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Building Theory of Green Supply Chain Management using Total Interpretive Structural Modeling (TISM)

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Abstract
Theory building in green supply chain management (GSCM) has in recent years received increasing attention from academia and practitioners. There are numerous published studies that have adopted a quantitative research methodology for building and testing theories in the fields of green supply chain management or environmental supply chain management. The aim of our paper is to build a GSCM theory using total interpretive structural modelling. To achieve this we have used an exhaustive literature review and identified the enablers of and barriers to GSCM. After identifying these enablers and barriers, we developed a questionnaire and distributed this among leading manufacturing firms who have embraced green supply chain management or environmental supply chain management as a guiding philosophy. The enablers were converted into a structural self-interaction matrix and we have further, based on expert opinion of individuals identified from academia and industry, developed a total interpretive structural model. The model presents the complex relationships among enablers and can in future be statistically validated using a larger sample size. The present study is an attempt to contribute in the field of theory building in GSCM, which is the pressing call of the time. Finally, we conclude our research and identify numerous research opportunities which may help to take the current study to the next level.

Key-Words: Green Supply Chain Management, Theory Building, Systems Theory, Interpretive Structural Modeling, and Total Interpretive Structural Modeling.

1. Introduction
Green supply chain management (GSCM) has in recent years been a subject of much debate among academia and practitioners. Increased environmental consciousness has triggered one of the greatest revolutions in human thought, uniting the entire world in a fight against the emissions which are produced during economic activities. Manufacturing and transportation activities are indicted as major reasons behind environmental degradation. While there is a rich body of literature on GSCM practices, the research on GSCM theory building is scant. One of the few studies which have used case methodology to build theory is the seminal work of Pagell and Wu (2009), who attempted to build a complete theory of sustainable supply chain management using multiple cases. Ketokivi and Choi (2014) have argued in their works that in recent years there has been a significant rise in case study methodology in the operations management field. However, the majority of such studies still lacks rigour in case research. Barratt et al. (2011) argued in their research that the use of theory can lead to better conclusions in terms of theoretical framework and insights. In our study, we argue that in a situation where the case approach fails to answer the research question 'How?', the systems approach may be a better scientific method (Sushil, 2012). In recent years interpretive structural modelling (ISM) and total interpretive structural modelling (TISM) have been significantly applied as scientific methods for building theory in the field of operations management. However, there is a pressing need for an appropriate TISM methodology in operations literature and for alternative methods for generating theory in GSCM. The present study represents an attempt to meet this need and extend the current GSCM literature using an alternative research method. We have identified our research objectives as:

(i) To develop a complete GSCM enabler framework using the TISM method

(ii) To identify further research opportunities.

The rest of the paper is organized as follows. In the next section we will discuss the theoretical foundation of our present paper. The third section will outline the research design. The fourth section of our paper will discuss the findings of our study, and finally we conclude our paper with a discussion of the limitations of the study and proposed future research directions.

2. Underpinning Theory
Systems theory has in the past attracted major attention from the scientific community as a tool to model complex problems. Warfield (1973, 1974) is credited with having used graph theory to solve complex social issues. The technique is popularly known as interpretive structural modeling (ISM). In recent years ISM has attracted significant attention from the operations management community (e.g. Raj et al., 2008; Mangla et al., 2013; Govindan et al., 2013; Panahifar et al., 2014; Luthra et al.,

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2014). The ISM methodology has gained popularity due to its ability to solve complex issues based on discrete mathematics. However, in recent years the ISM methodology has also attracted criticism from scholars due to a lack of consensus in terms of the level of confidence which may be attributed to the results due to variations in experts' opinions. Further, Sushil (2012) pointed out fundamental limitations of the ISM model in terms of transparency and suggested TISM as an alternative approach to build theory, which has demonstrated significant attraction for scholars (e.g. Nasim, 2011; Prasad and Suri, 2011; Dubey and Ali, 2014). However, to date TISM has not been exploited in the field of operations management. Hence, in an attempt to address this gap in the current literature, we have identified the TISM methodology as an alternative scientific method in our study.

3. Total Interpretive Structural Modelling

In this paper we have adopted interpretive structural modelling to build theory, as suggested by Sushil (2012).

