Mathematical modeling of recovering used oil filters and determining collection centers

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Summary

It is a fact known by researchers that the network to be established will be a complex structure because of the uncertainties that "reverse logistics" product returns have both in terms of product itself and time. In this study, we emphasize the reasons why regional collection centers (BTMs) should exist and where they should be established in the reverse logistics network structure which plays an important role in this complex structure. In Turkey, reverse logistics network design is planned for the recovery of finished oil filters. In order to be able to respond to the question of the establishment of the regional collection centers in the "reverse logistics" network structure, the most appropriate result has been achieved through the scenario analysis carried out with the full mathematical model.

Key words: Closed Loop Supply Chain, Reverse Logistics, Plant Selection, Life Oil Completion Filter.

1.ıntroduction

As the purchasing power of the consumers increases, the amount of waste increases day by day. As a result, increasingly scarce natural resources are increasing environmental concerns. In this context, the recovery of wastes has become an important issue because of the increased economic benefits of the laws and laws of the governments. The purpose of this study is to determine the location of special collection centers in a network structure by considering it as a mathematical problem rather than attempting to form a reverse logistics network structure type. For this purpose, a mixed-integer linear programming model has been established with a goal function of distance (cost) minimization considering the geographical conditions and road distribution of Turkey of special collection centers, which are among the prerequisites for establishing a reverse logistics network. The model that was installed was run in the Games program and the most appropriate solution was obtained. By solving the model, the cost was minimized and it was examined where the special collection centers to be opened should be opened.

2. Reverse logistics

The concept of logistics is divided into advanced logistics and reverse logistics. Advanced logistics means that products are transported from producers to customers within a distribution channel. On the contrary, logistics is the transfer of products from the customers back to the producers in a distribution channel (Murphy, 1986: 12). On the contrary, logistics refers more to product replicas, resource abatement, recycling, material substitutes, reuse of materials, waste disposal, renewal, repairs and reprocessing operations (Stock, 2001: 6).

On the contrary, logistics is a process involving all logistics activities from the used product that is no longer required to the user, to the product that can be reused in the market. In contrast to this definition, logistics involves physical transport of the used product from the end user to the manufacturer, in terms of distribution planning. The next step is to convert the recycled product into a reusable product by the manufacturer (Karachay, 2005: 318).

There are many definitions in the literature about the concept of reverse logistics. For example; Dowlatshahi (2005) defines the process as a process involving the systematic processing of products submitted for recycling, reproduction and destruction. Rogers and Tibben-Lembke (1998), on the other hand, refer to transport as a means of preserving their values at the final destination of logistic products, or in order to properly destroy the products. Jayaraman et al. (2003), reverse distribution refers to activities involving the removal of both defective and environmentally harmful products as well as products that are usable, but whose lifespan is the last, from the customers' hands (Jayaraman et al., 2003: 128). Conversely, the most commonly used definition for logistics activities is that the used product is physically moved from the last user to the manufacturer.

Retailers and producers also perceive reverse logistics as different. Retailers perceive reverse logistics as the return of used products from consumers, and the producers perceive the return of faulty products as users.

On the contrary, strategic factors of logistics systems are strategic cost, general quality, customer service, environmental issues and legal obligation. On the contrary, the factors for operating in logistics are; Cost-benefit analysis, transportation, storage, procurement management, recycling and re-production and packaging (Dinç, Erol and Yüceer, 2008: 328).

On the contrary, although it does not contain various methods which are valid in logistics, supply and distribution logistics, it also contains some unique methods in itself. It is possible to list these in the following way (Uslu and Akçadağ, 2012: 153)

* **Collection:** usually includes all activities related to the collection of wastes dispersed within the production area.

* **Decomposition:** involves the division of waste into smaller volumes to be passed through different processes.

