PERFORMANCE MEASUREMENT ON SUPPLY CHAIN MANAGEMENT; A MODEL FOR IRAN'S MACHINE-WOVEN CARPET INDUSTRY

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ABSTRACT

Supply chain is among the issues received a considerable attention. Today they are not companies who compete with each other, but supply chains, therefore it is vital to devote attention to the issue of supply chain. A lot of works have been made regarding this topic; this research is to review and summarize those works and then present a model so as to measure the performance of supply chain. The survey was carried out on Iran machine-made carpet's supply chain. Hand-woven is among crafts has achieved a favorable position in Iran though there are few scientific research has been performed into it so far; so it demands careful consideration. Explanatory and confirmatory factor analysis was adapted in this research. Indicators used to measure supply chain performance had been classified into specific groups, namely: customer, cost, product, financial, supplier, employee and chain supply after performing explanatory factor analysis. And all of these indicators and factors were validated in confirmatory factor analysis. Then they were valued separately through AHP method through which customer and supplier groups showed closer connection to supply chain performance than the others.

Keywords: Supply Chain, Factor Analysis, Machine-woven Carpet

INTRODUCTION

Supply chain is an integrated procedure in which raw materials convert into finished products, then being delivered into customers (Beamon, 1999). The term supply chain management, as concept, is a philosophy and a management process which was emerged in 1980s (Svensson, 2003).

Supply chain brings companies advantages through increasing customer services and their accountability, improving supply chain communication, reducing risk, shortening product development process, avoiding reparation in company's internal processes, inventory shortage, introducing and/or advancing e-business (Meechan, 2008).

In today's global economy, competition is becoming more "supply chain verses supply chain" and less "firm verses firm" (Hult *et al.*, 2007) consequently paying attention to supply chain have been widespread in academic works. Different aspects of supply chain have been investigated; among those are enablers of supply chain performance. Performance enabler refers to factors which make the supply chain more potent to achieve better performance. Analyzing and classifying those factors would contribute to supply chain success in gaining better performance.

Research Terminology

A wide range of definitions has been proposed for supply chain management (SCM). Some of those are as follow:

Performance measurement is the process to quantify both efficiency and effectiveness of actions (Neely *et al.*, 2005).

Performance measurement may constitute as feedbacks received from actions done so as to achieve customer's satisfaction, and reach strategic decisions and goals (Bhagwat and Sharma, 2007).

Performance measurement is so important that Murphy (1999) recognized the lack of measurement system is the key reason contributing to poor performance of supply chain (Varma *et al.*, 2006). Consequently developing an appropriate measurement system is crucial due to the great effect it has on the efficiency of SCM (Beamon, 1999; Shah and Singh, 2001).

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Performance measurement is difficult; the reason behind this complication is that it requires various indicators for measuring SCM from one filed of operation to another field (Beamon, 1999; Gunasekarana *et al.*, 2004).

Table 1: Definitions of supplychain management

Definition	Source
The management of a network of interconnected businesses involved in the ultimate	Harland (1996)
provision of product and service packages required by end customers	
Coordination and management of complex network of actions involved in delivering	Harvani <i>et al.</i> ,
a finished product to an end costumer/consumer	(2005)
An integrative philosophy to manage the total flow of distribution channel from	Ellram (1990)
supplier to the ultimate user	
The management of upstream-downstream relationships with suppliers and	Christopher
customers for delivering more value to customers while having the lowest cost to	(1992)
supply chain.	
Concurrent integration of customer requirements, internal processes and upstream	Tan et al., (1998)
supplier actions.	
The term SCM is used to describe activities to control and manage the flow of	Chen (2004)
material and information as well as logistic actions within and between	
organizations.	

Performance measurement wascarried outchiefly based on cost/efficiency, profit orientation in short period of timeand judged bynon-clustered, individual indicesin the past, but now, new approaches are adopted in calculating performance measurement such as value orientation, customer orientation, long period of time and application of clustered indices as competitiongetting more intense in market (Shafiei, 1390).