3.1 Identification of GSCM enablers

We have adopted a two-pronged strategy to identify enablers of GSCM. First, we adopted an extensiveliterature review approach and then attempted to identify enablers of GSCM in consultation with two experts: one from academia and one from industry (Debnath and Shankar, 2012). The enablers are presented in Table 1.

<< INSERT TABLE 1>>

3.2 Contextual relationships among enablers

In the present study, seven supply chain management experts were identified. Using management techniques like brainstorming sessions, the contextual relationships among these enablers were established, as shown in Table 2. The relationships among variables are shown using V, A, X & O (see Table 3). The symbols i and j are used to denote direction between two nodes.

<< INSERT TABLE 2>>

The symbols V, A, X and O represent:
V - Enabler i is responsible for j but not vice-versa;
A - Enabler j is responsible for i but not vice-versa;
X - Enabler i and j are responsible for each other; and
O - Enabler i and j are not responsible for each other.

3.3. Interpretation of Comparison

The SSIM matrix (see Table 3) is further converted into initial and final reachability matrices (see Table 4 and Table 5).

The SSIM matrix has been converted into a binary matrix, called the initial reachability matrix by substituting V, A, X and O by 1 and 0 as per given case. The substitution of 1s and 0s are as per the following rules (Dubey and Ali, 2014):

1. If the (i, j) entry in the SSIM is V, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0;
2. If the (i, j) entry in the SSIM is A, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1;
3. If the (i, j) entry in the SSIM is X, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1; and
4. If the (i, j) entry in the SSIM is O, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

In this case we have first derived the reachability matrix (Table 3) , which is further partitioned into various levels.

<< INSERT TABLE 3>>

3.4 Directed Graph

<<INSERT FIGURE 1>>

The ISM model is shown in Figure 1, from which we can see how integration of key business processes drives competitive advantage for organizations that have implemented GSCM. From this level we can see that among enablers of GSCM, integration of key business processes is found to be at level 6, green technology and information management at level 5, waste management process is at level 4, manufacturing flow management and logistics at level 3, customer focus and supplier relationship management at level 2 and competitive advantage at level 1. The hierarchical relationship among variables indicates how integration of business processes – mediated through green technology and information management – leads to waste management process. The waste management process, further mediated through manufacturing flow management and logistics management, results in customer relationship and supplier relationship, which provide further competitive advantage to the organization.

3.5 Binary Interaction Matrix

The binary interaction matrix is generated from Figure 1, as shown in Table 4.

<<INSERT TABLE 4>>

3.6 Interpretive Matrix

<<INSERT TABLE 5>>

3.7 TISM based model

<<INSERT FIGURE 2>>

The strategies which help to achieve the linkage are presented in the interpretive matrix.

4. Discussion

The above TISM model on GSCM provides an interesting insight. The present study has adopted an inductive approach in which we have adopted two major stages – a descriptive stage and a prescriptive stage. In the descriptive stage we have used three steps:

- Observation;
- Classification of literature;
- Establishment of relationships.

After the descriptive stage, the study moves to a prescriptive stage, which includes:

- Development of ISM model;
- Derived interpretive matrix;
- Creation of TISM-based model.

4.1 Theoretical Contributions

The present paper is an attempt to build theory surrounding green supply chain management. The existing literature on GSCM has relied heavily on deductive approaches associated with 'big data' empirical research, but which fail to explore some important aspects. Markman and Krause (2014), in a call for papers on 'Theory Building Surrounding Sustainable Supply Chain Management', have argued the need for inductive approaches to generating theory surrounding sustainable supply chains, as deductive approaches may in some cases limit the scope of study. The present work has attempted to extend the contribution of Pagell and Wu (2009), who attempted to build sustainable supply chain theory using ten exemplar case studies. However, we argue that sometimes, due to lack of support from industry, alternative approaches such as ISM and TISM can be equally effective in building theory. Hence, our present paper is an attempt to draw the attention of operations management scholars to other inductive approaches, which they may consider rather than focusing solely on a case study approach.

4.2 Managerial Implications

The TISM model can be used as a powerful tool for diagnosing the success and failure of any project. In our present study we have identified the enablers of GSCM. The TISM model further provides an insight that, rather than focusing on all enablers, it is important to understand the levels of the enablers. The TISM model helps managers to identify the enabler which drives other enablers, and can further be used to develop strategy through brainstorming exercises to achieve the linkage between any two enablers. This method can even be used as a powerful technique in place of a 'cause and effect' diagram.

