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Application of grey-based DEMATEL technique in designing of the aggregate green supply chain management's model

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A B S T R A C T

Nowadays, environmental issues are considered as the most important factor for competition. In this era, just modern companies can compete with each other and any environment friendly firm plays essential role in gaining more market share. Besides, the 21st century is the era of modern steel and Iranian iron steel industry plays important role in the domestic and international trade only through emphasizing on protection of environment. Therefore, designing a model for strengthening the environmental performance in steel industries is necessary to get some advantages such as energy saving, reducing pollutants, eliminating (declining) of waste, creating value for customers and improving the productivity. In this research, first, we explain green supply chain management and then grey-based DEMATEL Technique is used to identify different factors influencing the green supply chain. Eventually, the green supply chain model (GSCM) is applied for the steel industry. The result determines the most prominence factors of GSCM in Yazd Steel Industry.

1. Introduction

In the 21st century, industrial development has been replaced by Sustainable Development (Diabat & Govindan, 2011). Nowadays, sustainable development in each country depends on efficient utilization of existing resources. Hence, the governments deal with this issue through various actions such as green law enforcement, the use of environmentally friendly raw materials in manufacturing and industrial centers, reducing the use of oil and fossil energy resources, paper recycling, reuse of waste, etc. (Zhu & Sarkis, 2007; Diabat & Govindan, 2011). Obviously, organizations need to adopt green practices to comply with the laws and regulations (Bose & Pal, 2012). So, because of the governmental regulations, environmental standards and growing demand for green products, the new concept of "green supply chain" is emerged (Giunipero et al., 2012; Chan et al., 2012; Berns et al., 2009; Foerstl et al., 2010; Walker et al., 2008). The nascent concept of "green supply chain management" (GSCM) has started to gain more attraction (Olugo et al., 2011; Chien & Shih, 2007; Diabat & Govindan, 2011); whereas, GSCM comprises many steps of the product life cycle from

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design to recycling and may be dependent on a variety of environmentally oriented tools such as design for the environment and life cycle analysis. GSCM encompasses components of environmental management as well as closed-loop supply chains, which integrates design, operations, and control of a system for maximizing value over life cycle of a product including value recovery from return/disposal at the end of its use (Bose & Pal, 2012).

The purpose of GSCM implementation into business activities is to concurrently improve environment and economic performance (Diabat & Govindan, 2011). Since one of the important goals of supply chain management is to improve supply chain performance (Cai et al., 2009; Bose & pal, 2012), several studies analyze the effect of GSCM on environmental and organization performance (Testa & Iraldo, 2010). These studies attempt to conclude that green supply chain can influence companies' profit or even competitive advantages (e.g. Zhu & Sarkis, 2004). Bowen et al. (2001) argued that financial incentive is the major driver force for implementing green supply chain. Vachon and Klassen (2008) concluded that a correlation exists between environmental performance and competitive advantage in their survey. Rao and Holt (2005) investigated the relationship between green supply chain management practices and firms' competitiveness and confirmed that a positive relationship exists. Chiou et al. (2011) focused only on the Taiwanese market and they concluded that the relationship between GSCM and organizational performance is positive. Notwithstanding the huge amount of studies in the literature in relation to the above, designing a green supply chain model seems to be missing. Steel Industry is critical to many developing countries and spatially in Iran, and it has significant environmental burdens on them. In this paper, we try to model the GSCM of Yazd steel industry as one of the most important Iranian provinces are producing steel.

In order to achieve this model, we will study literature to find out factors related to green supply chain management of the Yazd steel industry. From this foundation, a model of GSCM based on organizational performance measures will be developed with a grey-based DEMATEL technique. These initial findings and results will provide initial insights for management and policy makers in Iran and potentially other developing countries with relatively immature GSCM and general sustainability practices.