*** Carriage and transfer:** involves the disposal of waste or relocation of the waste to the place of construction.

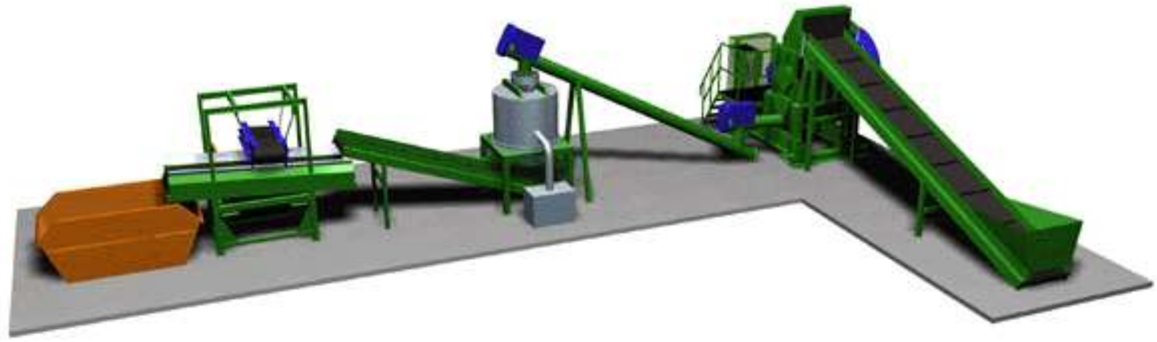
*** Storage**: takes place before transport and transfer or before processing of wastes. Storage is mainly used to collect the amount of waste that will provide the highest efficiency from transport and processing activities. The capital that is allocated to stocks because the wastes are not worth it or are of low value is not as high as in traditional storage activities.

*** Processing**: involves reusing or rendering harmless waste**.**

On the contrary, recycling in logistics is possible in many cases. For example, Barros et al. (1998) dealt with the design of a recycling network of scrap from construction waste in the Netherlands. In their designs they proposed a two-stage location model and performed optimization using the heuristic method. Kleineidam et al. (2000) dealt with a modeling method for the production chain containing recycling. They have examined the models using the methods of control theory. They have chosen paper recycling as a case study. De Koster et al. (2001) focused on the recycling of white and brown goods and examined the operations of nine supplier deposits in their work. They identified the factors that gave the decision to merge or separate incoming and outgoing streams and made suggestions for implementation. Kaçtıoğlu and Şengül (2010) have used reverse linear programming method in their studies in reverse logistics for the recycling of packaging waste in Erzurum province. Uslu and Akçadağ (2012) have studied the role of reverse logistics and distribution in the pharmaceutical sector. Aru ORGAN, İrfan ERTUĞRUL and Özlem Fedai DENIS (2013) studied the reverse logistics network model with full-fledged programming: an example of tire recovery that has completed its life cycle. Karahan KARA, Assoc. Dr. A. Zafer ACAR and Ar. See. İsmail ÖNDEN (2013) examined the determination of collection center locations in reverse logistics processes by mathematical modeling. In this study, we have Karahan KARA, Assoc. Dr. A. Zafer ACAR and Ar. See. İsmail ÖNDEN (2013) did not work before and they did a lot by taking advantage of the work they did, and adapting it to ourselves, without working with Aru ORGAN, İrfan ERTUĞRUL and Özlem Fedai DENİŞ (2013) te. On the contrary, the importance of many products entering the network has been better understood in recent years. Life-Filled Oil Filters are also one of the most important of these.

3. VEHICLE OIL FILTER RECYCLING LINE

Filters that come with trays licensed by Tesise will be divided into oil, iron-steel, paper-textiles (less than 1% oil content) materials by means of machinery and equipment of the EU standards (granulation, centrifuge, magnet etc.). The separated components will be sent to their respective refineries. There is no use of chemicals, but a working material other than electricity consumption is water. It is not used. At the Waste Oil Control Regulation, the basic principle of waste oil management is primarily to recover waste oils. Products consisting of waste treated according to the Flow Diagram shown in the figure are classified within themselves and stored before sale. Filters in the hazardous wastes category after the filter change of the vehicles will be economized after they are put through physical processes.



