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A conceptual model for factors affecting the relationship between supply chain integration and customer delivery performance

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Abstract

Supply chain is a widely used concept around the world. Nowadays, companies need to integrate their production processes, from the raw materials to the end-user. Supply chain management is a phenomenon that achieves this in a way that ensures customers get reliable and fast service and high quality products at the lowest possible cost. There is very limited and sporadic research on supply chain integration and how it affects supply chain performance. Therefore there is no real understanding of the concept of supply chain integration and how it affects supply chain performance nor is there a holistic model. This paper thus aims to present a model that identifies factors affecting the relationship between supply chain integration and customer delivery performance. After analyzing the collected data on supply chain integration and customer delivery performance, the preliminary model was proposed and completed, and using expert opinion in the Imam Khomeini Oil Refinery the final model and for factors affecting the relationship between supply chain integration and customer delivery performance were presented. To determine how these factors interrelate with each other, the DEMATEL method was then used. The statistical population included the staff at Imam Khomeini Oil Refinery in Shazand. The data, collected through the standard DEMATEL questionnaire, were analyzed using the DEMATEL method and a MATLAB program. The DEMATEL results indicate that intra-organizational factors, institutional norms, technological certainties are causal factors which influence other factors that affect the relationship between supply chain integration and customer delivery performance. Intra-organizational factor have a greater influence also among effect factors, substructures have the greatest influence.

Keywords: supply chain, supply chain management, supply chain integration, delivery performance

Introduction

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How well a supply chain performs is key factor in an organization's success and achieving its goals, especially profitability. Effective supply chain management and integration improve its performance and create competitive advantage for the organization. On the other hand in today's competitive world, organizations are have revised their strategies and now consider customer satisfaction their secret to survival. Therefore customer delivery performance and gaining competitive advantage are highly important. According to previous research, supply chain integration has a positive effect on supply chain performance. This relationship, however, may be influenced by other factors which might have positive or negative effects themselves. Identifying such factors and how they interrelate with each other improves supply chain performance, which leads to competitive advantage, improved customer service, reduced costs, and increased income. Boon-itt and Wong (2011) in their paper "The moderating effects of technological and demand uncertainties on the relationship between supply chain integration and customer delivery performance", analyze the effects of environmental and demand uncertainties on the relationship between supply chain integration and customer delivery performance by collecting data through questionnaires and regression. Their results indicate that supply chain integration positively affects supply chain performance and customer delivery performance. Internal and supplier integration positively affect customer delivery performance. However, this is not true for customer integration. Demand and technological uncertainties have a moderating effect on the relationship between supply chain integration (internal, supplier, and customer integration) and customer delivery performance (Boon-itt and Wong, 2011: 253-287).

Sukati et al. (2011) study company integration and supply chain direction in consumer goods industries. Their study analyzed the supportive effect of technology in the company on internal, supplier and consumer levels on supply chain direction (consumer direction, competitive, supplier, logistic, operational, and coordination of the chain) (Sukati et al., 2011). Vaart et al. (2007) in a study titled "A critical review of survey-based research in supply chain integration" analyze the effects of business conditions on the relationship between supply chain patterns and their activities and the supplier-customer relationship (Vaart and Donk, 2007: 42-55). Another paper titled "The impact of power and relationship commitment on the integration between manufacturers and customers in a supply chain" studies the effect of mentioned factors on customer and supplier integration. Market and management researchers had already studied the effects of power and inter-organizational relationship commitment but this paper studied the matter in the context of supply chain. The data were collected from 617 companies and the results showed that there were different forms of customer power and supplier relationship commitment impact. Expert power, referent power, and reward power are important in improving manufacturer's normative relationship commitment norms of the producer while reward power and coercive power increase instrumental relationship commitment. Furthermore, it was concluded that normative relationship commitment has a greater impact on customer integration (Zhao et al, 2008:368-388).

This paper aims to determine factors that affect the relationship between supply chain integration and customer delivery performance as well as if and how they interrelate with each other. It has a practical goal of designing a conceptual model in order to identify important factors in the relationship between supply chain integration and customer delivery performance so that they can be used to gain competitive advantage, increase customer satisfaction, as well as profitability, and reduce costs.

Theoretical framework

- **Supply chain**

The supply chain encompasses all activities associated with the flow of goods and information from sourcing of row materials through to the end user (Panayids & Venus Lun, 2009).

Another source defines supply chain as, the network of entities through wich material flows. Those entities may include suppliers, carriers, manufacturing sites, distribution centers, retailers and customers (Lummus and vokurka,1999).