2. Literature

The growth in the green supply chain literature goes back to the early 1990s (Diabat & Govindan, 2011). With the advent of issues such as corporate environmental management, environmentally conscious manufacturing strategy (Zhu & Sarkis, 2006), rising energy prices, the limits of available resources (not renewable), climate change, objectives in terms of reducing emissions (liquid, solid, and gaseous), and concerns for improving the quality of life, supply chain management has been redefined (Diabat & Govindan, 2011) and it has been integrated with environmental management practices. Based on these issues, the traditional supply chain has been extended to include the after-use phase of the products. This after-use phase cannot achieve its objectives in isolation and there is a need to develop an integrated approach for planning and controlling the features and manners in which materials flow within the supply chain. This integrated approach is embedded into green supply chain management (Olugu et al., 2011). Obviously, organizations need to adopt green practices to comply with the laws and regulations (Bose & Pal, 2012). Holt and Ghobadian (2009) concluded that there are seven categories of initiatives for greening supply chain: governments, trade associations and sector bodies, partnership groups, individual companies, business support organizations, not-for-profit green business-support organizations, and green business clubs (Diabat & Govindan, 2011). Susana et al. (2011) divided drivers into three types of operational (Bayraktar et al., 2009), economic (Rao & Holt, 2005) and environmental (Pochampally et al., 2009) terms. According to Zhu and Sarkis (2004), the economic performance is the most important driver for enterprises, which seeks to implement environmental management practices (Azevedo et al., 2011). In addition, many companies consider environmental management practices for greening SC to maintain competitive advantage (Rao & Holt, 2005; Linton et al., 2007; Azevedo et al., 2011). The scope of green supply chain includes environmental management, closed-loop supply chain, and a broad perspective of generating value for the organization and society (Bose & Pal, 2012). However, green supply chain management is defined as the totality of green purchasing, green manufacturing and material management, green distribution and marketing, and finally reverse logistics (Hervani et al., 2005; Linton et al., 2007; Zhu & Sarkis, 2006; Olugu et al., 2011). This is in line with the explanation given by Vachon and Klassen (2008) that suppliers, manufacturers and customers have to work together towards the reduction of environmental effects from production processes and products (Olugu et al., 2011). Nevertheless, other studies concluded that designing is one of the most important issues for greening the supply chain (Azevedo et al., 2011; Diabat & Govindan, 2011). Accordingly, Srivastava (2007) defines GSCM as ‘‘integrating environmental thinking into SCM, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life” (Azevedo et al., 2011). Based on these factors, the schematic echelons involved in a green supply chain management is presented in Fig. 1.

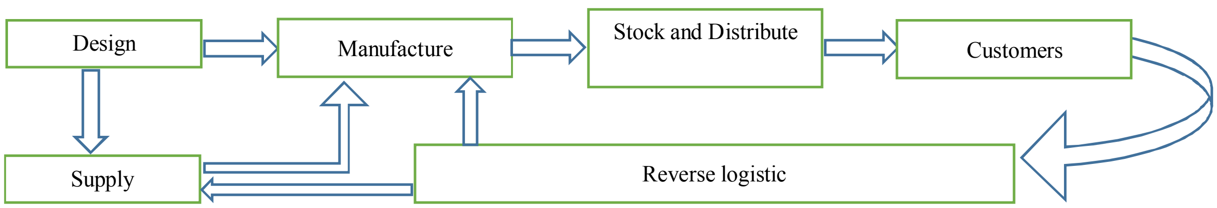

Fig. 1. Schematic summarizing GSCM activities

Pun (2006) investigated the critical processes and factors that affect Environmental Management System (EMS) planning and proposed a five-stage EMS planning framework starting from strategy formulation to system implementation and evaluation (Diabalt & Govindan, 2011). Hervani et al. (2005) identified more than 40 metrics to measure the environmental performance of a company, ranging from air emissions to energy recovery and recycling (Diabalt & Govindan, 2011). Sarkis (2003) refers to the following production process characteristics, which impact the greening of an SC: (i) the process’s capacity to include certain materials; (ii) the possibility of integrating reusable or remanufactured items into the system; and (iii) the design for waste minimization (energy, water, raw materials and non-product output) (Azevedo et al., 2011). Susana et al. (2011) stated that the proposed green practices are deployed at three levels of upstream, midstream and downstream (Azevedo et al., 2011).