4. METHODOLOGY

According to a 3-step methodology proposed in the study, the output of each phase will be the input of one another. As a first step, defining the problem and setting the structure of the logistic network in reverse, making the admissions and producing the data to be considered in the solution will be realized. A mathematical model proposal for probing, outlined in this step, will be carried out within the second step. The model will be set up as an integer 0-1 and the decision variables, the purpose and constraints of the model will be defined. A goal function will be defined that takes into account the density of the cities to be considered in the model and the distances and distances that specify the amount of flow to be given to the network in reverse. In this context, the objective function will be expressed in such a way that the facilities that are close to the zones with high distance and minimization of distance will be selected. Finally, the sensitivity analyzes will be performed to test the accuracy of the results of the mathematical model defined in the second step. Within this step, we are investigating the best at the point where the best case can not be achieved. As a result of the proposed flow, the findings obtained will be evaluated and the findings about the network which will serve in reverse logistics within Turkey will be evaluated.

4.1. DEFINITION OF PROBLEM

(Eg Forestry and Water Affairs, Energy and Natural Resources, Food and Agriculture, Livestock, Health, Environment and Urbanism, National Education, National Defense, Justice) and its affiliates (eg SSI, EGM and TSK) have a widespread provincial organization. These institutions and organizations are supported by the ministries they are affiliated with and are carrying out their activities under the control of the relevant ministry in order to carry out their related activities. It is a problem area of our work to bring the oil filters which have been used for the activities of the public institutions and organizations to the main gathering center for the reuse, reproduction, recycling and destruction activities by collecting the oil filters which can be reused by recycling and which are obligatory to be destroyed . The aim of the solution is to respond to the question of which ITMs should be installed in order to get the ATMs to be brought to the Main Collection Center (ATM) in Ankara by collecting and consolidating the BTMs primarily.

4.2. PROBLEMIN ANSWERS

* There are almost every organization of the central public institutions and organizations. The reverse logistics network to be created; It is accepted that it will be taken from the provincial organizations in the provinces to the BTMs and then the materials collected in the BTMs to Ankara.

* The materials of the public institutions and establishments in the areas close to Ankara will be taken directly to the main collection center without using BTM.

* Based on the highway routes, it is accepted that 4 BTMs should be established in the areas named X, Y, Z and T. Possible locations of these centers are in Annex-A.

It is accepted that the facilities to be installed in BTMs are assumed to be in the same capacity and same service conditions and there may be differences in province numbers according to their importance levels in the region.

* Province levels of importance; Highways, geographical conditions, population densities and living conditions (Annex B).

* BTM installation and operation costs are considered to be less costly than installation and operation costs of ATM (which can be found in sorting, sorting, maintenance-repair and destruction activities). However, the cost of installation is not included in the problem, considering that the objectives of the BTMs to be established are the same and that they are constructed by the public budget.

* Assuming that the products to be collected from public institutions and organizations are in uniform packages, the material weights will be calculated on tonnage basis.

* On the contrary, 25 m3 and 1.5 ton capacity vehicle types will be used to collect the materials in the logistics network and to be taken to the BTMs. 40 m3 and 12 ton capacity vehicle types will be used to consolidate the materials collected in the regional collection center and to be taken to the main collection center.

* The vehicles to be used will be operated according to their full occupancy principle and it is accepted that BTMs will wait until they are fully charged and the fuel consumption rates of all of them will be the same and thus the fuel consumption will only change depending on the distance and affect the cost in this way.

* It is accepted that the location of BTMs to be installed can be determined by minimizing the distances of the facilities within the zone and simultaneously the distance of the ATMs in Ankara.

4.3. MODEL INDEX SET

The mathematical expression of BTM opening alternatives for each province that is available in the accepted areas is shown below.

