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A STUDY AND ANALYSIS OF BARRIERS IN DEVELOPING END-OF-LIFE VEHICLES (ELV) REGULATIONS IN DEVELOPING COUNTRIES: THE INDIAN SCENARIO

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ABSTRACT----An end-of-life vehicle (ELV) is a vehicle that is being taken out of use, either because of its age or because of damage from a collision. ELVs have become a global concern as automobiles have become popular worldwide. Under the current situation where automobile ownership is growing rapidly, ELV management is of importance in terms of resource conservation, waste management, and traffic safety that involves human lives (Sakai et al, 2013). While it is observed that ELV legislations are in place and ELV recycling systems are established in the European Union (EU), Japan, Korea and China, it is seen that in countries like India, with growing automobile markets, no such regulations are in place, and establishing ELV regulations is an urgent issue and needs to be addressed. This paper makes a comparative analysis of ELV legislations/regulations existing in developed countries and also brings out the importance of putting up appropriate ELV regulations in Indian context. Barriers in developing such regulations in the context of India are also identified and further analysis of these barriers is carried out through Interpretive Structural Modelling (ISM).

KEYWORDS: End-of-Life vehicle, ELV regulation, Barrier analysis, Interpretive Structural Model (ISM).

1.INTRODUCTION

Vehicles, essential to society, are continually increasing in use. However, throughout their life cycle vehicles impact the environment in several ways: energy and resource consumption, waste generation during manufacturing and use, and disposal at the end of their useful lives (Kanari, 2003) End-of-Life Vehicles (ELV) are those vehicles, which have reached the end stage of their life cycle and which can be processed for recycling or either remanufacturing its parts by the automotive recyclers. For a vehicle, to reach this stage can happen by ageing, road accidents, natural calamities, technical failure or bank attachment due to financial defaultness (Harraz and Galal, 2011). ELVs have become a global concern as automobiles have become popular worldwide. Recently, the management of ELVs has become one of the most important environmental issues since the environmental pollutions by ELV increase significantly (Jeong et al., 2007). Further under the current situation where automobile ownership is growing rapidly, ELV management is of importance in terms of resource conservation, waste management, and traffic safety that involves human lives (Sakai et al, 2013).

While it is observed that ELV legislations are in place and ELV recycling systems are established in the European Union (EU), Japan, Korea and China, it is seen that in developing countries like India, with growing automobile markets, no such regulations exist. The importance of management of the ELVs in the developing countries where the number of vehicles on the roads is expanding at an alarming rate is becoming more apparent. The implementation of strict product-oriented legislation will sooner or later become of paramount interest in developing countries like India (Zarei et al., 2010). This paper highlights the various aspects concerned with ELV directives in developed countries and points out the barriers in developing such an ELV directive in India with an appropriate analysis performed through Interpretive Structural Modelling (ISM).

2. Growth of Vehicle Population: The Indian Scenario

Automobile manufacturing is among India's fastest growing industries. Rising income levels, low levels of entrance, demographic factors and rapid increase in gross domestic product have afforded to the growth. India currently ranks sixth in the world in production of cars and second in the production of two wheelers. This growth will be sustained in the foreseeable future. Unlike the United States and Europe, where gradual growth occurred over a large number of years, production of automobiles took off in the early 1990s in India at an exponential rate (Mohanram, 2012).

India has experienced a tremendous increase in the total number of registered motor vehicles and Figure 1 shows the details regarding the total number of registered motor vehicles during 1951-2012. The total number of registered motor vehicles increased from about 0.3 million as on 31st March, 1951 to 159.5 million as on 31st March, 2012. The total registered vehicles in the country increased at a Compound Annual Growth Rate (CAGR) of 10.5% between 2002 and 2012 (Source: Road transport year book,2011-12)

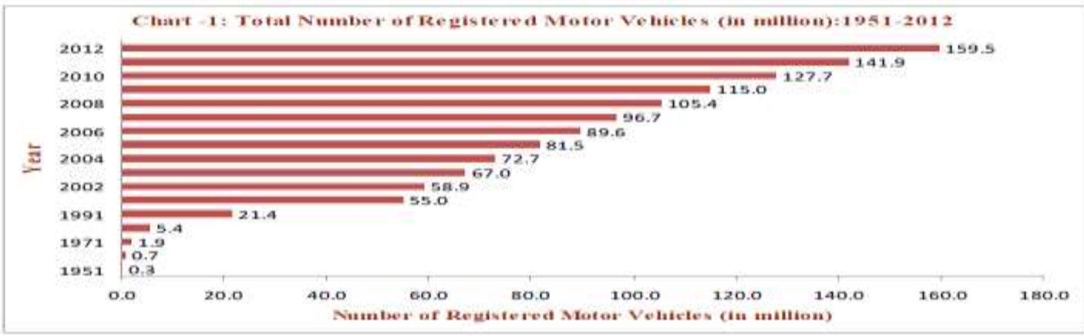

Fig 1: Total number of registered motor vehicles in India: 1951- 2012

Source: (Transport Research Wing, Ministry of Road Transport & Highways, Government of India, New Delhi. Road Transport Year Book (2011-2012))

It is observed that over the last two decades, vehicle populations have increased fivefold and production tenfold (Mohanram, 2012) and more so particularly the vehicle production has been on an exponential growth in India since the last decade (Garg et al., 2014). Although the vehicle population has increased enormously over the last decade and the number of ELVs requiring disposal in the future is likely to increase consequentially, the problem of ELV and treatment of the resulting automobile waste is yet to attract attention in India.