Table 1
The Factors of Green Supply Chain Management’s Model

Echelons	Factors	References
Supply	Environmental collaboration with suppliers (a1)	Azevedo et al., 2011
	Encouraging supplier to adopt more environmentally friendly	Holt & Ghobadian, 2009
	Environmental monitoring of suppliers (a3)	Paulraj, 2009
Design	Eco-design (Green design) (a4)	Diabat & Govindan, 2011’ Susana et al., 2011
	Green process design (a5)	Bose & Pal, 2012
Manufacture	Developing environmentally friendly products (a6)	Gonzalez et al., 2008
	Implementing internal environmentally friendly operations (a7)	Vachon, 2007
	Getting recognition for environmentally positive behavior (a8)	Zhu et al., 2008
Stock and Distribute	Stock (a9)	Zhu et al., 2005
	Transportation (a10)	Holt & Ghobadian, 2009
Customers	Environmental collaboration with customers (a11)	Azevedo et al., 2011
	To use environmentally friendly practices with customers (a12)	Holt & Ghobadian, 2009
Reverse logistic	Reverse logistic (a13)	Guide & Wassenhove, 2006: Bose & Pal, 2012
Green supply chain performance	Environmental performance (a14)	Dües et al., 2012
	Economic Performance (a15)	Olugu & Wong, 2012

As we can observe from Table 1, the green factors that are the focus of this study are not only those that are internal to the company but also the ones, which transcend the company's boundaries involving suppliers and customers.

3. Methodology

In this research, initial work involves interviews and meetings to gain an understanding of the problem situation. Then, with reviewing literature, we construct pairwise matrix for gathering data. Moreover, to build, to structure and to illustrate the causal relationships among different identified GSCM's factors, grey-based DEMATEL technique is used, which is a comprehensive technique for building and analyzing a structural model involving causal relationships through matrices or digraphs between a set of factors. The matrices or digraphs portray relationships between system's components with strengths of relationships amongst these relationships quantitatively portrayed. The DEMATEL method assumes a system contains a set of components $c = \{c_i \mid i = 1, 2, \ldots, n\}$, with pairwise relations, which can be evaluated. In order to apply DEMATEL effectively, this paper proposes the following four steps:

For the first stage in the process, we have multiple sub-steps 1a-1d.

Step 1a: Define a grey pairwise influence comparison scale for the components,

Step 1b: Develop the grey direct-relation matrix *X* by having evaluators introduce the grey pairwise influence relationships ($\otimes x_{ij}^k$) between the components in a $n \times n$ matrix. All the principal diagonal elements are initially set to a crisp value of zero ("*N*" = no influence),

Step 1c: Convert the grey direct-relation matrix into a crisp matrix *Z* based on the modified-factors process as exemplified by Eqs. (1)-(4).

Let us define $\otimes x_{ij}^p$ as the grey number for an evaluator (decision maker) *p*, which would evaluate the effect of factor *i* on a factor *j*. Also, $\underline{\otimes} x_{ij}^p$ and $\overline{\otimes} x_{ij}^p$ are respectively, the lower and upper grey values by an evaluator *p* for the relationship evaluation between factor *i* to a factor *j*.

That is: $\otimes x_{ij}^p = [\underline{\otimes} x_{ij}^p, \overline{\otimes} x_{ij}^p]$.

The modified-factors method involves three-step procedure described as follows:

（1）normalization

$$\underline{\otimes} \tilde{x}_{ij}^p = [\underline{\otimes} x_{ij}^p - \min_j \underline{\otimes} x_{ij}^p] / \Delta_{\min}^{\max}, \tag{1}$$

$$\overline{\otimes} \tilde{x}_{ij}^p = [\overline{\otimes} x_{ij}^p - \min_j \overline{\otimes} x_{ij}^p] / \Delta_{\min}^{\max}, \tag{2}$$

$$\text{where } \Delta_{\min}^{\max} = \max_j \overline{\otimes} x_{ij}^p - \min_j \underline{\otimes} x_{ij}^p . \tag{3}$$