- **Supply chain management**

The 1990s saw the development of supply management as an emerging academic discipline, firms began to see the effective and efficient supply chain management could yield large direct (cost reduction) and indirect (improvements in delivery performance, technology acquisition, etc.) improvements for the firm (cousins and Menguc, 2006).
Supply chain management is the integration of key business processes from the supplier to the end-user which leads to products, services, and information being produced. This integration creates added value for customers and other stakeholders (Wong and Kong, 2012).
SCM is understood to be a set of practices for managing and coordinating the transformational activities from raw material suppliers to ultimate customers (Kotzab et al., 2011).
As defined by Ellram and Cooper, supply chain management is “an integrating philosophy to manage the total flow of a distribution channel from supplier to ultimate customer”. Moncka and Morgan state that “integrated supply chain management is about going from the external customer and then managing all the processes that are needed to provide the customer whit value in a horizontal way” (Lummus & Vokurka, 1999).

Nowadays SCM is a combination of marketing, logistics, and production. Figure (1) shows the three dimensions of SCM.

- **Supply chain integration**

The debate on supply chain integration has spanned over two decades. Tha seminal work by Stevens (1986) gave stage-based and maturity dimensions to the subject (Aryee et al., 2008). This has been brought about by changes in manufacturing and supply strategies and increased levels of global competition. Firms have realized that in order to become competitive they have to offer higher quality products and cheaper prices than their competitors.this meant that firms needed not only to improve productiontechniques but to focus on the integration of the supply activity with what customers demand. These improvement would lead to the delivery of high quality products, on time, at low cost to maximize return (cousins and Menguc, 2006).
SCI as the degree to which a manufacturer strategically collaborates whit its supply chain partners and collaboratively manages intra –and inter- organization processes. The goal is to achieve effective and efficient flows of products and services, information, money and decisions, to provide maximum value to the customer at low cost and high speed (Flynn et al., 2010).
Suuply chain integration involves the processes of collaboration across functional departments, suppliers, and customers to arrive at mutually acceptable outcomes. Collaboration is a key element of supply chain integration because strategic collaboration is

required to enable cross-functional communication and joint effort. Furthermore. An integrated supply chain is linked organizationally and coordinated in terms of information flow from raw materials to the on-time delivery of finished products to customers. Thus supply chain integration includes the collaboration of functional departments, suppliers and customers to link and coordinate information flow and processes so that the supply chain is able to achieve on-time delivery (Boon-itt & Wong, 2011).

- ✓ **Delivery performance**

The delivery performance of a logistics system can be measured in terms of on-time delivery, delivery lead-time, and delivery reliability. Owing to the importance of the time element, customer delivery performance is often regarded as time-based performance. Customer delivery performance can be achieved by a high level of collaboration because it contributes to joint efforts in problem solving, product development, and collaborative panning (Boon-itt & Wong, 2011).

Delivery deviations –the earliness and lateness from the targeted delivery date- must be analyzed, as both early and late deliveries are disruptive to supply chain. Early and late deliveries introduce waste in the form of excess cost into the supply chain; early deliveries contribute to excess inventory holding cost, while late deliveries may contribute to production stoppages cost and loss of goodwill (Guiffrida & nagi, 2006).

- ✓ **DEMATEL methods**

The DEMATEL method, originated from the Geneve Research Centre of the Battelle Memorial Insitute, is especially pragmatic to visualize the structure of complicated causal relationships (Buyukozkan & Cifci, 2012). DEMATEL is built on the basis of graph theory, enabling analyses and solve problems by visualization method. This structural modeling approach adopts the form of a directed graph, a causal-effect diagram, to present the interdependence relationships and the values of influential effect between factors .Through analysis of visual relationship of levels among system factors, all elements are divided into causal group and effect group. And this can help researcher's better understanding the structural relationship between system elements, and find ways to solve complicate system problems. At first, DEMATEL method focused primarily on the fragmented and even contradictory phenomenon to find a reasonable solution. With further research, this method has been widely applied in more and more areas, since it is very useful for visualizing complex casual structure among multiple factor. Currently, DEMATEL method has been applied to many fields (Zhou et al,. 2011).

This paper also uses the DEMATEL method to identify causal relationships between the factors and categorize them into causes and effects. The steps are explained in a later section.

Research goals

- Which factors affect the relationship between supply chain integration and customer delivery performance?
- How do factors that affect the relationship between supply chain integration and customer delivery performance interrelate?