The disposal of ELVs is of high concern to achieve sustainable development in any country. Maximum recovery and recycling is needed to be achieved to reduce waste discharge and to change the image of the automobile industry through environmentally sound governing. Lately, ELV management has been launched extensively in developed nations to establish an appropriate recycling system using the best available technologies (Azmi et al., 2013). There is a strong need to have such kind of ELV directive in developing countries, like India, to manage the growing automobile population. In India, at present, there has been no framework setup for managing ELVs at a national level, and there is no agency that tracks their numbers and how they are handled.

India follows the European model in regulations governing design, construction, safety, and emissions. However, India has no formal regulations regarding the processing, recyclability and disposal of ELVs and there seems to be no infrastructure or standardized system for collection, dismantling, shredding and processing auto scrap.

Though vehicles are being used in India regardless of its age or condition, vehicles that last for 15 years may be considered as end-of-life Vehicle. In general, the extensive usage of such ELVs not only contributes to environmental pollution but also lead to vehicle failure which threatens the safety of its user as well as other road users. In order to overcome this and also to recover valuable metals and non-metals from such ELVs, a framework for ELV management needs to be developed and India is also in need of developing such a ELV management system. Currently there are no regulations in India to deal with the disposal of end-of-life automobiles. The present work focuses on ELV practices presently adopted in India and further attempts to identify the barriers in developing ELV regulation in India which are, then, analysed through ISM.

3.END-OF-LIFE-VEHICLES (ELV) TREATMENT PROCESSES

In Indian context, the end-of-life vehicle process involves three major stages, which attempts to maximise the amount of material that can be reused. The first step of pre-treatment involves removal of all fluids from the vehicle, i.e. petrol/diesel, engine oil, coolant, windshield washer fluid, etc., and after the fluids have been drained out parts such as gasoline tank, mercury switches, tires and battery are also removed from the vehicle. The second step involves removal of main parts of the car, which can be reused or remanufactured depending on their condition. Lastly, after all the parts and fluids have been removed from the vehicle it is either crushed and sold as scrap or directly sold to scrap dealers (Garg et al., 2014).

In developed countries, the process is slightly different in that after dismantling process, shredding process is adopted. From end-of-life vehicles, dismantling companies first remove the oil, engine, transmission, tire, catalytic converter, battery and other parts, which are generally recycled or reused. Dismantling process is the process or procedure of breaking down and end-of-life vehicle into its individual components and material-specific elements. Shredding companies then separate the ferrous and non-ferrous metals and resin from the remaining vehicle bodies. At shredder facilities, hulks are inspected prior to shredding to guarantee that potentially hazardous components such as batteries, gas tanks, and fluids have been removed.

Hulks (and other collected materials) are then fragmented into fist-sized pieces using large hammer mills. The post shredder process differentiates the stream of materials into the basic streams, ferrous material and non-ferrous material. By using air separation methods, the non-ferrous materials are separated into the metal (containing aluminium, brass, bronze, copper, lead, stainless steel, nickel, magnesium, and zinc) and non-metal known as ASR (Automobile Shredding Residues containing glass, plastic, rubber, carpet, foam, textile, etc.) fraction. The ferrous metal fraction is sent to the steel smelters for recycling. The metal fraction is typically sent to another, specialized facility to separate the stream into its individual metals by a variety of means. The ASR is disposed into landfill (Afrinaldi et al., 2008).

The economics of the two businesses are fundamentally different. Dismantling is a much more labour-intensive process as, typically, it appears difficult to introduce any advanced mechanization and automation in a dismantling plant. In contrast, shredding is a much leaner operation in terms of labour, however not at all equally so in terms of capital equipment and related financial costs as well as energy and maintenance. Shredding necessarily involves impressive equipment investments, high-energy bills and significant maintenance costs (Sakkas and Manios, 2003).

4.INDUSTRY STRUCTURE IN INDIA

There is a need for modern techniques for recycling and recovering materials from those vehicles, which are at the end of their useful life. The auto recycling industry goes hand in hand with the automobile production industry in countries like Europe and other developed countries,. It is mandatory to recycle the vehicles after the end of their lifespan. There are strict regulations worldwide on the treatment of ELVs but in India, there is no such regulation to deal with old and non-useable automobiles.

It is important to note that very little information is available as to the real fate of the decommissioned vehicles. The main problem for this is that the car deregistration process is not at all rationalized, nor closely monitored and controlled. However, few attempts have been made to study about the ELV management and the status of ELV processing facilities in India. According to a study report authored by Chaturvedi et al., (2012) the disposers of automobiles in India can be sorted based on their disposal practice as bulk disposers, such as government transport agencies operating large fleets, always sell at auction; Individual disposers, who return their old vehicle in exchange for a discount on a new one, or to local dismantlers and the medium-size disposers who would sometimes have enough ELVs to bring to auction, but would, most often, have to turn to automobile workshops. The Deutsche Gesellschaftfür Internationale Zusammenarbeit (GIZ), an international cooperation enterprise for sustainable development with worldwide operations, in collaboration with the Central Pollution Control Board (CPCB) of India has conducted a mapping study of ELV covering Northern India, with the focus on the major automobile hubs in India, namely Indore, Kolkata, Pune, Jamshedpur and Chennai.

Figure 2 illustrates the flow of ELVs and ELV processing by auto dismantlers. In short, auto dismantlers earn money by selling “recycled” parts from wrecked vehicles, primarily to auto body shops and individuals. Once useable parts are detached and sold, the hulk is sent to a scrap metal processor or otherwise disposed or abandoned.