5. Conclusions

Our present study has attempted to exploit the strength of interpretive logic to build theory where other, established inductive approaches sometimes fail to offer meaningful insights. To achieve this study adopted the TISM approach to develop a theory surrounding green supply chain management. However, the present study has its own limitations. First, the study is based on samples which are not statistically sufficient to test the theory. However, it can be recommended to use TISM in future for theory building in studies that can be tested using a large sample size. In this way the merits of this methodology can be fully realized. In our study we have not considered business ethics, institutional pressures, leadership, organizational culture or human resource issues. In future these factors can be included in building more comprehensive theories. Second we have seen that response of the respondents is expressed in 0 or 1. In case where respondents feel that there exists mediocre relationship which may not be expressed in either 0 or 1. In such case we can include fuzzy TISM.

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Appendix:

Table 1: Enablers of GSCM

Enablers	**References**
Green Technology	Sikdar and Howell (1998); Zhang et al. (2013); van Hoof and Lyon (2013)
Waste Management Process	Sushil and Vrat (1989);Schnitzer (1996); Yamakawa and Ueta (2002); Winzeler et al. (2003); Rehman and Shrivastava (2013)
Manufacturing Flow Management	Zhu et al. (2008); Seuring and Muller (2008)
Reverse Logistics	Lee and Klassen (2008); Mudgal et al. (2009);Stindt and Sahamie (2014);Subramaniyan et al. (2014)
Customer Focus	Lee and Klassen (2008); Mudgal et al. (2009); Diabat et al. (2014);Stindt and Sahamie (2014)
Supplier Relationship Management	Vachon and Klassen 2006; Hsu and Hu 2009; Bai and Sarkis 2010; Ku et al., 2010; Testa and Iraldo 2010; van Hoof and Lyon 2013
Information Management	Zhu et al. (2005); Zhu et al. (2007);Diabat et al. (2011)
Integration of Key Business Processes	Hervani et al. (2005);Zhu et al. (2008);Park et al. (2010)
Competitive Advantage	Simpson and Samson (2008); Testa and Iraldo (2010); Large and Thomsen (2011)

Table 2: Contextual Relationship among Enablers

Enablers numeric code	**Enablers**	**Enablers**							
		9	**8**	**7**	**6**	**5**	**4**	**3**	**2**
I	Green Technology	V	A	A	V	V	V	V	V
II	Waste management Process	V	A	A	V	V	X	V	-
III	Manufacturing flow management	V	A	A	O	V	O	-	-
IV	Reverse logistics	V	A	A	O	V	-	-	-
V	Customer Focus	V	A	A	O	-	-	-	-
VI	Supplier Relationship Management	V	A	A	-	-	-	-	-
VII	Information management	V	A	-	-	-	-	-	-
VIII	Integration of key business processes	V	-	-	-	-	-	-	-
IX	Competitive Advantage	-	-	-	-	-	-	-	-

Table 3: Reachability Matrix

Enablers alpha-numeric code	Enablers	Enablers									Driving Power
		1	2	3	4	5	6	7	8	9	
I	Green Technology	1	1	1	1	1	1	0	0	1	7
II	Waste Management Process	0	1	1	1	1	1	0	0	1	6
III	Manufacturing Flow Management	0	0	1	0	1	0	0	0	1	3
IV	Reverse Logistics	0	1	0	1	1	0	0	0	1	4
V	Customer Focus	0	0	0	0	1	0	0	0	1	2
VI	Supplier Relationship Management	0	0	0	0	0	1	0	0	1	**2**
VII	Information Management	1	1	1	1	1	1	1	0	1	**8**
VIII	Integration of Key Business Processes	1	1	1	1	1	1	1	1	1	**9**
IX	Competitive Advantage	0	0	0	0	0	0	0	0	1	**1**