Research methodology

This is a practical research, because it is looking for practical goals, it is also mathematical-causal in nature, because it is trying to identify the causes of a phenomenon. The statistical population includes experts and specialists in supply chain who hold Bachelor's or higher degrees in management or industrial engineering at Imam Khomeini Oil Refinery in Shazand. Data collection during the first stage of this research was done through literature review in order to identify factors that may affect the relationship between supply chain integration and customer delivery performance. This is because we aimed to design a model which identified factors that affect this relationship. The second stage of data collection was a field research. Questionnaires and interviews were used for data collection. After identifying known factors that affect the relationship between supply chain integration and customer delivery performance through literature review and interviewing experts, Lawshe's technique was used to ensure content validity of the identified factors and eliminate irrelevant ones. To this end, a questionnaire was designed and distributed among supply chain experts in the refinery which asked them to rate each factor on a three-band scale (very essential, essential but not required, not essential). Nine factors were consequently identified as affecting the relationship between supply chain integration and customer delivery performance. After that, the standard DEMATEL questionnaire was used, which studies how the factors interrelate. The DEMATEL questionnaire contains a matrix which shows all the factors on rows and columns. The respondent must specify the effect cells in each row on the corresponding column using signs in Table (1). Table (2) shows the designed DEMATEL questionnaire.

Table 1: the fuzzy linguistic scale

Linguistic variable	مخفف	Influence score	Corresponding triangular fuzzy numbers (TFNs)
NO INFLUENCE	NO	0	(0, 0, 0.25)
VERY LOW INFLUENCE	VL	1	(0, 0.25 , 0.5)
LOW INFLUENCE	L	2	(0.25, 0.5, 0.75)
HIGH INFLUENCE	H	3	(0.5, 0.75 , 1.0)
VERY HIGH INFLUENCE	HL	4	(0.75, 1.0, 1.0)

Table 2: DEMATEL* matrix sample

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1									
C_2									
C_3									
C_4									
C_5									
C_6									
C_7									
C_8									
C_9									

*Factors: (C_1)supply certainties, (C_2) Demand certainties, (C_3) Technologhical certainties, (C_4) Institutional norms, (C_5) Invironment, (C_6) Information, (C_7) Systems and processes, (C_8) Interal factors, (C_9) Trust

Research findings

DEMATEL run

Step 1: Generate the initial direct-relation matrix. Form a committee of experts, and acquire the assessments about direct affect between each pair of elements .converting the linguistic assessments into crisp values, we obtain the direct-relation matrix A=[c_{ij}], where A is a n×n non-negative matrix, c_{ij} indicate the direct impact a factor I on factor j; and when i=j, the diagonal elements $c_{ij=0.}$

Step 2: Normalize the initial direct-relation matrix.the normalized direct-relation matrix D=[d_{ij}] can be obtained through Eq.(1). All elements in matrix D are complying with 0≤ d_{ij}≤1, and all principal diagonal elements are equal to 0.

$$D= \frac{1}{\max \sum_{1\le i\le n}^{1\le j\le n} aij}$$

Table 3: normalized direct-relation matrix D

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1	-	0.082	0.13	0.104	0.136	0.133	0.136	0.12	**0.123**
C_2	0.089	-	0.117	0.111	0.127	0.114	0.13	0.108	**0.123**
C_3	0.13	0.12	-	0.114	0.13	0.142	0.127	0.117	**0.111**
C_4	0.098	0.117	0.104	-	0.108	0.12	0.114	0.117	**0.101**
C_5	0.152	0.123	0.123	0.104	-	0.114	0.117	0.117	**0.104**
C_6	0.133	0.123	0.12	0.108	0.114	-	0.117	0.12	**0.117**
C_7	0.127	0.13	0.13	0.117	0.123	0.127	-	0.13	**0.101**
C_8	0.139	0.12	0.123	0.104	0.127	0.127	0.152	-	**0.108**
C_9	**0.127**	**0.117**	**0.104**	**0.072**	**0.117**	**0.114**	**0.12**	**0.104**	**-**

Step 3: Acquire The total-relation matrix T using the Eq.(2) in which I is an n×n identity matrix. The element tij indicate the indirect effects that factor I have on factor j, so the matrix T can reflect the total relationship between each pair of system factors.