(2) Determine the total normalized crisp value as follows,

$$Y_{ij}^p = \frac{\left(\underline{\otimes} \tilde{x}_{ij}^p (1 - \underline{\otimes} \tilde{x}_{ij}^p) + (\overline{\otimes} \tilde{x}_{ij}^p \times \overline{\otimes} \tilde{x}_{ij}^p)\right)}{(1 - \underline{\otimes} \tilde{x}_{ij}^p + \overline{\otimes} \tilde{x}_{ij}^p)} \tag{4}$$

(3) Compute final crisp values

$$z_{ij}^p = \min_j \underline{\otimes} x_{ij}^p + Y_{ij}^p \Delta_{\min}^{\max} \tag{5}$$

The process will need to be completed for each of the evaluators' direct-relation matrices. If more than one evaluator exists, go to step 1d, otherwise go to step 2.

Step 1d: Evaluator weightings, for aggregation purposes, for each evaluator need to be determined. Either simple averaging (Eq. (6)) or weighted averaging (Eq. (7)) can be applied to calculate an aggregate score. We will utilize Eq. (7), which requires determination of evaluator weightings, and it can be defined by grey linguistic scale values for each evaluator p ($\otimes w_p$). Grey scaled evaluation weightings are required to crisp and sum to 1 as shown in Eq, (7).

$$z_{ij} = \frac{1}{p}(z_{ij}^1 + z_{ij}^2 + \ldots + z_{ij}^p), \tag{6}$$

$$z_{ij} = w_i z_{ij}^1 + w_2 z_{ij}^2 + \ldots + w_p z_{ij}^p \quad \text{such that} \sum_{i=1}^{p} w_i = 1, \tag{7}$$

where z_{ij} is the overall crisp evaluation for the relationship between factors i and j, z_{ij}^p is the crisp evaluation the relationship between factor i and j by evaluator p, w_p is the crisp evaluator weight assigned to evaluator p derived from the grey scale weight for each evaluator ($\otimes w_p$).

Step 2: On the basis of the overall crisp direct-relation matrix Z, the normalized direct-relation matrix N can be obtained through Eq. (8) and Eq. (9):

$$N = s \cdot N \tag{8}$$

$$s = \frac{1}{\max\limits_{1 \le i \le n} \sum_{j=1}^{n} z_{ij}}, i, j = 1,2,\ldots,n \tag{9}$$

Step 3: Determine the total relation matrix (T) by Eq. (10) where I represents an $n \times n$ identity matrix,

$$T = N + N^2 + N^3 + \cdots = \sum_{i=1}^{\infty} N^i = N(I - N)^{-1} \tag{10}$$

Step 4: Develop the causal influence and digraph diagram in DEMATEL based on the following three sub-steps:

Step 4a: Determine row (R_i) and column (D_j) sums for each row i and column j from the total relation matrix (T), that is:

$$R_i = \sum_{j=1}^{n} t_{ij} \quad \forall i, \tag{11}$$

$$D_j = \sum_{i=1}^{n} t_{ij} \quad \forall j. \tag{12}$$

The row values R_i are the overall direct and indirect effect of a factor i on the model. Similarly, the column values D_j represent the overall direct and indirect effects of all factors on factor j.

Step 4b: Determine the overall importance or prominence (P_i) of a factor i and net effect (E_i) of factor i using Eq. (13) and Eq. (14).

$$P_i = \{R_i + D_j | i = j\} \tag{13}$$

$$E_i = \{R_i - D_j | i = j\} \tag{14}$$

The larger the value of P_i, the greater the overall prominence (visibility/importance/influence) of factor i in terms of overall relationships with other factors, If $E_i > 0$ then factor is a net cause, foundation, for the model. If $E_i < 0$, then factor i is reliant on (net effect of) implementation or operation of other factors (Tzeng et al., 2007). These values may then be plotted onto a two-dimensional axis for each GSDP.

Step 4c: A digraph relationship can be determined for GSCM's model of case study. To complete this step a threshold value θ should be determined by the evaluators, experts or the analysts (Liou et al., 2007). If $t_{ij} \geq \theta$, then factor i influences or causes factor j and a directed arrow is incorporated into the analysis.

