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Investigation of chemical effects of electronic wastes on environment based on reverse logistic

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Nowadays the influence of chemical side effects of electronic tools and their decomposition on the environment is increasingly becoming a real concern and adopting a stable approach toward consumption patterns is increasingly becoming important, particularly about the electronic wastes. Recycling, decomposition and waste management are two of the major issues in this area. Reverse logistics is a new and appropriate guideline to this aim. The present study aims to provide a conceptual model for electronic waste reverse logistics. In order to provide a more efficient level of energy and material recycling as well as environmental safety, chemical functions are used for treatment of electric waste. The research population included 43 professors and experts, 14 of which were selected as the sample size using cluster sampling method. A mixed integer number planning model presented for designing the reverse logistic network with limited capabilities and in uncertain situation. It covers the supply options, producing centers, distributing and collecting centers, disposal and recycling centers together. It is aimed at minimizing the total cost of electronic wastes recycling and finding the best location for collecting the electronic wastes. The developed network of reverse logistic applies a mathematical model and is a seven-section network, which includes 5 suppliers, 5 producing centers, 8 distribution center, 10 customer collecting centers, 2 recycling centers and 4 disposal centers.

Keywords: electronic wastes, reverse logistics, municipality of Tehran, Chemical effects, environmental management

PROBLEM STATEMENT

Electronics industry has improved the life quality in general. On the other hand the high growth rate and the short lifecycle of electronics (due to the newer technologies) have increased the wastes of outdated electronics. The harmful effects of the electronics due to their toxins including lead, mercury and cadmium are big concerns these days. In some advanced countries electronic wastes are the biggest resource of heavy metals in urban dry wastes. Technical institutions are required to manage these wastes and clarify whether the used goods should be repaired, recycled or disposed. Therefore managing the wastes can generate an income for the institution. Categorizing and detecting the electronic wastes and sending them to the factories create value in the supply chain. Recycling and reusing the wastes through an efficient waste categorizing system will have satisfying results. The process may be performed by the government, companies or even unlawful entities. The cooperation of the citizens with the government facilitates and improves the process besides maintaining the health.

In some advances countries the electronic wastes are the main source of heavy metals. Hence recycling the electronic wastes has become a necessity. Moreover recycling these wastes helps save the natural resources through retrieving useful metals including copper, Iron, aluminum, gold, silver etc. [1]. Accordingly, the question of article is that what is Reverse logistics model for electronic waste is in Tehran municipality?

Electronic waste (E-waste) is a general term which refers to the electronic or electronic appliances that are thrown away by the users. The appliances may range from big home appliances such as refrigerators, microwave ovens, televisions, and computers to small digital sets, cell phones and toys. They may be categorized based on their contents [2]. In term of weight iron, aluminum, plastics and glass are used more than the other materials. However wood, ceramics and rubber also exist in the wastes. Electronic and electric wastes are known for having toxic and harmful materials inside. If these materials spread during recycling and disposing steps they can be really dangerous for human and environment health [3].

The researches demonstrated that the effects of the dangerous components on our nerve and immune system are the most important subject related to the E-waste. Being exposed to these pollutants may cause cancer, so protective measure must be applied. However this situation is the result of incorrect planning [4].

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The infrastructures define the procedures and amount of recyclable wastes. The factors affecting the recycling infrastructure are the amount of the wastes, available recycling technologies, governmental rules and the economy of electronic wastes [5].

Reverse logistic as a new subject in the field of logistics is a profitable and stable commercial approach [6]. Reverse logistic is a process in which the manufacturers systematically receive (return) the products they have sold (after they are used) for recycling, reproducing or disposing. In reverse logistic the supply chain is redesigned to manage the flow of the products that are supposed to be recycled, reproduced or disposed and use the resources in a more effective way [7]. General issues related to the functions, channels, the difference between direct and reverse operations, costs and general information about reverse logistic are studied by a number of researchers including: [8-12].

The strategic factors of reverse logistic are: strategic costs, general quality, services to the customers, environmental and legal concerns. Tactical factors in this area are: cost and benefit analysis, transportation, warehouse, supply management, reproducing, recycling and packaging. Reverse logistic can help the companies gain considerable competitive advantages in their industry, particularly for the industries with high competition rate [13].

Hilty [14] believes that while applying reverse logistic approach companies should consider activities such as collecting, detecting, sorting, and defining marketing strategies. Collection means gathering the goods from customers to a certain point of retrieving, where the goods are investigated, selected and sorted for recycling. Based on the current guidelines goods are sorted and tracked as follows: reusing directly, reprocessing and disposing.