Brewer and Speh (2001) suggested some problems in connection withmeans and performance measurement systems in supply chain (Hervani *et al.*, 2005) as follow:

- 1- Overcoming mistrust
- 2- Misunderstanding of indicators
- 3- Lack of control (managers would like to be evaluated by indicators which they can control)
- 4- Various goals
- 5- Disability of databases to gather information
- 6- Difficulty of making a relationship between indicators and customer value
- 7- Making decision about when to start measuring system performance

Following indicators were set for measuring the supply chain performance through review of literature:

Table 2: Indicators	to measure supply	chain performance

Indicators Inventory	Source	Indicators Competition	Source
Average order size	Soni (2010)	Domestic Market	Fitzgerald <i>et al.</i> , (1991)
Optimal Order quantity	Gunasekarana <i>et al.,</i> (2001)	Share and Status	Hubbard (2009) Chia et al., (2009) Sidiropoulos et al., (1991) Ray et al., (2006) Guurumurthy (2008)
Incoming stock level	Gunasekarana <i>et al.</i> , (2001)	Sale growth	Fitzgerald <i>et al.</i> , (1991)
Work-in-	Soni (2010)	Customer-oriented indicators	Fitzgerald et al.,

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processinventory level	Gunasekarana <i>et al.</i> , (2001)		(1991)
Finished goods inventory level	Gunasekarana <i>et al.</i> , (2001)	Emerging market	Hubbard (2009)
In-transit inventory level	Gunasekarana <i>et al.,</i> (2001)	Sale, Income, Profit	
Waste of inventory level	Zhu <i>et al.</i> , (2008) Ray <i>et al.</i> , (2006) Gunasekarana <i>et al.</i> , (2001)	Turnover	Xiaoping (2008) Gurumurthy (2008) Beamon (1999)
Inventory carrying cost	Levy (1997) Lee (1992) Stewart (1995)	Lost-sales rate	Beamon (1999)
Average inventory level	Zhu <i>et al.</i> , (2008) Ray <i>et al.</i> , (2006) Soni (2010)	Profit	Brewer (2000) Fitzgerald <i>et al.</i> , (1991) Gurumurthy (2008) Ray <i>et al.</i> , (2006) Beamon (1999)
Inventory replenishment batch size	Soni (2010)	Pretax profit	Brewer (2000) Chia <i>et al.</i> , (2009)
Average safety	Soni (2010)	Income	Gurumurthy (2008)
Replenishment rate	Soni (2010)	Gross income	Chia et al., (2009)
Inadequate inventory	Soni (2010)	Profit growth	Ip et al., (2011)
Inventory obsolescence	Soni (2010)	Selling rate of new products	Cai et al., (2009)
Seasonal inventory	Soni (2010)	Days sales outstanding	Soni (2010) Stewart (1995)
Inventory holding costs Inventory flow rate	Angerhofer (2006) Felix (2003)	Range of periodic sales Sales growth	Sonic (2010) Hubbard (2009)
Inventory accuracy	Felix (2003)	Sales rate of return	Hubbard (2009) Bigliardi (2010)
Inventory capacity customer	Felix (2003)	Reducing costs Employee	China <i>et al.</i> , (200)
Order replenishment rate	Felix (2003)	Employee' morale and satisfaction	Hubbard (2009) Chia <i>et al.</i> , (2009) Sidiropoulos <i>et al.</i> , (2004) Ray <i>et al.</i> , (2006) Gurumurthy (2008)
Availability	Fitzgerald <i>et al.</i> , (1991)	Manpowerperformance	Ray <i>et al.</i> , (2006)
Security	Fitzgerald <i>et al.,</i> (1991)	Employee replenishment	Ip et al., (2011)
Level of customer understanding of product value	Gunasekarana <i>et al.</i> , (2004) Gunasekarana <i>et al.</i> , (2001)	Annual investment in employee training	Chia <i>et al.</i> , (2009) Gurumurphy (2008) Zhu <i>et al.</i> , (2008)