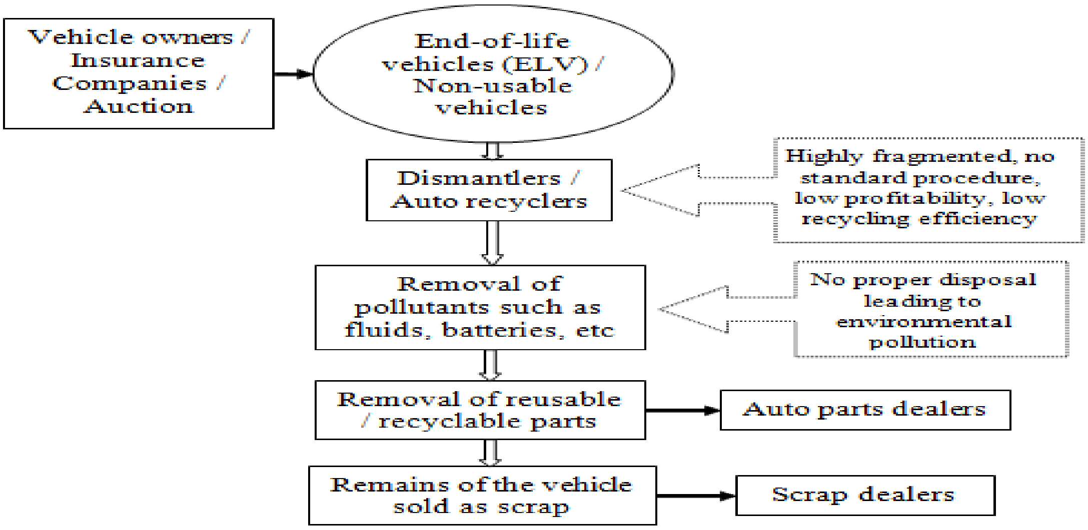

Fig 2: ELV management in Indian context

In India currently, the ELVs management is basically left to an informal, unorganized and unregulated sector. The recycling of ELVs is currently carried out by small units using primitive methods. According to a report published by the Automotive Recyclers Association (Understanding the economics and material flow of ELV, June 2012), more than 100,000 family units are involved in ELV dismantling in India, usually organised around informal centres specialised in particular tasks. These units were originally formed around the outskirts of major towns, but have now been integrated into highly densely populated areas as a result of the explosive expansion of urban cities in India. Mayapuri in Delhi, a densely-populated residential area, houses Asia's largest automobile recycling complex employing over thirty thousand people. likewise recycling takes place in Pudupet, in the heart of Chennai, Shivaji Market in Bangalore and crowded areas in Mumbai, Kolkata, and elsewhere.

This informal sector performs a critical role in recovering valuable resources from ELVs. However it does not adhere to any particular environmental norms and is responsible for large amounts of toxic compound releases into the air, ground and water (Mohanram, 2012). It is observed that the whole system is very unhygienic and can handle only low volumes.

The ELV processing facilities in India are characterized by an underdeveloped market and a low operational sophistication (Sakkas and Manios, 2003). The dismantling units employ primitive and poor unhygienic processes that result in drainage of oils and fluids to the ground thereby polluting the air and ground water. Copper is recovered by burning of insulation releasing dioxins into atmosphere. The risk of heavy metal contamination is totally ignored. It is observed that persons employed in these activities are largely uneducated and are unaware of the effects these unhygienic methods have on their own health and safety as well as on the environment.

As observed by Mohanram (2012), there is an urgent need to relocate the processing units to less crowded areas, retrain the personnel and orient them towards using modern methods, proper equipment, as well as to compliance with standards of safety and hygiene. This is not just a technical issue, but a problem with socio-economic dimensions, as it involves relocating and retraining a large number of people with marginal incomes.

With the rush in automobile production in the mid-1990s, increases are expected in the number of end-of-life vehicles. The present processing units have neither the capacity nor the capability to deal with the surge. To cope up with such an increased volume and also for efficient disposal of ELVs, India needs to set up a modern recycling infrastructure drawing from experience of the advanced countries, to avoid a major pileup of derelict automobiles. It is also pertinent that measures need to be initiated so that vehicle manufacturers tie up with authorised recyclers to recycle their products at the end of their useful life in an environment-friendly manner taking care of the health and safety of the involved workers and citizens of the country.

5. ELV LEGISLATION IN DEVELOPED COUNTRIES

In recent years, environmental issues and sustainability have become one of the main items of debate in the automotive industries. In relation to that, most countries have set legislations because the situation is getting worse especially in developed countries (MatSaman and Blount, 2006).

Indeed European countries started regulating car recycling sector in 1960s –70s, when the problem of end-of-life vehicles abandoned in nature became notable. Potential to improve conservation of material and energy resources along the lifecycle of a vehicle, particularly in its end-of-life management was realised, and by 1990s, the need for harmonised Europe-wide legislation was acknowledged (Afrinaldi et al., 2008). Consequentially, end-of-life management of cars in Europe is regulated by a common legislative framework since 2000, when the Directive 2000/53/EC on end-of-life vehicles was adopted. This directive aims at improving the ELV treatment in an environmentally sound manner (Jeong et al., 2007), laying down rules for the correct environmental management thereof and also preventive measures to be taken into account in the vehicle design and construction phase (Lopez, 2011).

The main objectives of the European Union's (EU) ELV Directive (2000/53/EC) are prevention of waste from ELVs, which is to be achieved through design improvements and extending producers responsibility over end-of-life management; and facilitating better treatment and recycling of ELV components through improving environmental performance of treatment facilities, and achieving quantitative targets for material recycling and recovery (Afrinaldi et al., 2008). To accomplish these objectives, the EU ELV Directive:

- provides for free take-back for all ELVs;
- eliminates the use of certain heavy metals in vehicles in order to prevent their release into the environment and the contamination of vehicle waste;
- requires permits for treatment facilities that handle ELVs;
- requires depollution of vehicles; and,
- sets recycling and recovery targets for 2006 and 2015;

This was to be achieved through the implementation of several measures that include:

- the setting up of a system for the collection of ELVs by economic operators (producers, dismantlers, and shredders etc.);
- the assurance that delivery to treatment facilities is at no cost to the last owner by 2007;
- the establishment of standards for storage, treatment, de-pollution, and the regulation of authorised treatment facilities (ATFs);
- the recycling and recovery of 85 per cent (80 per cent recycling) of a vehicle's weight by 2006, and 95 per cent (85 per cent recycling) by 2015 (Edwards et al 2006).