Electronic industry has experienced changes due to the public awareness about the environment and competition in the industry [15]. The governments of developed countries have set rules about manufacturing, recycling goods after their economic lifetime and transporting the wastes during recycling process and brought them in force [16]. The necessity of following the state rules, reaching more benefits through reducing the wastes, and improving the image of the firm through recycling have made the manufacturers insert the reverse logistic processes in the supply chain. However, quick technological advances along with fashionable designs, which are made to increase sale, have reduced the lifetime of the products and put pressure on reverse logistic [17].

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Investigating the factors affecting the reverse logistic systems [18] suggest a conceptual model in which all the internal and external factors are considered. In the model the external (macro) environment is made up of 4 parts: inputs (suppliers), legislators (government and lobbying groups), outputs (buyers), and competition (competitors). Internal environment includes strategic factors (e.g. strategic expenses, overall quality, services, environmental issues and legal issues) and operational factors (cost and benefit analysis, shipment, storage, supply management, reproduction, recycling and packaging), which must be considered in designing the reverse logistic system by every firm [19].

2. RESEARCH METHOD

This is an applied research and referring to the data collection methods it is considered a survey research therefore it is generally a descriptive research. The sample of the research includes faculty members and municipality top managers, who are experts at managing wastes and reverse logistics. The primary population was 43 and using Cochran method the sample size was defined to be 14. Cluster sampling is applied in this research. Questionnaires were used for collecting data. In order to develop the reverse logistic model of electronic wastes in Tehran, the steps of logistic process were presented to the experts in a questionnaire and they were asked to rate the steps for the case study based on their knowledge. Based on their opinions the final model was developed, reviewed and validated.

The steps of identifying the dimensions of reverse logistic model of electronic wastes are presented in Fig 1. Referring to the Fig, the fourth step is analyzing the date collected through questionnaires then the results of this step are reviewed and validated by the experts and the validity and reliability are verified, finally the final hierarchical structure is developed. The other steps are will be explained later.

3.RESEARCH RESULTS

In order to develop an appropriate model for the electronic wastes reverse logistics, first the main dimensions and steps of the reverse logistics models were identified and classified. It was meant to create a comprehensive view of reverse logistic concept and define the main and effective steps. After the corrections and changes the final model was developed which is presented in Fig 1.

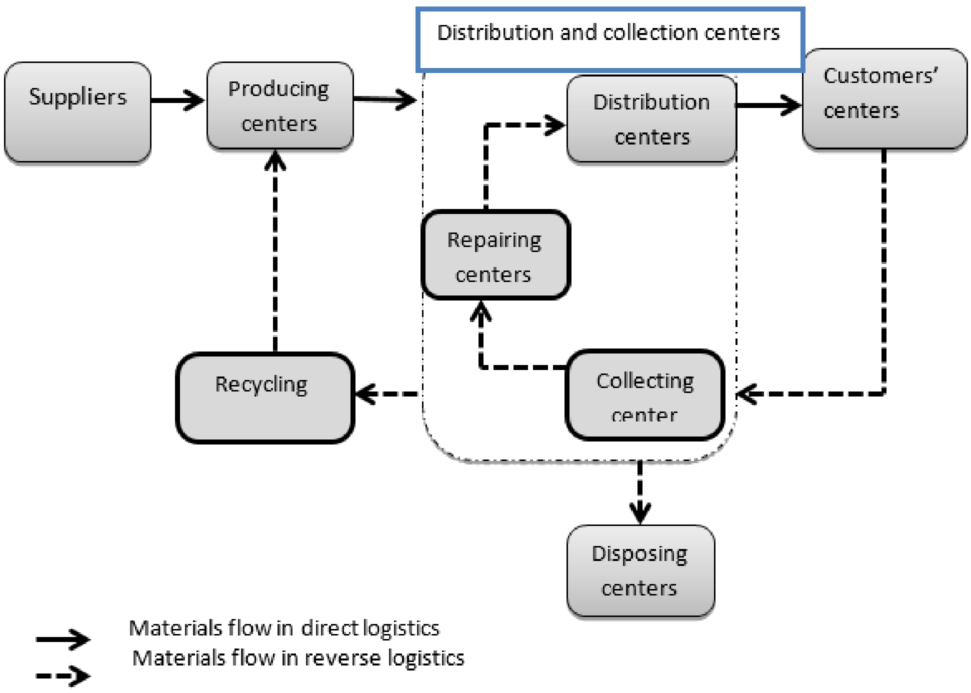


Fig1: Electronic wastes reverse logistics model for Tehran.