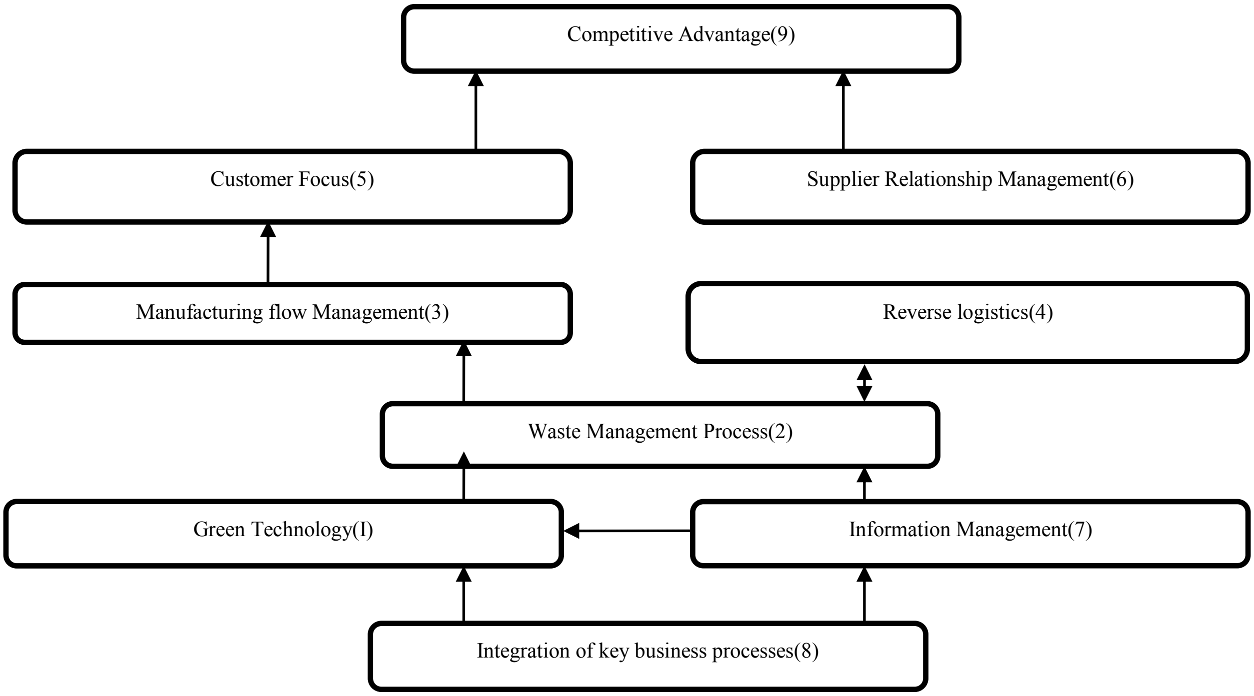

Figure 1: ISM based model

Table 4: Binary Interaction Matrix

Enabler numeric code	Enablers	Enablers								
		1	2	3	4	5	6	7	8	9
1	Green Technology	-	1	1	0	0	0	0	0	0
2	Waste Management Process	0	-	1	1	1	0	0	0	0
3	Manufacturing Flow Management	0	0	-	0	1	0	0	0	1
4	Reverse Logistics	0	1	0	-	0	0	0	0	0
5	Customer Focus	0	0	0	0	-	0	0	0	1
6	Supplier Relationship Management	0	0	0	0	0	-	0	0	1
7	Information Management	1	1	0	1	0	0	-	0	0
8	Integration of Key Business Processes	1	1	0	0	0	0	1	-	0
9	Competitive Advantage	0	0	0	0	0	0	0	0	-

Table 5: Interpretive Matrix

	I	II	III	IV	V	VI	VII	VIII	IX
I	The green technology can be exploited to reduce wastes, for which appropriate training should be provided to achieve the desired outcome.		The work stations are designed in such a way that the distance travelled by the materials and other resources is least.						
II			Waste management process has a strong impact on design of manufacturing flow.	)ptimizing the route and reducing carbon emissions can help in establishing mutual association between waste management and logistics management.	Waste reduction using value engineering concept and sustainable product design can help waste management process to link with customer focus.				
III					Improving efficiency of production line.	By improving efficiency of production line, the cost of production per unit decreases.			
IV		Hub and spoke distribution, full truck load and proper storage help in waste reduction.							

