities (factories, warehouses, sorting centres and customers), proper functions are defined for each one: production, postponement, usage and selection. An example, base on a Portuguese industry case, is applied in order to corroborate the model applicability and adequacy to real world problems.

Keywords: Supply chain design, MILP model, forward and reverse flows, graph network.

1. Introduction
In Europe, governments are taking the disposal of end-of-life (EOL) products very seriously. As a result, the responsibility for handling these products has increasingly been shifted from consumers to producers. Thus, EOL products can no longer be ignored by companies which might regard them has either an economic opportunity or an environmental liability. In order to remain competitive while meeting this challenge, companies need therefore to develop adequate strategies and adapt their supply chains accordingly (Geyer and Jackson, 2004). Changes into existing supply chains open a number of questions which require to be answered: Should collection centres be opened? If so, where to place them? How to plan collection? How to