Mathematical model:

Table 2 represents a conceptual model for the reverse logistics of electronic wastes which is developed based on the literature and the views of experts. Diversity of the components and electronic wastes increased the variables to be investigated. We tried to limit and simplify the variables in order to obtain more realistic and appropriate results. Therefore the electronic appliances were evaluated and the weaknesses and strengths of each were Fig d out. Finally cellphone, which has an up to date and complete cycle, was selected for the basis of developing a model.

Collections:

H: stable locations of suppliers, $h \in H$

I: potential locations of production centers, $i \in I$

J: potential locations of distribution centers, $j \in J$

K: stable location of customers, $k \in K$

L: potential locations for collecting/detecting, $l \in L$

M: potential locations for recycling centers, $m \in M$

N:stable locations for disposing centers, $n \in N$

E: stable potential locations for corresponding distributing centers and collecting/detecting centers, $e \in E$, $E \subset J$ & $E \subset L$

R: materials for manufacturing, $r \in R \& R = Q \cup S$

S: the recyclable materials for manufacturing, $s \in S \& \subset R$

Q: unrecyclable materials for manufacturing, $q \in Q \& Q \subset R$

T: time periods, $t \in T$

Parameters:

Table 1. The parameters applied in the mathematical model.

d_{kt}	The demand of customer k center in time period t
Ps_t	The price of each product in a customer center in time t
π_t	The cost of each missing sale in a customer center in time period t
Pr_{0t}	The price that customers expect for each product in time period t
a_t	The maximum price that customers expect for each product in time period t
Rc_t	Supportive incentives for collecting each used product in time period t
α_t	Average non-returnable fraction of products in time period t
β	Percentage of the capacity dedicated to distribution in case of correspondence of the facilities of collecting/ investigation in common points e
Cp_{rhi}	Total transport costs of each unit of material r from supplier h to manufacturing center i in time period t
Co_{ij}	Total transport costs of each unit of product from manufacturing center i in time period
Cq_{jk}	Total transport costs of each unit of product from manufacturing center j in time period
Cu_{kl}	Total transport costs of each unit of returned product from customer center k to collecting/detecting center l in time period t
Cv_{ln}	Total transport costs of each unit of non-return able product from collecting/detecting center l to disposing center n in each time period
Cw_{lm}	Total transport costs of each unit of recyclable product from collecting/detecting center l to recycling center m in each time period
Cs_{smi}	Total transport costs of each unit of recycled product type "s" from recycling center m to manufacturing center i in each time period
φ_{rh}	Total cost of providing materials type "r" for each unit of product from supplier h in each time period
γ_i	Total cost of manufacturing each unit of product in manufacturing center i in each time period
δ_j	Total cost of processing each unit of product in distributing center j in each time period
θ_l	Total cost of processing each unit of product in collecting/detecting center l in each time period
λ_n	Total cost of disposing each unit of non-recyclable product in disposing center n in each time period
ρ_m	Total cost of disposing each unit of recyclable product in disposing center m in each time period
b_i	Fixed cost of establishing manufacturing center i
c_j	Fixed cost of establishing manufacturing center j
f_l	Fixed cost of establishing collecting/detecting center i
g_m	Fixed cost of establishing recycling center m
Fcs_e	Reducing the foxed costs due to corresponding the manufacturing centers and collecting/detecting centers in common point electronic
Sca_{rh}	Maximum capacity of supplier h for supplying material r in each time period
Pca_i	Maximum capacity of manufacturing center i in each time period
Dca_j	Maximum capacity of distributing center j in each time period
Cca_l	Maximum capacity of collecting/detecting center l in each time period
Rca_m	Maximum capacity of recycling center m in each time period