It is observed that the EU ELV Directive (2000/53/EC), therefore, places a responsibility on producers of vehicles exported to and manufactured in the EU to eliminate certain heavy metals and meet re-use, recycling, and recovery targets. It also implements stringent standards for the facilities involved in the dismantling and environmentally sound treatment of vehicles.

The European Union countries and other countries such as Japan, Australia, Korea and China have taken an aggressive stance in attempting to regulate management operations and outcomes, and have enacted regulations aimed at minimizing the detrimental environmental impact of ELVs. In contrast, in the US, relatively little in the way of laws and regulations applicable to ELV management activities, save for waste management regulations dealing with vehicle fluids and, to a lesser extent, disposal of scrap tires and ASR. Instead, market forces have for the most part dictated operations and outcomes (Staudinger and Keoleian, 2001).

In the area of end-of-life vehicle recycling, Japan passed the Automobile Recycling Law in January 2005, the first in Asia. The main purpose of the Japanese ELV Law is to create a new recycling system for the proper processing and disposal of ELV waste flow and its efficient use of resources (Simic, 2013). It holds similar provisions to the EU Directive, but goes one step further in applying "the polluter pays" principle. Indeed, vehicle manufacturers and importers are tasked with creating reverse logistics systems for any parts and components that are not recyclable or reusable. These include Automobile Shredding Residue (ASR), airbags and chloro-fluorocarbons (CFCs). Manufacturers and importers are not simply in charge of collecting these materials but must also organise and fund their safe dismantling. As a result of this regulation, the cost of recycling a vehicle is absorbed by the industry. This has pushed the industry to take disposal costs into account when designing and manufacturing new vehicles (US EPA, 2008).

Korea followed suit with the passage of the resource circulation method in 2009. China is expected make a new recycling law. The Chinese government came up with a policy regulating ELV disposal also known as Statute 307 (Chen, 2005 & 2006). In this law, five major vehicle components, namely: engine, power transmission box, steering axle and chassis are mandated to be recycled as metal materials (Che, 2011).

As observed above, most of the developed countries with vehicle or parts manufacturing activities have legislation governing end-of-life vehicles and the following characteristics are generally observed with such regulations.

- Legislation generally provides for tracking of ELVs through deregistration, and sets targets for recycling. Depollution is mandatory, and many countries list components and materials which must be recovered.
- Legislation has increased the recovery of ELVs, increased the level of recovery for materials in ELVs, and resulted in environmental and health-related improvements.
- The trend in Europe is to use post shredder technology to meet recycling and recovery targets, rather than maintaining more labour-intensive dismantling/disassembly centres (Wordsworth, 2011).

6.BARRIERS IN DEVELOPING ELV REGULATIONS IN INDIA

Currently there are no regulations or directive in India to deal with the disposal of end-of-life automobiles. A number of factors combine to impose significant limitations or barriers on the options available to India when dealing with ELVs (Cassels et al., 2005).

Lack of effective regulation is the biggest hindrance to improve the ELV recycling industry in India and there are some obstacles or barriers to develop suitable ELV directive in India. However the effective regulation is difficult to achieve because there are many stakeholders who are part of the ELV processing industry. These stakeholders include: national or governmental authorities, car manufacturers, recycling businesses and consumers or last owners of the vehicles. The development of ELV directive can be met with an integrated approach that involves the participation of all stakeholders.

The governmental authorities are setting goals and regulate operations of other actors by the means of licencing, imposing legal compliance and reporting obligations and subsequent monitoring. Governmental authorities are represented by (i) authority responsible for development and implementation of legislation and (ii) authority responsible for vehicles registration and deregistration.

Car manufacturers may be considered the most important actor, because ultimately the materials used in car manufacturing and eventually undergo dismantling and recycling are put there by the producers. Therefore producers have the most influence on ELV recycling in the long run. Extended producer responsibility, as envisaged in developed countries, is meant to give producers an incentive to choose materials and construction methods with regard to dismantling and recyclability.

Recycling businesses include scrap dealers, dismantlers, waste management companies, metal and other recyclers. Generally the interest of these actors lies in recovery of valuable parts and materials from ELVs, which bring profit exceeding the treatment costs. At the moment those value adding components are used spare parts and metal contents of an ELV.

Consumers also play an important role because it is up to the owner of a vehicle to decide about the disposal of the vehicle. Due to every stakeholder there are certain barriers in developing suitable ELV regulation in India. Apart from these social, financial and other factors also affect the development of ELV directive by way of acting as barriers. These various barriers are listed in Table 1.

