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REVERSE LOGISTICS: A SURVEY

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ABSTRACT
Due to the threatening level of environmental problems, environmental initiatives, which are enforced by governments, customers or companies themselves, have become an obligation. As a part of environmentally conscious initiatives, reverse logistics has taken considerable attention both from academicians and practitioners. As a result of this interest, a large body of reverse logistics related study has been built. This article gives general information about reverse logistics and provides an overview of the related literature.
Keywords: survey, reverse logistics

1. INTRODUCTION
Due to the threatening level of environmental problems, environmental initiatives, which are enforced by governments, customers or companies themselves, have become an obligation. As a part of environmentally conscious initiatives, reverse logistics has taken considerable attention both from academicians and practitioners. Rogers and Tibben-Lembke (1998) defined reverse logistics (RL) as "*the process of planning, implementing and controlling the cost effective flow of row materials, in-process inventory, finished goods and related information from the point of origin for the purpose of recapturing value or proper disposal*" [1]. Traditionally, the term of "logistics" is perceived only with the forward side of the concept. On the other hand, many reasons, such as [2]:

- manufacturing returns,
- commercial returns (B2B and B2C),
- product recalls,
- warranty returns,
- service returns,
- end-of-use returns,
- end-of-life returns,

, cause reverse direction product corridors and this additional reverse side of the logistics provides a closed-loop.

Usually, RL can be perceived as exactly the reverse of the forward logistics (FL), however, in lots of decision making areas, RL is not similar to the FL. RL may have different channels, collection points, decision making units, product characteristics, etc. Differences between forward and reverse logistics are in Table 1 [3]:

Table 1. Differences between forward and reverse logistics [3]

Forward Logistics	Reverse Logistics
Forecasting relatively straightforward	Forecasting more difficult
One to many transportation	Many to one transportation
Product quality uniform	Product quality not uniform
Product packaging uniform	Product packaging often damaged
Destination/routing clear	Destination/routing unclear
Standardized channel	Exception driven
Disposition options clear	Disposition not clear
Pricing relatively uniform	Pricing dependent on many factors
Importance of speed recognized	Speed often not considered a priority
Forward distribution costs closely monitored by accounting systems	Reverse costs less directly visible
Inventory management consistent	Inventory management not consistent
Product lifecycle manageable	Product lifecycle issues more complex
Negotiation between parties straightforward	Negotiation complicated by additional considerations
Marketing methods well-known	Marketing complicated by several factors
Real-time information readily available to truck product	Visibility of process less transparent

Given the above differences, it is obvious that, there is a need to examine the RL concept as an independent research area. Considering this need, a large body of study has been built since 1992 (the time that the first recognized the RL field). The researchers examine the RL concept in different point of views and the various sides of the field are investigated. The aim of this paper is to give general information about RL and provide an overview of the related literature. In the next section, a literature survey is presented. In the last section the importance of the concept and its future scopes are given.

2. LITERATURE SURVEY

There are several RL literature survey papers in the literature and all classified RL literature with different point of views. One of the leading literature surveys, which reviewed the quantitative models for reverse logistics networks, prepared by Fleischmann et al. in 1997 [4]. In this paper, RL investigated in three classes. In the first class, distribution side of the RL is examined with its two sub dimensions: (1) separate modeling of the reverse flows, (2) integration of the forward and reverse distribution. In the second class, the inventory control in systems with return flows, which examined into two dub dimensions as deterministic and stochastic models, is examined. Finally they investigated the production planning with reuse of parts and materials side of the RL concept. They examined this part into two dimensions such as: (1) Selection of recovery options, (2) Scheduling in a product recovery environment.

In 2002, Brito et al. reviewed case studies in RL. In their valuable study [2], they reviewed the case studies in five main classes. First class is related with RL network structures which contain four subclasses: (1) networks for reusable items, (2) networks for remanufacturing, (3) public reverse logistics networks, (4) private reverse logistics networks for product recovery. In the second class, they studied on the RL case studies related with the RL relationships which classified as two subclasses: (1) economic incentives to stimulate/enforce the acquisition or withdraw of products for recovery, (2) non-economic incentives to stimulate/enforce the acquisition or withdraw of products for recovery. In the third class, they reviewed the literature related with the inventory management which can be investigated in four subclasses: (1) commercial returns cases, (2) service return cases, (3) end-of-use returns cases, (4) end-of-life returns cases. In the fourth class, they investigated planning and control of recovery activities into five subclasses: (1) disassembly planning, (2) planning

and control of collection activities, (3) planning and control of processing, (4) integral planning and control of collection-distribution, (5) integral planning and control of processing-distribution. In the last class, they reviewed the studies related with ICT.
In addition to these two valuable studies, several studies can be helpful to the researchers, which are interested in RL concept, prepared by Fleischmann et al. [5], Carter [6], Subramaniam [7], etc. Based on [2,4,5,6,7,], a RL literature survey is prepared below.

RL studies can be investigated into three classes: ***RL network structures, inventory control in RL, production planning in RL.*** Based on Fleischmann et al. [5] RL networks can be investigated in three classes. First class is the bulk recycling networks which are related to the material recovery from rather low value products. [8, 9, 10, and 11] can be shown as examples of this class. Second class is the assembly product remanufacturing networks which are related to re-use on a product or parts level of relatively high value assembled products. [12, 13, 14, 15] can be shown as examples of this class. The last class is related with the re-usable item networks which are concerning containers, pallets, etc. [16] can be shown as an example of this class.

As a second research area in RL, inventory control problem can be investigated. Based on Fleischmann et al. [4]'s classification, this area can be investigated in two main classes. First subclass contains the studies which have deterministic models. In this class, information on all components of the framework is assumed to be known with certainty [4]. [17, 18, 19, 20] can be shown as examples of this class. Second subclass contains the studies which have stochastic models. In the stochastic models, demands and returns are assumed to be stochastic. [21, 22, 23, 24, 25, 26, 27, 28] can be shown as examples of this class.

The last research area in RL is related with the production planning and control activities. In this subclass, the actual decision is *where* should *when how much of what* be collected, disassembled or processed [2]. These kind of planning activities are arising from traditional production planning, but have specific characteristics and differences. [29, 30, 31, 32, 33, 34, 35] can be shown as examples of this class.

3. CONCLUSIONS

Increasing environmental problems, the level of product returns, legal obligations, etc. motivates the practitioners and academicians to study on RL concept. As a scientific field, RL has been known and applied in many countries such as USA, Spain, German, etc. for many years. However, for Türkiye, this concept is still very young and there is a need to study on. In this study, we addressed this important research field in logistics. This study gives a beginning insight and brief literature survey to the researchers interested in RL. In the future researches, more detailed investigations need to be prepared which contain recent studies.

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