$$T= D\,(I-D)^{-1} \qquad (2)$$

Table 4: total- relation matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
C_1	2.0674	2.0173	2.0986	1.8552	2.1574	2.1708	2.2124	2.0359	**1.9694**
C_2	2.0558	1.8542	1.9989	1.7820	2.0587	2.0631	2.1136	1.9567	**1.8861**
C_3	2.2298	2.0931	2.0302	1.9051	2.2006	2.2261	2.2545	2.0972	**2.0040**
C_4	1.9867	1.8837	1.9158	1.6178	1.9688	1.9927	2.0245	1.8925	**1.8003**
C_5	2.1781	2.0299	2.0737	1.8383	2.0181	2.1356	2.1773	2.0321	**1.9366**
C_6	2.1564	2.0243	2.0648	1.8357	2.1137	2.0266	2.1706	2.0283	**1.9410**
C_7	2.2171	2.0917	2.1358	1.8994	2.1855	2.2045	2.1322	2.0981	**1.9871**
C_8	2.2581	2.1128	2.1603	1.9153	2.2193	2.2353	2.2960	2.0125	**2.0205**
C_9	2.0066	1.8827	1.9124	1.6822	1.9726	1.9840	2.0253	1.8782	**1.7052**

Step 4: calculate the sum of rows and columns of matrix T. To make the outcome more visible, we compute r_i and c_j through Eq.(3) and (4), respectively. The sum of row I,

which is denoted as r_i, represents all direct and indirect influence given by factor I to all other factors, and so r_i can be called the degree of influential impact. Similarly, the sum of column j, which is denoted as c_j summarizes both direct and indirect impact received by factor j from all other factors.

$$r_i = \sum_{1 \leq i \leq n} tij \quad (3)$$

$$ci = \sum_{1 \leq i \leq n} tij \quad (4)$$

So naturally, when i=j, r_i+c_i shows all effects given and received by factor i. That is, r_i+c_i indicate both factor i's impact on the whole system and other system factors' impact onfactor i. So, the indicator $ri+c_i$ can represent the degree of importance that factor I plays in the entire system. On the contrary, the difference of the two, r_i-c_i, shows that the net effect that factor i has on the system. Specifically, if the valu of r_i-c_i is positive, the factor i is a net cause, exposing net causal effect on the system. When r_i-c_i is negative, the factor is a net result clustered into effect group.

Table 5: the score of each factor and related values for cause and effect group

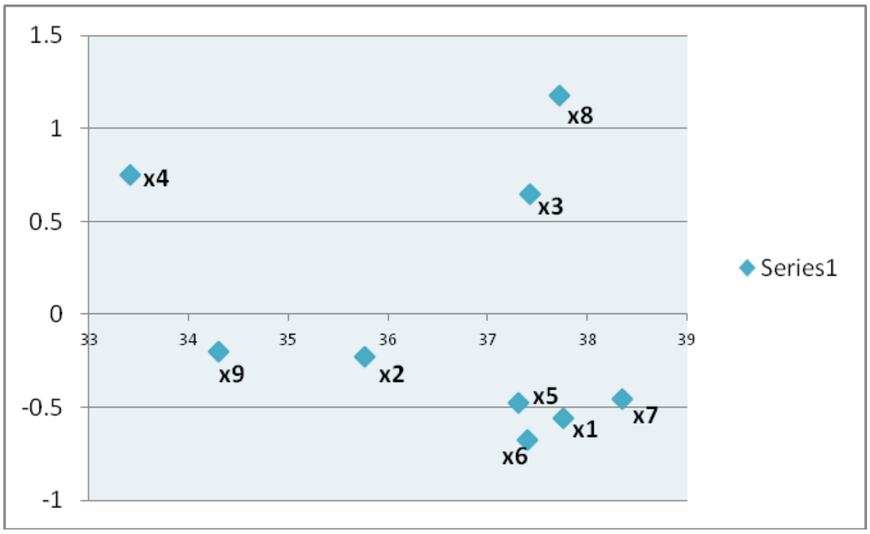
	ri	Ci	ri + ci	ri – ci
C_1	18.6024	19.159	37.7614	-0.5566
C_2	17.7691	17.9933	35.7624	-0.2242
C_3	19.0406	18.3905	37.4311	0.6501
C_4	17.0828	16.331	33.4138	0.7518
C_5	18.4197	18.8947	37.3144	-0.475
C_6	18.3614	19.0387	37.4001	-0.6773
C_7	18.9514	19.4064	38.3578	-0.455
C_8	19.2301	18.0495	37.7251	1.1806
C_9	17.0492	17.2502	34.2994	-0.201

According to Table (5), the maximum row sum ri shows the sequence of constraints that strongly influence other constraints and maximum column sum ci show the sequence of constraints that are influenced. Therefore, the sequence of constraints from row ri shows the hierarchy of influential factors and the sequence of constraints from column ci show the hierarchy of influenced constraints.