Table 2. The variables applied in the mathematical model

	Definition
h_{kt}	The number of products consumed in customer center k in time period t, $\boldsymbol{h_{kt}} = \sum_{j\in J} \boldsymbol{Q_{jk(t-1)}}$
r_{kt}	The number of returned products customer center k in time period t
P_{rhit}	The flow of material r from supplier h to manufacturing center i in time period t
O_{ijt}	The flow of products from the manufacturing center i to distribution center j in time period t
Q_{jkt}	The flow of products from the manufacturing center j to customer center k in time period t
U_{klt}	The flow of returned products from the customer center k to collecting/detecting center in time period t
V_{lnt}	The flow of non-recyclable products from the collecting/detecting center l to recycling center m in time period t
W_{lmt}	The flow of recyclable products from the collecting/detecting center l to recycling center m in time period t
S_{smit}	The amount of recycled materials in the recycling center m to manufacturing center i in time period t
Pr_t	The proposed price for buying each unit of used product in time period t
$\mathbf{X_i} = \begin{cases} \mathbf{1}, & \text{if the manufacturing center is located in i} \\ \mathbf{0}, & \text{otherwise} \end{cases}$	
$\mathbf{Y_j} = \begin{cases} \mathbf{1}, & \text{if the manufacturing center is located inj} \\ \mathbf{0}, & \text{otherwise} \end{cases}$	
$\mathbf{Z_l} = \begin{cases} \mathbf{1}, & \text{if the collecting/detedting center is located in l} \\ \mathbf{0}, & \text{otherwise} \end{cases}$	
$\mathbf{T_m} = \begin{cases} \mathbf{1}, & \text{if the manufacturing center is located in j} \\ \mathbf{0}, & \text{otherwise} \end{cases}$	

Mathematical model:

$$Max\ \Pi = total\ expected\ income - total\ expected\ cost$$

$$\begin{aligned} Max\ \Pi = & \sum_{j\in J}\sum_{k\in K}\sum_{t\in T} Q_{jkt}Ps_t + \sum_{k\in K}\sum_{t\in T} r_{kt}(Rc_t - Pr_t) - \sum_{k\in K}\sum_{t\in T}\left(d_{kt} - \sum_{j} Q_{jkt}\right)\pi_t \\ & - \sum_{i\in I} b_i X_i - \sum_{j\in J} c_j Y_j - \sum_{l\in L} f_l Z_l - \sum_{m\in M} g_m T_m + \sum_{e\in E} Fcs_e \psi_e \\ & - \sum_{i\in I}\sum_{j\in J}\sum_{t\in T}(\gamma_i + Co_{ij})O_{ijt} - \sum_{j\in J}\sum_{k\in K}\sum_{t\in T}(\delta_j + Cq_{jk})Q_{jkt} \\ & - \sum_{k\in K}\sum_{l\in L}\sum_{t\in T}(Cu_{kl} + \theta_l)U_{klt} - \sum_{l\in L}\sum_{n\in N}\sum_{t\in T}(Cv_{ln} + \lambda_n)V_{lnt} \\ & - \sum_{l\in L}\sum_{m\in M}\sum_{t\in T}(Cw_{lm} + \rho_m)W_{lmt} - \sum_{s\in S}\sum_{m\in M}\sum_{i\in I}\sum_{t\in T} Cs_{smi}S_{smit} \\ & - \sum_{r\in R}\sum_{h\in H}\sum_{i\in I}\sum_{t\in T}(Cp_{rhi} + \varphi_{rh})P_{rhit} \end{aligned}$$

S.t.

$$\sum_{j\in J} Q_{jkt} \le d_{kt} \qquad \forall\, k \in K, \forall t \in T$$

$$\sum_{l\in L} U_{klt} = r_{kt} \qquad \forall\, k \in K, \forall t \in T$$

$$h_{kt} = \sum_{j\in J} Q_{jk(t-1)} \qquad \forall\, k \in K, \forall t \in T$$

$$r_{kt} = h_{kt} * Pr_t / a_t \qquad \forall\, k \in K, \forall t \in T$$

$$\sum_{h\in H} P_{shit} + \sum_{m\in M} S_{smit} = \sum_{j\in J} O_{ijt} \qquad \forall s \in S, \forall\, i \in I, \forall t \in T$$

$$\sum_{h\in H} P_{qhit} = \sum_{j\in J} O_{ijt} \qquad \forall q \in Q, \forall\, i \in I, \forall t \in T$$

$$\sum_{i\in I} O_{ijt} = \sum_{k\in K} Q_{jkt} \qquad \forall\, j \in J, \forall t \in T$$

$$\alpha_t \sum_{k\in K} U_{klt} = \sum_{n\in N} V_{lnt} \quad \forall\, l \in L, \forall t \in T$$

$$(1-\alpha_t) \sum_{k\in K} U_{klt} = \sum_{m\in M} W_{lmt} \quad \forall l \in L, \forall t \in T$$