4. Results

In our case, we have utilized a five level scale with the following scale items: N (no influence), VL (very low influence), L (low influence), H (high influence), and VH (very high influence). The grey scales for these linguistic values are defined in the case application. There are 13 mines in Yazd that they provide steel's material. Yazd steel industry produces more steel's material than any other provinces in Iran. It produces about 80% of steel's material in Iran. The main products of the Yazd steel industry are iron ore concentrate phosphate (Apatite), concentrates lump and fine ore, pellet, sponge iron and rolling. More than 43 percent of products in Yazd's steel industry are exported to foreign countries. Ten percent of the products are consumed in Yazd companies, and the rest is sent to companies in Iran. In our initial step of the process, we have provided 10 experts in the field of Steel Industry to complete pairwise matrices. Table 2 shows the weighted and aggregate data in Yazd Steel Industry.

Table 2
The weighted aggregate data in Yazd Steel Industry

factor	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15
a1	0,0	0.1,.6	0.1,.6	0.4,1	0.3,.9	0.4,1	0.4,1	0.4,1	0.4,1	0.7,1	0.4,1	0.6,1	0.2,.8	0.6,1	0.7,1
a2	0.1,.6	0,0	0,.4	0,.4	0,.4	0,.4	0,.4	0,.4	0,.4	0.1,.6	0,.4	0,.4	0,.4	0,.4	0,.4
a3	0.1,.6	0.1,.6	0	0,.4	0,.4	0.1,.6	0.2,.8	0.1,.6	0,.4	0,.4	0,.4	0.2,.8	0,.4	0.3,.9	0.3,.9
a4	0.3,.9	0.2,.8	0.1,.6	0,0	0.4,1	0.7,1	0.4,1	0.4,1	0,.4	0,.4	0.4,1	0.4,1	0.7,1	0.6,1	0.6,1
a5	0.3,.9	0,.4	0.1,.6	0,.4	0,0	0.3,.9	0.9,1	1,1	0.1,.6	0.1,.6	0.2,.8	0.2,.8	0.4,1	1,2	0.9,1
a6	0.4,1	0,.4	0.1,.6	0.2,.8	0.3,.9	0,0	0.4,1	0.6,1	0,.4	0,.4	0.8,1	0.8,1	1,1	0.6,1	0.6,1
a7	0.3,.9	0,.4	0.1,.6	0.2,.8	0.2,.8	0.2,.8	0,0	1,2	0.1,.6	0.3,.9	0.3,.9	0.4,1	0.8,1	1,1	0.8,1
a8	0.7,1	0.6,1	0.3,.9	0.2,.8	0.3,.9	0.3,.9	0.3,.9	0,0	0,.4	0.3,.9	0.2,.8	0.2,.8	0.2,.8	1,2	0.9,1
a9	0,.4	0,.4	0,.4	0,.4	0,.4	0,.4	0.4,1	0.3,.9	0,0	0.6,1	0.2,.8	0.2,.8	0,.4	0.2,.8	0.1,.6
a10	0.6,1	0,.4	0,.4	0,.4	0,.4	0,.4	1,1	0.7,1	0.7,1	0,0	0.2,.8	0.4,1	0.4,1	0.4,1	0.4,1
a11	0.1,.6	0.1,.6	0.1,.6	0.6,1	0.2,.8	0.4,1	0.3,.9	0.4,1	0.3,.9	0.6,1	0,0	0.9,1	0.6,1	0.4,1	0.7,1
a12	0,.4	0.1,.6	0,.4	0.2,.8	0.2,.8	0,.4	0.3	0.7,1	0.2,.8	0.6,1	0.6,1	0,0	0.7,1	0.4,1	0.3,.9
a13	0,.4	0.2,.8	0,.4	0.2,.8	0.4,1	0.1,.6	0.4,1	0.4,1	0.3,.9	0.6,1	0.2,.8	0.4,1	0,0	0.2,.8	0.4,1
a14	0.8,1	0.6,1	0.7,1	0.4,1	0.4,1	0.3,.9	0.3,.9	1,2	0.2,.8	0.2,.8	0.7,1	0.6,1	0.4,1	0,0	0.9,1
a15	0.6,1	0.4,1	0.3,.9	0.8,1	0.9,1	0.6,1	0.7,1	0.7,1	0.3,.9	0.6,1	0.4,1	0.4,1	0.3,.9	0.9,1	0,0