Step 5: Construct cause-effect relationship diagram based on r_i+c_i and r_i-c_i. A cause-effect diagram can be draw by mapping the dataset of (r_i+c_i, r_i-c_i). And the complex interrelationship among factors is visualized through the diagram costruction process.

Such that the value of ri-ci for each criterion remains positive, the criterion belongs in the group of causes and is definitely an influential factor. However, if the value of ri-ci is negative the criterion belongs in the effects group and is an influenced factor. Furthermore, ri+ci shows the sum intensity of a factor (along the x-axis) for both the influential and influenced factors i.e. ri + ci shows the effect of factor i on the whole system as well as the effect of other factors on i. Thus ri + ci can show the importance of i in the whole system. According to the position of every factor in the whole system, we can determine factor that are able to greatly improve system efficiency and pay more attention to them.

Figure (1). Cause and effect diagram



As Diagram (1) shows, factors are divided into two categories based on whether the value of ri – ci is positive or negative. The causes group, which has a positive value for ri – ci, includes technological certainties (X3), institutional norms (X4), and intra-organizational factors (X8). The other factors, which are, supply certainty (X1), demand certainty (X2), the environment (X5), information (X6), infrastructure (X7), and trust (X9) belong in the other group.

Table (6) the sekuence of factors influencing each other

Rows and D		**Columns and R**		**D+R**		**D-R**	
Items	**values**	**Items**	**values**	**Items**	**values**	**Items**	**values**
Interal factors	**19.2301**	Systems and processes	**19.4064**	Systems and processes	**38.3578**	Interal factors	**1.1806**
Technologhical certainties	**19.0406**	supply certainties	**19.159**	supply certainties	**37.7614**	Institutional norms	**0.7518**
Systems and processes	**18.9514**	Information	**19.0387**	Interal factors	**37.7251**	Technologhical certainties	**0.6501**
supply certainties	**18.6024**	Invironment	**18.8947**	Technologhical certainties	**37.4311**	trust	**0.201-**
Invironment	**18.4197**	Technologhical certainties	**18.3905**	Information	**37.4001**	Demand certainties	**0.224-2**
Information	**18.3614**	Interal factors	**18.0495**	Invironment	**37.3144**	Systems and processes	**0.455-**
Demand certainties	**17.7691**	Demand certainties	**17.9933**	Demand certainties	**35.7624**	Invironment	**0.475-**
Institutional norms	**17.0828**	trust	**17.2502**	trust	**34.2994**	supply certainties	**0.556-6**
trust	**17.0492**	Institutional norms	**16.331**	Institutional norms	**34.4138**	Information	**0.677-3**

According to Table (6), the maximum row sum of ri shows the sequence of factors that strongly influence other factors and intra-organizational factors are the most influential; and maximum column sum ci shows the sequence of influenced constraints and substructures are the most influenced. Thus, the sequence of constraints from row ri shows the hierarchy of influential factors and the sequence of constraints from column ci show the hierarchy of influenced constraints. The maximum value of ri + ci shows the sum intensity of a factor for both the influential and influenced factors and substructures has the highest value. Furthermore, for ri – ci, intra-organizational factors are the most influential and information is the most influenced.

Analyzing the causes

As mentioned before, technological certainties, institutional norms, and intra-organizational factors belong in the group of causes. In this group intra-organizational factors, with the highest value of ri – ci, have the highest influence on the system and are the least influenced. The value is 19.2301 this proves the significance of this factor over other factors. Institutional norms and technological certainties are in the second and third place according to their ri – ci.