Percentage of finished goods in transport	Gunasekarana <i>et al.</i> , (2004)	Manpower efficiency	Gunasekarana <i>et al.,</i> (2004) Chan (2003)
Identifying the future demands of customers Tracking ability	Mabert (1998) Chan (2003)	Manpower turnover	Hubbard (2009) China <i>et al.</i> , (2009)
Customer replenishment	Ip <i>et al.</i> , (2011)	Delivery time set by supplier proportionate to type of industry	Bhagwat (2007) Xu <i>et al.</i> , (2009) Holmberg (2000)
Customer loyalty	Fitzgerald <i>et al.</i> , (1991) Chip et al. (2000)	Supplier innovation to reduce costs	Bhagwat (2007) Kim (2007)
Customer satisfaction	Sidiropoulos <i>et al.</i> , (2004) Xiaoping (2008) Fitzgerald <i>et al.</i> , (1991) Kainuma (2006) Gurumurthy (2008)	Supplier delay in delivery comparing to average standard delivery time in respective industry	Gunasekarana <i>et al.,</i> (2004) Gunasekarana <i>et al.,</i> (2001)
Reputation	Surendra (2007)	Supplier price fixing comparing to market	Gunasekarana <i>et al.</i> , (2004) Gunasekarana <i>et al.</i> , (2001)
Replenishment rate Customer complaint rate	Beamon (1999) Chan (2003) Beamon (1999) Shepherd (2006)	Cycle time of a purchase order Effectiveness of cycle time of purchase	Gunasekarana <i>et al.</i> , (2001) Gunasekarana <i>et al.</i> , (2004)
Error-free invoices	Billiardi (2010)	Supplier booking in procedures	Gunasekarana <i>et al.</i> , (2004)
Customer query time	Gunasekarana <i>et al.</i> , (2004) Bigliardi (2010) Gunasekarana <i>et al.</i> , (2001)	Average purchase price	Soni (2010)
Trading indicators for after sale service	Bigliardi (2010)	Average purchase quantity	Soni (2010)
Understanding of flexible response	Brewer (2000)	Days payable outstanding	Soni (2010)
The number of customer touch points	Brewer (2000)	Percentage of on-time deliveries	Soni (2010)
The number of retained customers	Brewer (2000) Chia <i>et al.</i> , (2009)	Order flexibility	Soni and Kodali (2010) Felix (2003)
The number of new customers	Hubbard (2009) Xiaoping (2008) Fitzgerald <i>et al.</i> , (1991)	Range of purchase price	Soni (2010)
Customer value	Xiaoping (2008)	Satisfaction with supplier relationship	Soni (2010)
Products return rate	Hubbard (2009)	Supplier booking in methods	Soni (2010)

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Order answer time	Brewer (2000) Xiaoping (2008) Bhagwat (2007) Lai <i>et al.</i> , (2002) Davis (1993) Fitzgerald <i>et al.</i> , (1991) Soni, Kodali (2010)	Supplier ability to respond to quality problems	Soni (2010)
Order cycle period	Felix (2003) Hubbard (2009)	Supply quality	Soni (2010)
Warranty cost	Bolstorff (2003)	Choosing a supplier	Bigliardi (2010)
Service quality	Stewart (1995) China <i>et al.</i> , (2009)	Supplier delivery performance	Gunasekarana <i>et al.</i> , (2004) Gunasekarana <i>et al.</i> , (2001)
chain chain		Supplier cost saving	Gunasekarana <i>et al.</i> , (2001)
whole supply chain costs	Bolstorff (2003) Cavinato (1992) Bigliard (2010)	Achieving error-free delivery	Gunasekarana <i>et al.</i> , (2001)
Total time of cash flow	Bigliard (2010)	Delivery cost	Felix (2003)
Total inventory holding cost	Stewart (1995) Christopher (1992) Slack <i>et al.</i> , (1995) Angerhofer (2006) Bigliardi (2010) Stewart (1995) Christopher (1992) Slack <i>et al.</i> , (1995) Lee (1992) Levy (1997)	Consistent delivery (delivered in-full, on-time)	Felix (2003)
Total supply chain costs	Stewart (1995)	Production	
Supply chain answer time	Stewart (1995)	Product/machine set up time	Christopher (1992) Bigliard (2010)
Supply chain response	Beamon (1999) Bolstorff (2003) Davis (1993) Lee (1993) Newhart <i>et al.</i> , (1993)	Domestic production capacity	Soni (2010)
Total supply chain management costs	Bolstorff (2003)	Production/operation cost per hour	Bhagwat and Sharma (2007) Felix (2003) Gunasekarana <i>et al.</i> , (2004) Gurumurthy (2008) Zhu <i>et al.</i> , (2008) Angerhofer (2006) Beamon (1999)