$$\sum_{l\in L} W_{lmt} = \sum_{i\in I} S_{smit} \qquad \forall s \in S, \forall\, m \in M, \forall t \in T$$

$$\sum_{i\in I} P_{rhit} \le Sca_{rh} \qquad \forall r \in R, \forall h \in H, \forall t \in T$$

$$\sum_{j\in J} O_{ijt} \le X_i Pca_i \qquad \forall\, i \in I, \forall t \in T$$

$$\sum_{i\in I} O_{ijt} \le Y_j Dca_j \qquad \forall\, j \in J, \forall t \in T$$

$$\sum_{i\in I} O_{iet} \le \psi_e \beta Dca_e + M(1-\psi_e) \qquad \forall e \in E, \forall t \in T$$

$$\sum_{k\in K} U_{klt} \le Z_l Cca_l \qquad \forall\, l \in L, \forall t \in T$$

$$\sum_{k\in K} U_{ket} \le \psi_e (1-\beta) Cca_e + M(1-\psi_e) \quad \forall e \in E, \forall t \in T$$

$$\sum_{l\in L} W_{lmt} \le T_m Rca_m \qquad \forall\, m \in M, \forall t \in T$$

$$Pr_t \le a_t \qquad \forall\, t \in T$$

$$2\psi_e \le Y_e * Z_e \qquad \forall e \in E$$

$$X_i, \quad Y_j, \quad Z_l, T_m \in \{0,1\} \forall i \in I, \ \forall j \in J, \ \forall l \in L, \ \forall m \in M$$

$$P_{hit}, O_{ijt}, Q_{jkt}, U_{klt}, V_{lnt}, W_{lmt}, S_{mit}, Pr_t \ge 0 \qquad \forall h \in H, \forall i \in I, \ \forall j \in J, \forall k \in K, \forall l \in L, \forall m \in M, \forall n \in N, \forall t \in T$$

Assumptions of the model:

1. How to define the amount of returned products: it is assumed that the customers are free to choose to return the used product when buying a new one. Therefore the number of used products in each center in each period equals the amount of products that are bought from the shopping center by them last time. The following formula calculates the amount:

$$h_{kt} = \sum_{j\in J} Q_{jk(t-1)} \qquad \forall \boldsymbol{K}$$

The buyer decision to return depends on the proposed price(Pr_t). It means the owners of the products expect a minimum price Pr_{0t} for returning them. If the proposed price is higher than what they expect the return them. Since the expected price depends on a variety of factors including the customers' knowledge of environment, the expected prices may vary form one customer to another. It is assumed that the parameter follows a steady distribution as:

$$Pr_{0t} \sim U(0, a_t)$$

Accordingly:

$$Probability = P(Pr_{0t} < Pr_t) = \frac{Pr_t}{a_t}$$

Therefore the return rate of products is:

$$r_{kt} = h_{kt} * Pr_t / a_t \qquad \forall\, k \in K, \forall t \in T$$

With the following limitation:

$$\mathrm{Pr_t} \le \mathrm{a_t}$$

2. In this model the facilities of distributing and collecting/detecting can be integrated on order to benefit from the savings (Fcs_e). Accordingly in some potential points of (E) simultaneous establishment of distribution and collecting/detecting facilities is possible. The facilities have a lower capacity when they are established next to each other. In such case the capacity of distribution β is a percent of the facilities that are established in isolation and the capacity of collecting facilities reduces $(1-\beta)$ percent. In linear situations ψ is:

$\psi_e = Y_e * Z_e$

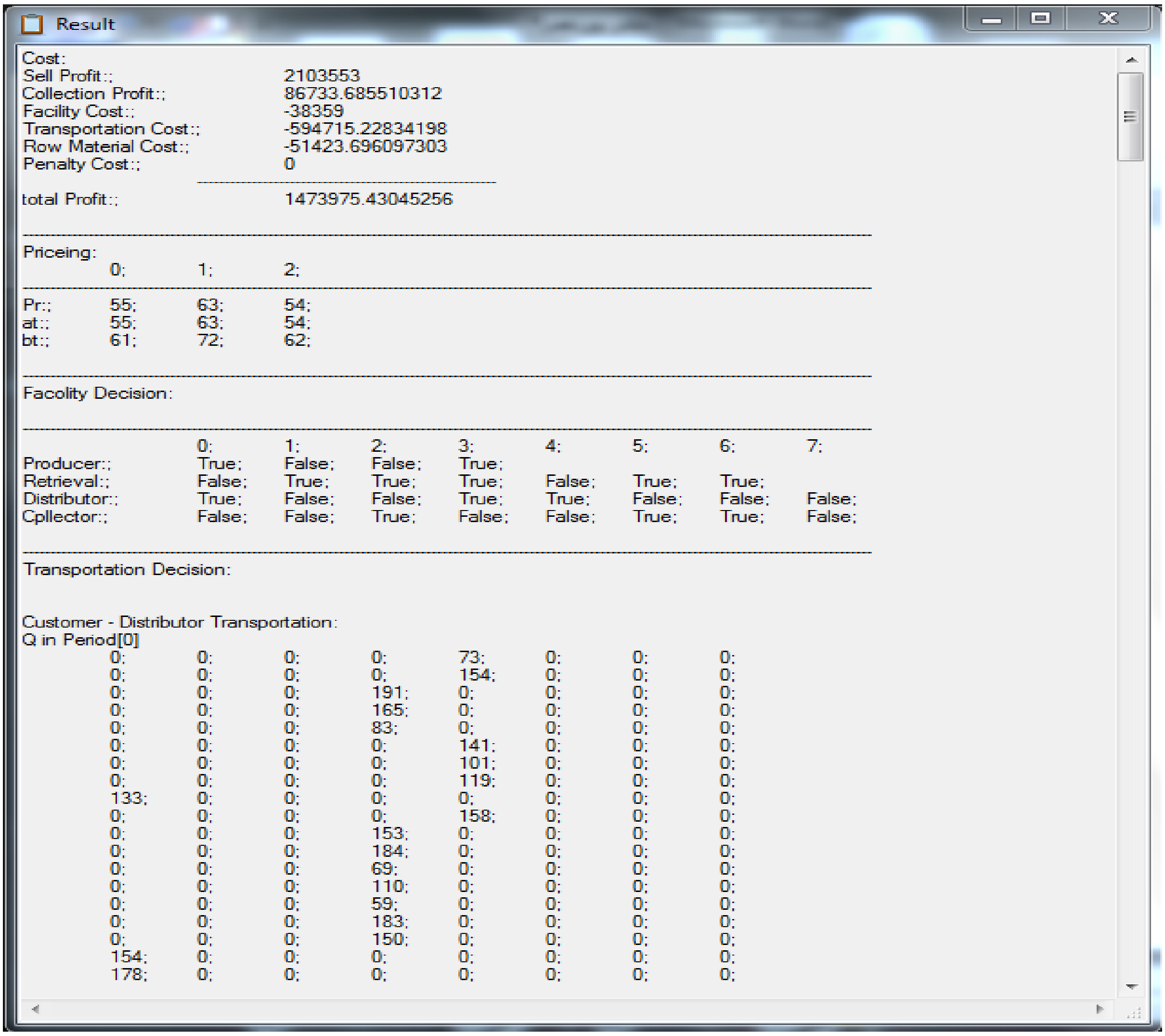
$\psi_e \in \{0,1\} \qquad \forall e \in E$

The following limitation is also added: $\forall e \in E 2\psi_e \leq Y_e + Z_e$

4.SOLVING THE MATHEMATICAL MODEL

The software that was developed by researchers was used to assess the efficiency of the model. The toolbar has four tabs namely File, Data, Solve, and about. The file menu is used for opening saved files, saving new data and closing the software. Data menu is used for updating the data, entering data from a certain direction or test the software using random data. Solve is the most important menu which includes solve problem, results on a diagram, results in a table, lingo model, save the result of solving problems and open the saved results. In about menu some information is presented about patent and the developer of the software. The variables that are provided in the reverse logistics model include: Home, Customer, Distributer &Collector, Producer, Dispose, Retrieval, Supplier, Product and GA. In Home menu the specifications of the problem are presented. The ways of managing the variables, subjects such as the time periods, the number of manufacturers, distributers, collecting centers etc., the range of entered variables, the fine of the factors having negative effects, the range of variable costs, and probable rates of logistics process are presented. This menu affects problem solving practically. Customer menu presents the specifications of customer centers. The locations of the main customer centers along with the relative capacity of each market, cost of establishment, process cost, the amount of demand for each three, six, and 12 month period. Distributer &Collector menu presents the data of collecting and distributing centers. In the model all of collecting and distributing centers are assumed as one in order to simplify the model and improve the results. The following parameters of the electronic products distribution and electronic wastes collecting are investigated: geographical location, capacity and the volume of activities, cost of establishment and cost of process. In Producer menu the specifications and parameters of manufacturers is provided. Some manufacturers in Tehran produce cellphone. To this aim the data of location, production capability, cost of establishment and cost of process is presented. In dispose menu the information of disposal centers, which is collected through questionnaire, is presented. Therefore geographical location, disposing capacity, cost of establishing a quarter and cost of process were estimated using collected data. The data of recycling centers is provided in the next menu. The data includes four following parameters: geographical location, recycling capacity, cost of establishing a quarter and cost of process. In Supplier menu the data about main suppliers of electronic products, cell phone in particular, in Tehran is provided. Parameters of the variable are: geographical location, cost of establishing a quarter and cost of process and capacity in each period. Product is the next menu, which provides some data about cell phones. The menu includes price and raw materials. The data in Genetic Algorithm menu are about limiting and defining the intervals to obtain better results. After providing the facilities and the software the problem can be solved by entering the data. To this purpose, click on solve item in Solve menu enter the data and let the software analyze the data and provide tables and graphs. Samples of the processes are provided here. The software processes the data and provides the output in tables and in the framework of the map of Tehran. Fig. 3 provides the output of the software in form of solved tables of reverse logistics in uncertainty condition.