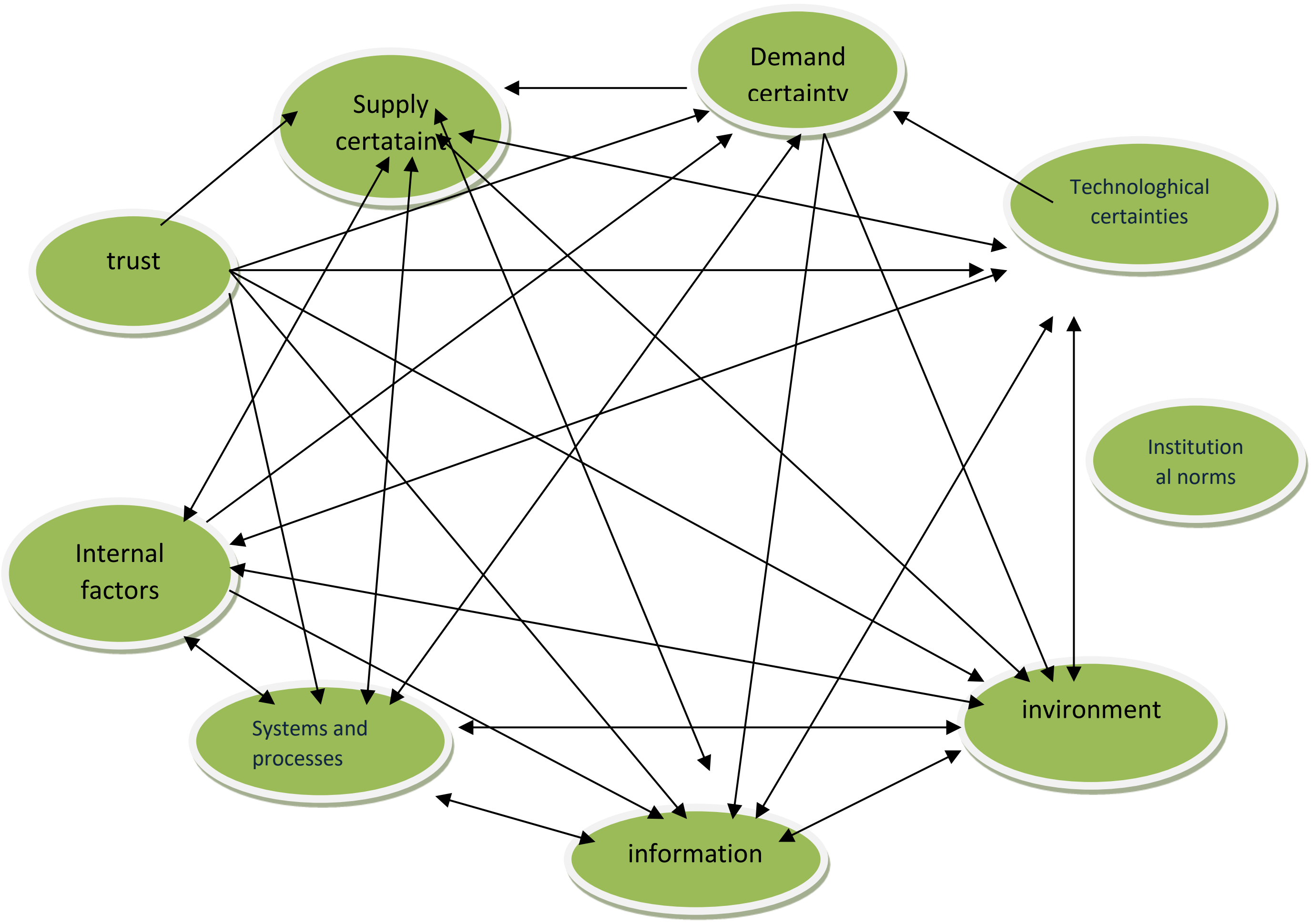
Analyzing the effects

Organization infrastructure has the highest ri + ci, which shows this factor plays an important role in the system and since ri – ci is negative for this factor, it is influenced by other factors and improving this factor can improve other factors. Similarly, according to the numerical value of ri – ci the information factor is most influenced by other factors. Supply certainty, environment, demand certainty, and trust are in the next places.

Conclusion and designing the model of relationships between the factors using the DETAMEL technikue

Factors influencing the relationship between supply chain integration and customer delivery performance were divided into two groups: causes and effects. The causes include intra-organizational factors, institutional norms, and technological certainties in order of their influence and the causes include infrastructure, supply certainty, information, environment, demand certainty, and trust. To design the model only significant relationships must be considered. Therefore, a threshold needs to be determined for the significance of relationships. There have been multiple methods for determining this threshold (Chen, 2008:28). The most common method, however, is the mean of values in matrix T or agreeing on a fixed value. This value should balance the complexity of the model and loss of valuable information. If the threshold is too high a major part of meaningful relationships will be ignored on the other hand if it is too low there will be too many relationships. Therefore after testing numerous values, the value of 2.031 was chosen as the threshold and the following model was designed.

Figure (2): The model of factors that affect the relationship between supply chain integrity and customer delivery performance


Supply certatainty
Demand certainty
Technologhical certainties
trust
Institutional norms
Internal factors
Systems and processes
environment
information

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