7. Interpretive Structural Modelling (ISM) of Barrier Analysis

Interpretive structural modelling (ISM) is a methodology developed for identifying relationships among specific items, which defines a problem or an issue. This approach has been increasingly used by various researchers to represent the relations among various elements related to the issue. The ISM process involves the identification of elements or factors, the definition of their interrelationships, and the imposition of rank order and direction to illuminate complex problems from a systems perspective (Chandramowli et al., 2011). ISM is an interactive learning process in which a set of dissimilar and directly related elements are structured into a comprehensive systematic model. The model so formed, portrays the structure of a complex issue or problem, a system or a field of study, in a carefully designed pattern implying graphics as well as words. The basic idea of ISM is to use experts' practical experience and knowledge to decompose a complicated system into several sub-systems (elements) and construct a multilevel structural model (Mathiyazhagan, 2013)

ISM approach begins with an identification of variables or elements, which are relevant to the problem or issue. Then a contextually apt subordinate relation is chosen. Having decided the contextual relations, a structural self-interaction matrix (SSIM) is formed based on pairwise comparison of elements. After this, SSIM is converted into a reachability matrix (RM) and checked for its transitivity. Once transitivity embedding is complete, a matrix model is obtained. This is followed with the partitioning of the elements and an extraction of the structural model called ISM is derived. The various steps involved in ISM modelling are as follows:

a) Identify the elements which are relevant to the problem. This could be done by a survey or group problem solving technique.

b) Establish a contextual relationship between elements with respect to which pairs of elements would be examined.
c) Develop a structural self-interaction matrix (SSIM) of elements. This matrix indicates the pairwise relationship among the elements of the system. This matrix is checked for transitivity.
d) Develop a reachability matrix from the SSIM.
e) Partition the reachability matrix into different levels.
f) Convert the reachability matrix into conical form.
g) Draw digraph based on the relationship given in reachability matrix and remove transitive links.
h) Convert the resultant digraph is converted into an ISM based model by replacing element nodes with the statements.
i) Review the model to check for conceptual discrepancy and make necessary modifications.

Figure 3 shows the steps involved in the ISM based analysis of barriers for developing ELV regulations in India.

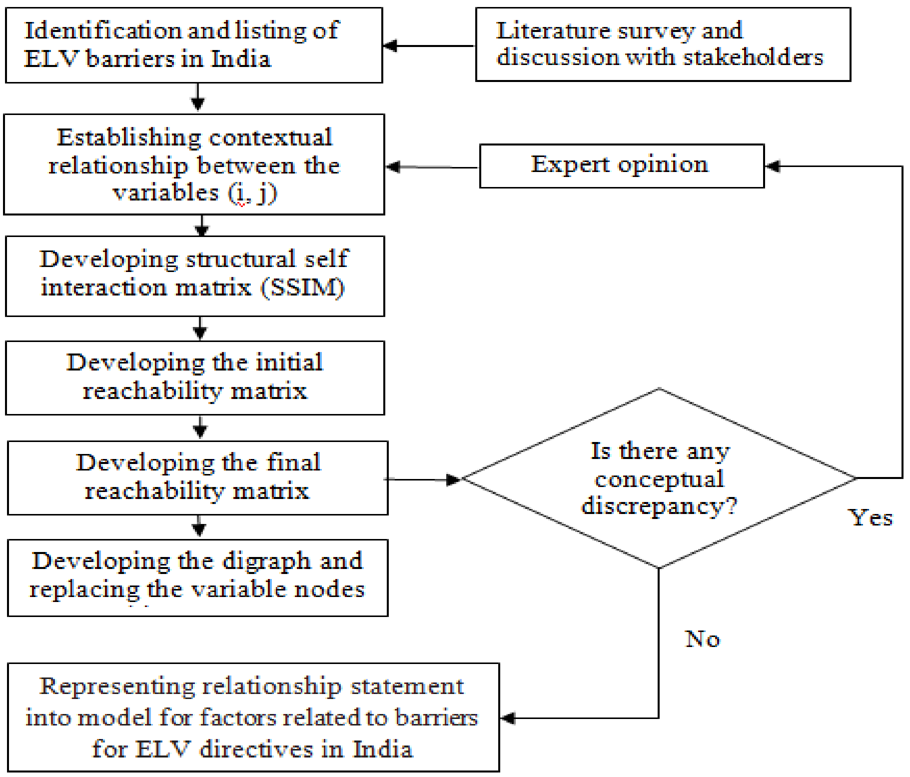

Fig 3: ISM based barrier analysis for developing ELV regulations in India

Identification of barriers

The ISM process starts with the identification of elements or factors that are to be considered in the context of the problem under study and in the present case these are the barriers that impede the development of ELV regulations in India. These are identified through literature review and discussion with stakeholders and Table 1 presents the list of barriers identified.

TABLE 1. LIST OF BARRIERS IDENTIFIED

Barrier Code	Barriers	Description
B1	Unaware citizens	For implementation of any regulation or law, the cooperation of the citizens is a major factor and citizens

		should be aware of the existence of such regulations. Moreover, the citizens of India are unaware of the positive impact of implementation of ELV directives. The social, economic and other potential benefits have to be promoted.
B2	Attitude of people	The Indian people have an emotional attachment towards their belongings. Many people are reluctant to dispose the old vehicles due to emotional attachment towards the vehicle.
B3	Lack of initiative of the government	The government has to step in to regulate and define legal aspects of ELV management mainly from an environmental point of view and at present there seems to be no support from the government.
B4	Lack of coordination among Union and state Governments	The vehicle registration and responsibility for traffic maintenance in India is divided among the state governments. But the environmental and pollution control board is under the Union ministry. This needs coordination among the Union and various state governments and it is observed that neither of the party takes an initiative for development of ELV directive.
B5	Need for setting up many systems within Government	Systems are to be set up to monitor the implementation of suitable regulations and to monitor the recycling processes or units
B6	No proper definition of ELV	Unlike in developed countries, there is no proper definition for ELV. The Motor Vehicles Act of 1988 and the Central Motor Vehicles Rules of 1989 place no limit on the age of vehicles plying on the road. They also lack any provision that addresses the scrapping of old commercial vehicles.
B7	Practical problem for developing ELV network	India is the 7th largest country by area and the 6th largest automobile manufacturer in the world. The geography and non-uniformity of urbanization makes the setting up of an ELV recovery network throughout India impractical.
B8	Inefficiency in developing infrastructure facilities	There is a need for establishing the recollection and refurbishing centres throughout the country. The vast area and the cost involved makes it difficult to develop the necessary infrastructural network.
B9	Lack of infrastructure or authorized units not in place	A major issue for India is the lack of appropriate system for collection, treatment, dismantling of vehicles and the recovery infrastructure.
B10	Lack of interest among	The car manufacturers are reluctant to implement any initiative