On the basis of the overall grey direct-relation matrix Z, the normalized grey direct-relation matrix N can be obtained through related expressions described in the previous section. Table 3 shows the results of the N matrix for the aggregate data.

Table 3
The normalized aggregate data in Yazd Steel Industry

factor	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15
a1	0,1	0,.5	0,.5	.3,.3	.2,.4	.3,.2	.2,.4	.2,.4	.3,.2	0.5,0	.3,.3	.3,.2	.1,.5	.2,.3	.4,.1
a2	0,.6	0,1	0,.6	0,.7	0,.7	0,.6	0,.7	0,.7	0,.6	0,.5	0,.7	0,.7	0,.7	0,.7	0,.7
a3	.0,.6	0,.5	0,1	0,.7	0,.7	0,.5	.1,.5	0,.6	0,.6	0,.6	0,.7	.1,.5	0,.7	.1,.5	.2,.4
a4	.2,.4	.1,.3	0,.5	0,1	.2,.3	.5,0	.2,.4	.2,.4	0,.6	0,.6	.3,.3	.2,.3	.3,.2	.2,.3	.3,.2
a5	.2,.4	0,.6	0,.5	0,.7	0,1	.2,.3	.5,0	.5,0	0,.5	0,.5	.1,.5	.1,.5	.2,.4	.5,0	.5,0
a6	.3,.3	0,.6	0,.5	.1,.5	.2,.4	0,1	.2,.4	.2,.3	0,.6	0,.6	.5,0	.4,0	.5,0	.2,.3	.3,.2
a7	.2,.4	0,.6	0,.5	.1,.5	.1,.5	.1,.4	0,1	.5,0	0,.5	.2,.3	.2,.4	.2,.3	.4,.1	.5,0	.4,0
a8	.4,,.1	.4,0	.2,.3	.1,.5	.2,.4	.2,.3	.1,.5	0,1	0,.6	.2,.3	.1,.5	.1,.5	.1,.5	.5,0	.5,0
a9	0,.7	0,.6	0,.6	0,.7	0,.7	0,.6	.2,.4	.1,.5	0,1	.4,.1	.1,.5	.1,.5	0,.7	.1,.6	0,.6
a10	.3,.2	0,.6	0,.6	0,.7	0,.7	0,.6	.5,0	.3,.3	.5,0	0,1	.1,.5	.2,.3	.2,.4	.2,.4	.2,.3
a11	0,.6	0,.5	0,.5	.3,.2	.1,.5	.3,.2	.1,.5	.2,.4	.2,0	.4,.1	0,1	.5,0	.4,.3	.2,.4	.4,.1
a12	0,.7	0,.5	0,.6	.1,.5	.1,.5	0,.6	.1,.5	.3,.3	.1,.4	.4,.1	.3,.2	0,1	.3,.2	.2,.4	.2,.4
a13	0,.7	0,.3	0,.6	.1,.5	.2,.3	0,.5	.2,.4	.2,.4	.2,.3	.4,.1	.1,.5	.2,.3	0,1	.1,.6	.2,.3
a14	.5,0	.4,0	.5,0	.3,.3	.2,.3	.2,.3	.1,.5	.5,0	.1,.4	.1,.4	.4,.1	.3,.2	.2,.4	0,1	.5,1
a15	.3,.2	.3,.1	.2,.3	.5,0	.5,0	.4,.1	.3,.2	.3,.3	.2,.3	.4,.1	.3,.3	.2,.3	.1,.5	.4,.1	0,1

The total relation matrix (T) is determined by Eq. (8). The case study total relation matrix is shown in Table 4.