X = {1, ..., 9} Alternatives to opening the X Region Collection Center

Y = {1, ..., 17} Alternatives to opening the Y Region Collection Center

Z = {1, ..., 16} Alternatives to opening Z Region Collection Center

T = {1, ..., 15} T District Pickup Center opening alternatives

4.4. MODEL VARIABLES

The mathematical expression of the variables accepted to open the BTM in the model is shown below.

Yx = {0,1} In the X region, opening the regional collection center, x C x

Yy = opening the regional collection center in the region {0,1} Y, y ϵ Y

Yz = opening the regional collection center in the region {0,1} Z, z Є Z

Yt = {0,1} T, opening the regional collection center, t C T

4.5. MODEL PARAMETERS

The parameters affecting the objective function, ie the distance between the illusions, the distances of the illusions to Ankara, and the mathematical expressions of the importance given to them are shown below.

Cx = x In-zone transport distance for the regional collection center, x C x

CxA = distance from x collection center to Ankara,, x ϵ X

Cy = y In-zone transport distance for the regional collection center, y ϵ Y

CyA = y transportation distance from collection center to Ankara, y ϵ Y

Cz = z In-zone transport distance for the regional collection center, z Є Z

CzA = z transportation distance from collection center to Ankara, z z

Ct = t In-zone transport distance for the regional collection center, t C "T

CtA = t transport distance from collection center to Ankara,, t ϵ T

Px = level of importance for x-region charts, x C x

Py = y level of significance for the y regions, y ϵ Y

Pz = z the level of importance for the z-regions, z C "Z

Pt = t The importance level for the territory illustrations, t C T

4.6. MODEL RESTRICTIONS

The relevant constraints of the model are shown below.

Σ Yx = 1 x ϵ X xϵX

Σ Yy = 1 y ϵ Y yϵY

Σ Yz = 1 z ϵ Z zϵZ

Σ Yt = 1 t ϵ T tC "T

Yx, Yy, Yz, Yt? {0,1}

4.7.MODEL

The aim was to function as the effect of the importance levels of the illusions of the illusions of the illusions and at the same time as the minimization of the distances of the illusions to Ankara.

= Min

C? Y? Px + CxA? Yx +? CyYyPy + CyAYy +? CzYzPz + CzAYz +

XϵX yϵY zϵZ

Σ [Ct Yt Pt + CtA Yt]

Tϵt

4.8. MODELING SOLUTION

The Games program was used to solve the established numbered programming model. The models established in the related program were entered by taking the distances of the ones located in the regions and their distances to Ankara from the official data of the General Directorate of Highways. Then, with the program running, model 9 reached the optimum result in iteration. The optimum and alternative solutions obtained are presented in Table 1

ZONE	OPTIMUM SOLUTION	ALTERNATIVE SOLUTION
X Region	İstanbul	Çanakkale
Y Region	Diyarbakır	Gaziantep
Z Region	Kars	Erzincan
T Region	İzmir	Afyon

Tablo 1: Model Results

5. CONCLUSION AND EVALUATION

In our work, we have solved the need for the collection centers to be opened on the reverse logistics network structure to be used for the recycling, reuse and destruction of the unused oil filters in the representatives of the public institutions and organizations in the provinces. If we will evaluate the findings obtained by running the model; It is proved that the best result for X region is developed between the provinces within the X region of Istanbul province and the result obtained on the Ankara road is valid due to applicability. As an alternative solution, Çanakkale province emerges as the most appropriate solution for the transportation of the materials to be collected from the parts of Turkey that are located in the European region without entering the complex structure of Istanbul.

We can see that Gaziantep province, which is an alternative solution with Diyarbakır province, which is anticipated as the optimum solution for Y Region, has high level of development in the region and supports the applicability of the result that is found in connection points of roads.

In the Z zone, the optimum result is that it is more suitable for the collection center to be installed in the region when considering the highway routes of Erzincan province, which is an alternative solution to Kars province.