	car manufacturers	towards ELV recycling because of the cost involved.
B11	Economic feasibility	India is a developing country with 22% of its citizens below poverty level. In a developing country with lot of other major goals it is financially impractical to introduce an ELV set up which demands huge economic investment.
B12	Low volume of ELVs	Volumes of end-of-life vehicles are low in India. The car penetration in developed countries is much higher than in the developing countries. Developed countries like Germany and USA have car penetration rates (car/1000 persons) higher by factors of about 12 and 14 to that of China and by factors of 34 and 42 to that of India.

Structural Self Interaction Matrix (SSIM)

ISM mainly depends on the establishment of a contextual or the structural relationship between the factors, which may be done through consultation with experts from industry and academia who are well conversant with the problem under study. The various possibilities of relation between the factors are to be evaluated. The establishment of relation between the factors directly will not be legible and a matrix for easier comparison between the factors is developed. This matrix is called as Structural Self Interaction Matrix (SSIM).

Depending on the situation and factors, a contextual relation is chosen viz. “leads to”, “depends on”, “increases”, “decreases”, etc. Each factor is compared with every other factor to decide the presence and direction of chosen relationship. This pairwise comparison generates the self-interaction matrix. Four symbols are generally used for the type of the relation that exists between the two factors (i and j) under consideration.

A: Factor for j leads to factor i

V: Factor for i leads to factor j

X: Factor for i leads factor j and factor j leads to factor i

O: No relationship between i and j

Table 2 shows the structural self interaction matrix developed for the present problem.

TABLE 2 Structural Self Interaction Matrix (SSIM)

	12	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
1	O	O	O	O	O	O	O	O	O	A	X	
2	O	O	O	O	O	O	O	O	O	X		
3	X	X	V	V	V	X	V	V	X			
4	X	X	V	V	V	X	V	V				
5	X	X	O	V	V	X	O					
6	O	O	O	V	V	X						
7	O	X	X	X	X							
8	A	X	X	X								
9	A	A	X									
10	A	A										
11	A											
12												

Reachability Matrix

The next step in ISM approach is to develop an initial reachability matrix from SSIM. The SSIM is transformed into a binary matrix, called the initial reachability matrix by substituting V, A, X, O by 1 and 0 as per the case, following the rules for substitution. The rules for the substitution of 1’s and 0’s are the following:

(a) If the (i, j) entry in the SSIM is V, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0.

(b) If the (i, j) entry in the SSIM is A, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1.

(c) If the (i, j) entry in the SSIM is X, then the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1.

(d) If the (i, j) entry in the SSIM is O, then the (i, j) entry in the reachability matrix becomes 0 and the(j, i) entry also becomes 0.

Following these rules, initial reachability matrix for the problem under study is developed and presented in Table 3. The final reachability matrix for the factors is obtained by incorporating the transitivity. It is to be noted that transitivity of the contextual relation is a basic assumption in ISM which states that if element i is related to k and k is related to j, then i is related to j. The final reachability matrix is shown in Table 4.

TABLE 3. INITIAL REACHABILITY MATRIX

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	1	1	0	0	0	0	0	0	0	0	0	0
2	1	1	1	0	0	0	0	0	0	0	0	0
3	1	1	1	1	1	1	1	1	1	1	1	1
4	0	0	1	1	1	1	1	1	1	1	1	1
5	0	0	0	0	1	0	1	1	1	0	1	1
6	0	0	0	0	0	1	1	1	1	0	0	0
7	0	0	1	1	1	1	1	1	1	1	1	0
8	0	0	0	0	0	0	1	1	1	1	1	0
9	0	0	0	0	0	0	1	1	1	1	0	0
10	0	0	0	0	0	0	1	1	1	1	0	0
11	0	0	1	1	1	0	1	1	1	1	1	0
12	0	0	1	1	1	0	0	1	1	1	1	1

TABLE 4. FINAL REACHABILITY MATRIX

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**DP**
1	1	1	1	1	1	1	1	1	1	1	1	1	12
2	1	1	1	0	0	0	0	0	0	0	0	0	3
3	1	1	1	1	1	1	1	1	1	1	1	1	12
4	0	0	1	1	1	1	1	1	1	1	1	1	10
5	0	0	1	1	1	0	1	1	1	1	1	1	9
6	0	0	0	0	0	1	1	1	1	0	0	0	4
7	0	0	1	1	1	1	1	1	1	1	1	0	9
8	0	0	0	0	0	0	1	1	1	1	1	0	5
9	0	0	0	0	0	0	1	1	1	1	0	0	4
10	0	0	0	0	0	0	1	1	1	1	0	0	4
11	0	0	1	1	1	0	1	1	1	1	1	0	8
12	0	0	1	1	1	0	0	1	1	1	1	1	8
DEP	3	3	8	7	7	5	10	11	11	10	8	5	

Level partitions

From final reachability matrix, for each factor, the reachability set and antecedent sets are derived.