Table 4
The grey direct-relation matrix for GSCM factor by the Aggregated model

Aggregated	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15
a1	0.26	0.18	0.20	0.26	0.28	0.24	0.27	**0.34**	0.22	0.20	0.23	0.28	0.28	**0.36**	0.31
a2	0.22	0.21	0.20	0.26	0.28	0.23	0.27	**0.34**	0.20	0.19	0.23	0.27	0.28	**0.35**	0.31
a3	0.22	0.18	0.23	0.25	0.28	0.23	0.26	0.33	0.19	0.19	0.22	0.27	0.27	**0.35**	0.30
a4	0.25	0.20	0.22	0.32	0.32	0.30	0.31	**0.37**	0.22	0.21	0.26	0.30	**0.34**	**0.39**	**0.35**
a5	0.25	0.21	0.22	0.29	**0.35**	0.27	**0.35**	0.42	0.22	0.21	0.26	0.31	0.32	**0.44**	**0.37**
a6	0.24	0.20	0.22	0.28	0.30	0.29	0.30	**0.38**	0.22	0.21	0.29	0.31	**0.35**	**0.39**	**0.34**
a7	0.25	0.21	0.23	0.30	0.32	0.27	**0.34**	**0.44**	0.23	0.22	0.26	0.31	**0.36**	**0.43**	**0.38**
a8	0.25	0.22	0.22	0.29	0.31	0.26	0.30	**0.41**	0.22	0.22	0.26	0.31	0.31	**0.45**	**0.39**
a9	0.22	0.18	0.20	0.26	0.28	0.23	0.27	**0.34**	0.23	0.20	0.22	0.27	0.28	**0.35**	0.30
a10	0.23	0.19	0.20	0.27	0.29	0.24	0.28	**0.35**	0.24	0.23	0.23	**0.28**	0.29	**0.36**	0.31
a11	0.23	0.19	0.21	0.28	0.30	0.25	0.28	**0.36**	0.22	0.21	0.28	**0.34**	0.30	**0.38**	**0.35**
a12	0.22	0.18	0.20	0.26	0.28	0.24	0.27	**0.34**	0.20	0.20	0.24	0.31	0.31	**0.36**	0.31
a13	0.23	0.19	0.21	0.27	0.30	0.25	0.28	**0.35**	0.21	0.23	0.24	0.28	0.32	**0.37**	0.33
a14	0.30	0.25	0.27	0.31	**0.34**	0.28	0.32	**0.44**	0.24	0.23	0.29	0.33	**0.34**	**0.46**	**0.39**
a15	0.27	0.24	0.25	**0.35**	**0.38**	0.29	**0.35**	**0.42**	0.25	0.26	0.28	0.33	**0.34**	**0.44**	**0.41**

In the next step, we determine the overall importance or prominence (P_i) of factor i and net effect (E_i) of factor i .

Table 5
The Degree of Prominence and Net Cause/Effect of factors by Yazd Steel Industry

factor	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15
D	3.7	2.6	2.9	3.5	3.9	3.0	4.5	5.4	2.9	3.2	3.5	4.0	4.5	5.4	4.7
R	3.7	3.5	3.5	3.7	4.2	4.01	4.08	4.2	3.5	3.9	3.8	3.6	3.5	4.5	4.2
Prominence D+R	7.5	6.3	6.5	7.3	8.3	7.1	8.6	9.7	6.5	7.2	7.5	7.7	8.1	10.1	9.0
Net Effect D-R	-0.1	-0.9	-0.5	-0.2	-0.3	-0.9	0.5	1.2	-0.6	-0.7	-0.3	0.4	0.9	0.9	0.5

These values may then be plotted in a two-dimensional axis for each factor. Fig. 2 shows graphic of the overall prominence and net effect results of factors and the relationship between them.