V	Customer focus helps in improving product quality and increasing product utility.		
VI	Through collaboration with suppliers and building trust, the risk in the supply chain network can be mitigated, cost can be reduced, the emission of carbon is reduced and quality of product improves. These outcomes provide distinct competitive advantage to the organization.		
VII	Use of ERP and RFID chips helps in successful implementation of green technology.	Information management can help in improving supply chain visibility.	Information management can help in improving vehicle turnaround and managing warehouse stock level.
VIII	Integration of business process helps optimal utilization of green technology.	Just in time, conservation of energy, recycling, reduced wastage and recovery help in achieving waste management process.	Business integration improves flow of information. This further increases visibility across the supply chain and further improves velocity.
IX	-		

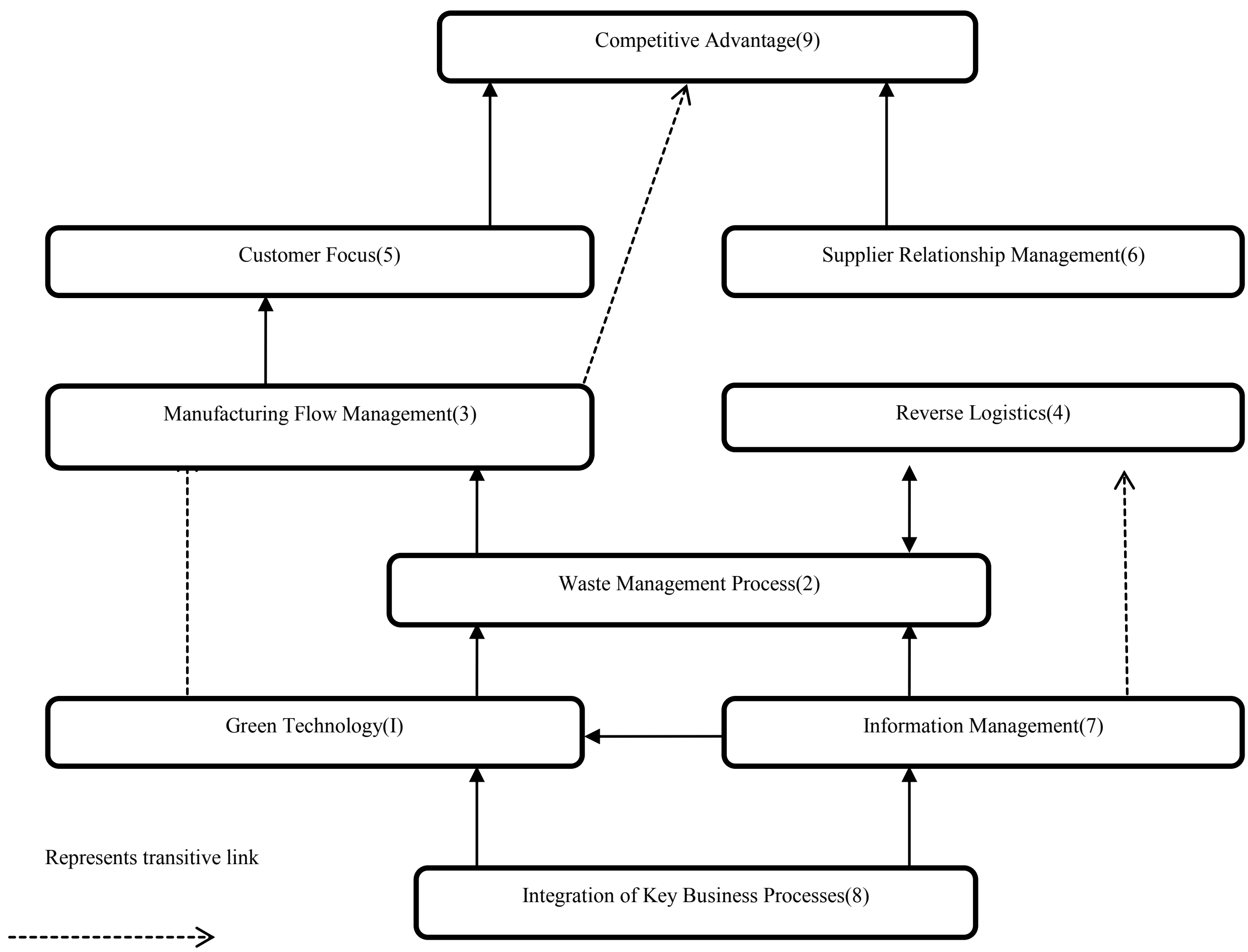

Figure 2: TISM Model