Reachability set contains the factor itself and also the other factors to which it may reach. Antecedent set contains the factor itself and other factors, which may reach to it. Depending on the intersection of these sets, the factors are partitioned into hierarchical levels. The element for which the reachability and intersection sets are the same is the top-level element. Once the top-level element is identified, it is then removed out from the other elements. Then, by the same process, the next level of elements is found. These identified levels helps in developing the diagraph and the final model. In the present case the barriers along with their reachability set, antecedent set, intersection set and the levels are shown in Table 5

TABLE 5. LEVEL PARTITIONS FOR BARRIERS IN DEVELOPING ELV DIRECTIVES IN INDIA

Barrier	Reachability set	Antecedent set	Intersection set	Level
B2	1,2,3	1,2,3	1,2,3	I
B7	3,4,5,6,7,8,9,10,11	1,3,4,5,6,7,8,9,10,11	3,4,5,6,7,8,9,10,11	I
B8	7,8,9,10,11	1,3,4,5,6,7,8,9,10,11,12	7,8,9,10,11	I
B9	7,8,9,10	1,3,4,5,6,7,8,9,10,11,12	7,8,9,10	I
B10	7,8,9,10	1,3,4,5,7,8,9,10,11,12	7,8,9,10	I
B5	3,4,5,11,12	1,3,4,5,11,12	3,4,5,6,11,12	II
B6	6	1,3,4,6	6	II
B11	3,4,5,11	1,3,4,5,11,12	3,4,5,11	II
B3	1,3,4,12	1,3,4,12	1,3,4,12	III
B4	3,4,12	1,3,4,12	3,4,12	III
B12	3,4,12	1,3,4,12	3,4,12	III
B1	1	1	1	IV

Formation of ISM based model

From the final reachability matrix, the structural model is generated. The relationship that exists between the factors i and j is shown by an appropriate arrow linking i and j. This resulting graph is called a digraph. Removing the transitivity as described in the ISM methodology, the digraph is finally converted into the ISM model as shown in Figure4.

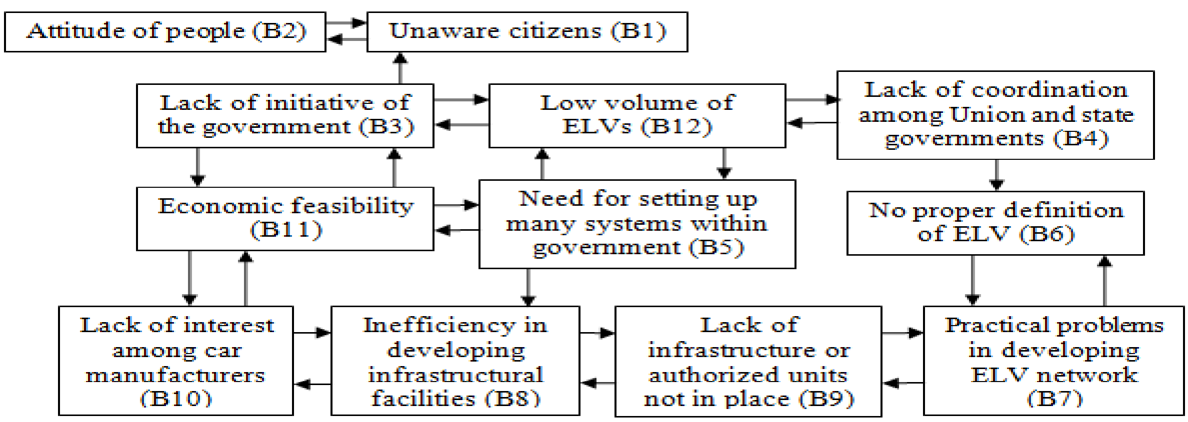

Fig 4: ISM based model for barriers in developing ELV directives in India

MICMAC analysis

Matrice d'Impacts croises-multipication appliqu´eanclassment (cross-impact matrix multiplication applied to classification) is abbreviated as MICMAC. The MICMAC principle is based on the multiplication properties of matrices. The purpose of a MICMAC analysis is to analyse the driver and dependence power of the barriers. This is done to identify the key barriers that drive the system. Based on their driver and dependence power, the barriers, in this present case, have been classified into four categories as follows:

Autonomous barrier

Autonomous barriers are those barriers that have weak driver power and weak dependence and these barriers do not have much influence on the system. From the driver power dependence matrix it may be inferred that barrier B2 (attitude of people) and B6 (no proper definition of ELV) are identified as autonomous barriers.

Dependent barrier

These are the barriers that have weak driver power but strong dependence. Three barriers fall in the category of dependent barriers are: B8 (inefficiency in developing infrastructure facilities), B9 (lack of interest among car manufacturers) and B10 (lack of infrastructure or authorised units not in place).

Linkage barrier

The barriers that have strong driver power as well as strong dependence are called linkage barriers and five barriers fall under the category of linkage barriers in the present case, namely B3 (lack of initiative by the government), B4 (lack of coordination among union and state government, B5 (need for setting up many systems within government, B7 (practical problem in developing ELV network), B11 (economic feasibility). As these five barriers are having strong driving power as well as strong dependence power, any action on any of these barriers will have an effect on other barriers and also a feedback effect on themselves.

Independent barrier

These barriers do have strong driving power with weak dependency. Two barriers, namely B1 (unaware citizens) and B12 (low volume of ELV's) fall into this category. It is generally observed that a barrier with a very strong driver power called a 'key barrier' falls into the category of independent or linkage barriers.