Every logistics action is presented in a particular color and with particular signs. If the results are provided on a map, they may be either presented according to different time periods, or every transport may be presented separately or they may be presented as a whole. The communications and transports may be presented as a whole for a better analysis. There is another item in this menu. It presents the data based on transport routs. The results of the software are provided in Fig 4. It shows transporting electronic wastes from customers to collecting centers. Estimation of the centers is fairly correct. However for better results the locations (points) must be calibrated to get more precise geographical information. The software can provide reports based on data-collected through questionnaire- on locations, distribution, supplying, customers, recycling, disposing, environmental and social limitations and other related criteria.


Result

Cost:

Sell Profit::	2103553
Collection Profit::	86733.685510312
Facility Cost::	-38359
Transportation Cost::	-594715.22834198
Row Material Cost::	-51423.696097303
Penalty Cost::	0
total Profit::	1473975.43045256

Priceing:

	0;	1;	2;
Pr::	55;	63;	54;
at::	55;	63;	54;
bt::	61;	72;	62;

Facolity Decision:

	0;	1;	2;	3;	4;	5;	6;	7;
Producer::	True;	False;	False;	True;				
Retrieval::	False;	True;	True;	True;	False;	True;	True;	
Distributor::	True;	False;	False;	True;	True;	False;	False;	False;
Cpllector::	False;	False;	True;	False;	False;	True;	True;	False;

Transportation Decision:

Customer - Distributor Transportation:
Q in Period[0]

0;	0;	0;	0;	73;	0;	0;	0;
0;	0;	0;	0;	154;	0;	0;	0;
0;	0;	0;	191;	0;	0;	0;	0;
0;	0;	0;	165;	0;	0;	0;	0;
0;	0;	0;	83;	0;	0;	0;	0;
0;	0;	0;	0;	141;	0;	0;	0;
0;	0;	0;	0;	101;	0;	0;	0;
0;	0;	0;	0;	119;	0;	0;	0;
133;	0;	0;	0;	0;	0;	0;	0;
0;	0;	0;	0;	158;	0;	0;	0;
0;	0;	0;	153;	0;	0;	0;	0;
0;	0;	0;	184;	0;	0;	0;	0;
0;	0;	0;	69;	0;	0;	0;	0;
0;	0;	0;	110;	0;	0;	0;	0;
0;	0;	0;	59;	0;	0;	0;	0;
0;	0;	0;	183;	0;	0;	0;	0;
0;	0;	0;	150;	0;	0;	0;	0;
154;	0;	0;	0;	0;	0;	0;	0;
178;	0;	0;	0;	0;	0;	0;	0;

Fig. 3. The results of the model in tables.