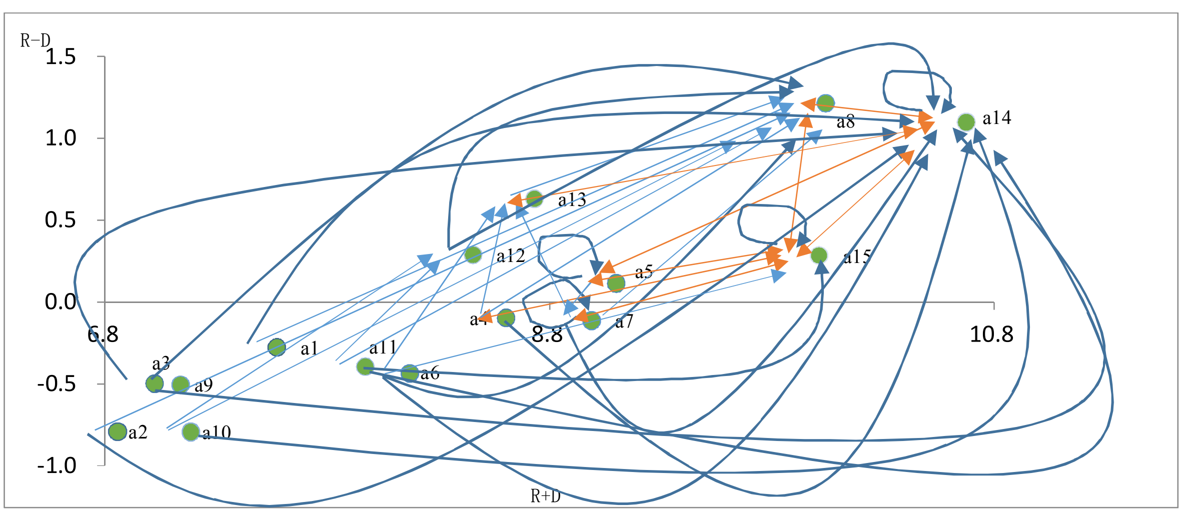

Fig. 2. The graph of aggregate GSCM's Model

5. Discussion and conclusion

The GSCM DEMATEL evaluation reveals two clusters. The “net effect cluster” comprises GSCM factors that mainly influence other GSCM factors, whereas the “net cause cluster” contains GSCM factors that are mainly influenced by others. Fig. 2 illustrates that the aggregate GSCM model informant regards, Environmental performance (a14), Getting recognition for environmentally positive behavior (a8), Economic Performance (a15), Green process design (a5), Reverse logistic (a13) and To use environmentally friendly practices with customers (a12) as net cause factors, and Implementing internal environmentally friendly operations (a7), Eco-design (Green design) (a4), Developing environmentally friendly products (a6), Environmental collaboration with customers (a11), Environmental collaboration with suppliers (a1), Transportation (a10), Stock (a9), Environmental monitoring of suppliers (a3) and Encouraging supplier to adopt more environmentally friendly behaviors (a2) as net effect factors.

Prominence includes the integration of the factors from both a cause (influencing) and effect (resulting) perspective. This analysis will provide us with an ordinal (temporal) perspective on what factors need to be in place initially (require immediate resource investment), and which ones will require attention at a future time. We now separate and evaluate each of these relationships.

As we can observe from the results of Fig. 2, Environmental performance (a14), Getting recognition for environmentally positive behavior (a8), Economic Performance (a15), Green process design (a5) and Implementing internal environmentally friendly operations (a7) are among the most important factors in aggregate GSCM of case study. It’s considerable Reverse logistic (a13), Eco-design (Green design) (a4), To use environmentally friendly practices with customers (a12), Developing environmentally friendly products (a6), Environmental collaboration with customers (a11), Environmental collaboration with suppliers (a1), Transportation (a10), Stock (a9), Environmental monitoring of suppliers (a3) and Encouraging supplier to adopt more environmentally friendly behaviors (a2) are not so important factor influencing on GSCM model. The clusters indicated by Fig. 2 are summarized in Table 5.

Table 5
Allocation of factors into cause-effect and Prominence-Not prominence clusters

	Not Prominence cluster	Prominence cluster
Cause cluster	a13, a12	a14, a8, a15, a5
Effect cluster	a4, a6, a11, a1, a10, a9, a3, a2	a7

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