Optimum result for T Region in the same way It is thought that Afyon province, which is anticipated as an alternative solution to İzmir province, will be more appropriate when considering the geographical structure of the region and distance distances to Ankara.

In this study, the most important cost among the logistics costs is considered as a mathematical problem which can be achieved with the minimization of the transportation costs, which can be achieved by decreasing the transportation cost and the logistics costs. By solving the problem and achieving the results, mathematical models can be used to reduce the logistical costs. The network design used in this study can be developed and used in a study involving the recovery of all oil waste oil filters. Also the model can be added to the secondary market transportation network. On the contrary, as the work on logistics increases, significant improvements in recovery will occur.

RESOURCES

http://www.askgeridonusum.com/ask-geri-donusum-projeleri/

http://www.oznakgeridonusum.com/file/katalog.pdf

http://www.kilicoglucevre-enerji.com.tr/hizmetlerimiz/arac-yag-filtresi-geri-donusum-hatti/

http://bertaraf.com.tr/atik-filtre.asp

Aru ORGAN, İrfan ERTUĞRUL ve Özlem Fedai DENİŞ (2013); Design of the reverse logistics network model with full-fledged programming in the work they do: a sample of the completed tire recovery

Karahan KARA, Doç. Dr. A. Zafer ACAR ve Ar. Gör. İsmail ÖNDEN (2013); In reverse logistics processes, collecting center locations are determined by mathematical modeling

Neslihan ÖZGÜN DEMİREL ve Hadi GÖKÇEN; Logistics network design for recycled manufacturing systems: literature review

EKLER

EK-A BÖLGELER VE İLLER

X BÖLGESİ	Y BÖLGESİ	Z BÖLGESİ	T BÖLGESİ
İstanbul	Malatya	Elazığ	İzmir
Edirne	Diyarbakır	Erzincan	Aydın
Tekirdağ	Şanlıurfa	Van	Muğla
Çanakkale	Mardin	Ağrı	Manisa
Kırklareli	Şırnak	Bitlis	Balıkesir
Bursa	Hakkari	Bingöl	Denizli
Yalova	Siirt	Erzurum	Burdur
Kocaeli	Batman	Kars	Isparta
Sakarya	Adana	Ardahan	Antalya
	Antep	Trabzon	Afyon
	Hatay	Tunceli	Konya
	Maraş	Artvin	Kütahya
	Kilis	Bayburt	Uşak
	Adıyaman	Sivas	Eskişehir
	Kayseri	Muş	Karaman
	Niğde	Iğdır	
	Mersin		

EK-B İLLERE VERİLEN ÖNEM SEVİYELERİ

ÖNEMSEVİYELERİ	1	2	3	4	5
İLLER	İstanbul	Edirne	Şanlıurfa	Kocaeli	Bursa
	Çanakkale	Tekirdağ	Mardin	Sakarya	Yalova
	Diyarbakır	Kırklareli	Şırnak	Malatya	Batman
	İzmir	Hakkâri	Gazi Antep	Siirt	K. Maraş
		Hatay	Kayseri	Elazığ	Kilis
		Erzincan	Kars	Adana	Adıyaman
		Ağrı	Ardahan	Niğde	Artvin
		Erzurum	Tunceli	Van	Bayburt
			Sivas	Trabzon	Mersin
			Isparta	Bitlis	Muş
			Afyon	Bingöl	Iğdır
			Konya	Aydın	Kütahya
				Muğla	Uşak
				Manisa	Eskişehir
				Balıkesir	Karaman
				Denizli	
				Burdur	
				Antalya	

Note:

The data contained in the application section of the work, Karahan KARA, Assoc. Dr. A. Zafer ACAR and Ar. See. Ismail ÖNDEN (2013) has been taken from the article "Determining the locations of collection centers by mathematical modeling in reverse logistics processes".