5. CONCLUSION

The model comprehensively covered the different factors of reverse logistic process. However, it is a firm-based model that does not pay much attention to the macro environment. Current paper is efforts to design a model for implementing a reverse logistic system that can help the organization optimize the management of electronic wastes. Reviewing the literature of electronic wastes highlighted the importance of investing on reverse logistics and managing recycling them. As a matter of fact electronic wastes result in environmental problems with vast dimensions. The main purpose of this research is to identify the dimensions of electronic wastes reverse logistics model. Through investigating different models in the literature it was concluded that there is no generally accepted model for reverse logistics. The model represented by the researchers is dependent upon different variables including the industry, the volume of activities… The activities relevant to reverse logistics were identified to be 29 activities with high overlapping. This can be rooted in the approaches of the researchers. After reviewing the steps it was concluded that 8 steps have been used in at least 5 models and are important. The aforementioned steps include collecting, storing and warehousing, compacting, reusing, recycling, transportation, disposing with the frequency of 10, 6,6,4,5,6,4,8 respectively. Therefore collecting, disposing, storing and warehousing, reusing, and reproducing are more important. The formation of considerable amounts of hydrogen bromide and high-molecular-weight organ brominated compounds, as well as the potential formation of limited quantities of polybrominated dibenzo-p-dioxins and dibenzofurans, is an important element of concern in the safety and environmental assessment of the thermal degradation processes of electronic boards containing brominated flame retardant.

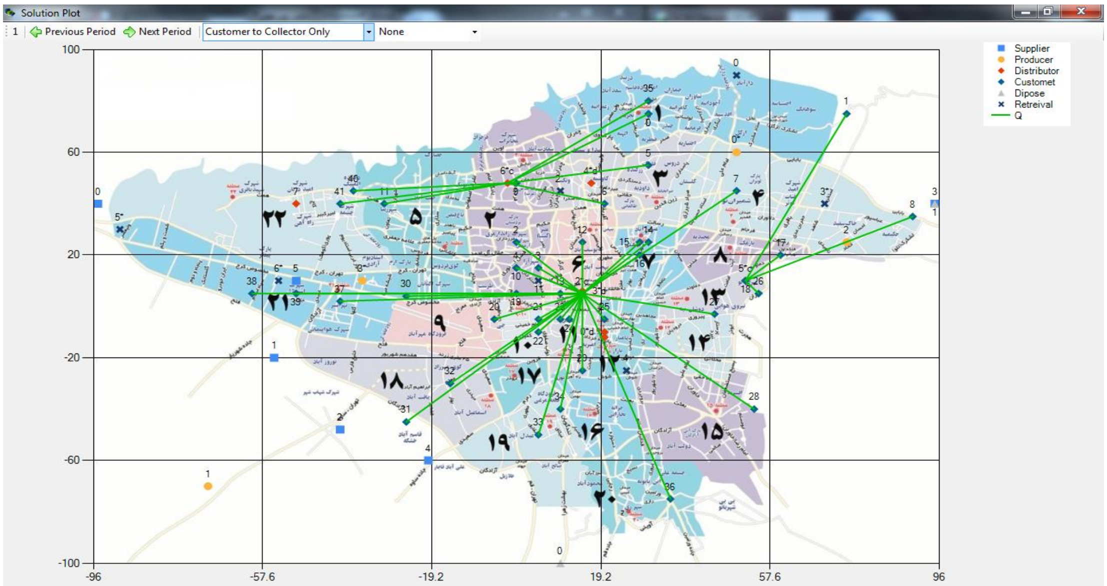


Fig 4. Solving reverse logistic development model of electronic wastes in Tehran.

Generally this research is a combination of 17 reverse logistics models and the ideas of scholars and industry experts. Therefore it has merits over other models. This paper defines reverse logistics model in for main steps (e.g. collecting and storing, repairing, recycling and disposing) along with some sub-activities, which have similar contents with the study of genandrialine & Psyche, 2006. Their research defines three probable steps for electronic wastes including warehousing, recycling, and burying. However our model has four steps including collecting, repairing, recycling and disposing. The main difference between the two models is that the current research puts more emphasis on “repairing” step which is not as highlighted in Genandrialine & Psyche model. The study of Giuntini & Andel [10] is mainly focused in activities such as collecting, detecting, selecting, sorting, and defining strategies for recycling industrial goods, which have been considered as initial processed in collecting step in the current model. Therefore the model developed in this study has a more comprehensive view on reverse logistics. El korchi &Millet [8] divides the factors affecting reverse logistics system into external and internal environment. He further defines operational and strategic factors for internal environment. Operational factors include activities and steps of transporting, storing, supply management, reproducing, recycling and packaging. This model is acceptable since it identifies the effective factors of different dimension. On the other hand it is not focused on identifying the steps of reverse logistics. Based on research results we recommend that appropriate models for reverse logistics be selected referring to the high diversity of the products. Moreover to make the model more effective we recommend the steps and their order be meticulously investigated since the costs may lead to monetary problems in the plan.

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