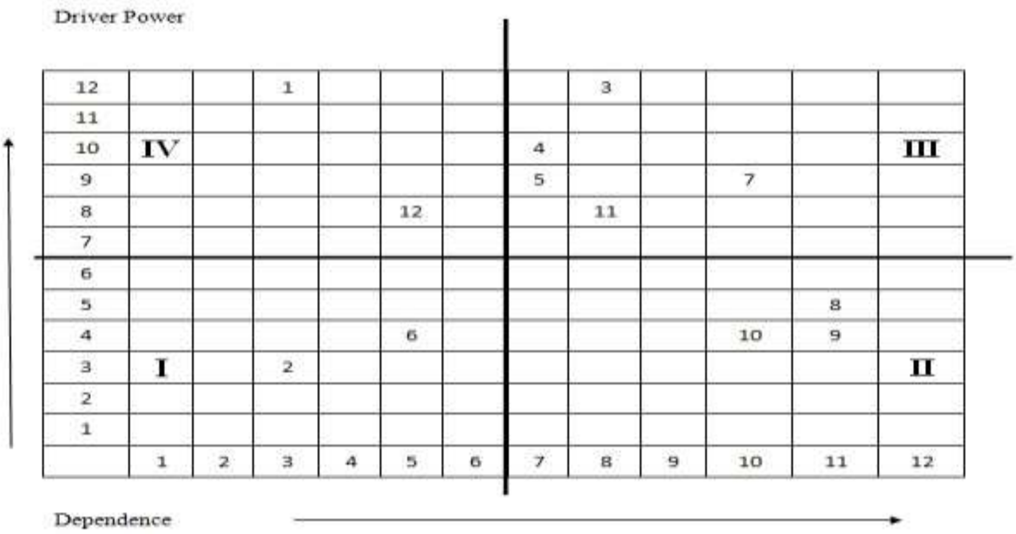

Fig 5: MICMAC analysis for barriers in developing ELV directives in India (Driver power vs. Dependence Matrix)

8. Results and Discussion

The environmental consciousness of the governing agencies in the developed countries with the aim of cleaner production has resulted in ELV directives. India does not have an ELV directive and some of the major barriers, which hinder the implementation of ELV directives, are analysed through ISM.

It is observed that barriers B1 and B12 fall in the category of independent barriers signifying that they have strong driving power and hence it may be inferred that unaware citizens (B1) and low volume of ELVs (B12) are mainly responsible for the non-development of ELV directives in India. Barriers B3, B4, B5, B7 and B11 are found to be the linking barriers implying that they will affect other barriers as well as have effect among themselves. The ISM digraph also shows the kind of relationship existing between these barriers. These barriers may be said to be the key barriers in developing the ELV directives in India for the following reasons: Low volume of ELVs (B12) seems to be the root cause for the Union government showing very little interest in developing any ELV directive (B3) which consequently leads to the barrier of lack of coordination among Union and state governments (B4).

It can also be realised that the poor economic feasibility (B11) and the consequential result of lack of infrastructure (B7) are mainly due to the low volume of ELVs. Investors, for fear of economic viability, are reluctant to invest in units with modern facilities. Nevertheless with the increasing volume of vehicles, particularly in recent times, due to globalisation, the increased purchasing power of people, etc it becomes imperative that the Union government should initiate actions in formulating appropriate ELV directives for the sake of safe disposal of pollutants from ELVs, reduction of health hazards of people working in present-day dismantling units, and increasing the potential job opportunities.

The ISM also reveals that lack of initiative of the government (B3) leads to unaware citizens (B1) and it is obvious that the role of government in creating awareness among its citizens about the need for disposing off their old or end-of-life vehicles and educating them on the environmental impacts of using such vehicles is very important and the government needs to give emphasis to these aspects. It is to be noted that because of the citizens being unaware of the consequences of using ELVs they are reluctant to dispose of old and obsolete vehicles which results in low volume of ELV's (B12), which, as explained earlier becomes the root cause for the ELV directives not in place. It is further seen from the analysis that there is no proper definition of ELV (B6) in Indian context and there again is the responsibility of the government wherein suitable amendments are to be made in the Motor Vehicle Rules.

The role of manufacturers is also to be analysed as presently there is lack of interest among car manufacturers (B9) in India towards proper treatment of ELVs. The absence of proper definition of ELV, lack of appropriate infrastructure to handle ELVs (that includes lack of appropriate collection, treatment, dismantling of vehicles) and practical problems that exist in developing ELV network seem to be the drivers behind the car manufacturers having less interest in ELV recycling. With appropriate ELV directives in place the automobile manufacturers will also be required to adhere to procedures that enable safe and methodical disposal of ELVs.

To summarise, the low volume of ELVs in India, primarily, is the reason for the kind of attention the ELV directives receive from the various stakeholders. However the changing lifestyle of Indian population, the ever increasing vehicle population in India and the growing awareness regarding environmental protection not only in India but all over the globe have necessitated the ELV directives put in place. In this regard, the role of government seems to be the most important one and realising this, the government has taken some initiatives in recent times that includes setting up a pilot plant in Chennai. This kind of initiatives has to be continued to develop and put in place ELV directives in place that will help enhance the environmental protection and optimal utilisation of the resources and materials that go into the production of automobiles.

9. Conclusion

Proper handling, dismantling and disposal of ELVs with minimal environmental degradation are the objectives of ELV regulations or directives. This becomes imperative in view of the growing automobile population all over the world. The Indian automobile market is also expanding rapidly as any other global automobile market. But unlike the developed countries India doesn't have end-of-life vehicle (ELV) directives or ELV recovery and recollection network or ELV legislation in place. Moreover, implementation of ELV legislation is not an easy task and there exist many obstacles for implementing ELV directives. An in-depth analysis of the factors that hinder the development of ELV directives will help the stakeholders to understand them and take remedial or responsive actions so as to fall in line with other developed countries in this regard.

This paper makes a comparative analysis of ELV regulations/directives existing in developed countries and also brings out the importance of putting up appropriate ELV regulations in Indian context. Barriers in developing such regulations in the context of India are also identified and further analysis of these barriers is carried out through Interpretive Structural Modelling (ISM) to get an insight into the problem of dealing with ELVs.

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