			Bigliardi (2010) Mapes <i>et al.</i> , (1997) Slack <i>et al.</i> , (1995) Gunasekarana <i>et al.</i> , (2001)
Total cycle time	Gunasekarana <i>et al.</i> , (2004) Christopher (1992) Stewart (1995) Gunasekarana <i>et al.</i> , (2001)	Failure rate	Gunasekarana <i>et al.,</i> (2004)
Innovation and improvement		Production/process cycle time	Gunasekarana <i>et al.</i> , (2001)
Improving process	Cai <i>et al.</i> , (2009)	Percentage of wrong products manufactured	Soni, Kodali (2010)
New products/processes	Hubbard (2009) Xiaoping, Chen (2008) Fitzgerald <i>et al.</i> , (1991) Soni, Kodali (2010)	Production costs	Xiaoping, Chen (2008) Angerhofer (2006) Beamon (1999)
Research and development cost/sales	Hubbard (2009)	Economic value added	Sidiropoulos <i>et al.</i> , (2004)
Product development cycle time	Gunasekarana <i>et al.</i> , (2004) Christopher (1992) Bigliardi, Bottani (2010) Gunasekarana (2001)	Planning	
Time required to produce new product	Soni, Kodali (2010)	Forecast period	Soni (2010)
mix Combining ability	Soni, Kdali (2010)	Product cycle theory	Soni (2010)
per year	Chie et al., (2009)	Budget variance	(2004)
Quality		Order fulfilment delay	Gunasekarana <i>et al.</i> , (2004)
Quality of products delivered to customer	Mbert (1998) Chan (2003) Bhagwat, Sharma (2007) Chia <i>et al.</i> , (2009) Schonsleben (2004)	Order entry Method	Gunasekarana <i>et al.,</i> (2004)
Quality of products transported	Gunasekarana <i>et al.</i> , (2004)	Planning process cycle time	Gunasekarana <i>et al.</i> , (2004)
Aesthetics	Fitzgerald <i>et al.</i> , (1991)	Order registration method	Gunasekarana <i>et al.</i> , (2004)
Quality	Sidiropoulos <i>et al.</i> , (2004)	Routing customer order	Bigliard (2010)

	Xiaoping (2008) Zhu <i>et al.</i> , (2008) Ray <i>et al.</i> , (2006) Bigliard (2010) Mapes <i>et al.</i> , (1997) Slack <i>et al.</i> , (1995) Felix (2003)		
Price		incoming registration methods	Gunasekarana <i>et al.</i> , (2001) Gunasekarana <i>et al</i>
Average sales price	SonimKodali (2010)	Accuracy of forecasting method	(2004) Gunasekarana <i>et al.</i> , (2001)
Incremental fixed cost per order	Soni (2010)	Variance from plan	Soni, Kodali (2010)
Incremental variable cost per unit	Soni (2010)	Information	
Profit margin	Soni (2010)	Cost of information	Gunasekarana <i>et al.</i> , (2001)
Range of sales price	Soni (2010)	Costs of information management	Bolstorff (2003)
Delivery		Cost of exchange of information	Bhagwat and Sharma (2007) Stewart (1995)
Delivery speed	Bigliard (2010) Mapes <i>et al.</i> , (1997) Slack <i>et al.</i> , (1995) Fitzgerald <i>et al.</i> , (1901)	Accurate demand forecasting	Fisher (1997) Stewart (1995)
Delivery reliability	Bigliard (2010) Mapes <i>et al.</i> , (1997) Slack <i>et al.</i> , (1995) Felix (2003)	Accurate information	Van and Beulens (2001)
Delivery flexibility	Soni (2010) Felix (2003) Beamon (1999)	Timely information	Van and Beulens (2001)
Respond to immediate delivery	Chan (2003) Soni (2010) Gunasekarana <i>et al.</i> , (2001)	Availability of information	Van and Beulens (2001)
Delivery time	Davis (1993) Schonsleben (2004) Mabert and Venkataramanan (1998) Holmberg (2000) Chia <i>et al.</i> , (2009) Xu <i>et al.</i> , (2009) Bhagwat and Sharma (2007)	Information share	Angerhofer and Angelides (2006)

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	Felix (2003)		
	Ip et al., (2011)		
Delivery performance reliability	Gunasekarana <i>et al.</i> , (2004)	Forecast error	Soni (2010)
Error-free delivery	Gunasekarana <i>et al.</i> , (2004)	Frequency of update	Soni (2010)
Percentage of immediate delivery	Gunasekarana <i>et al.</i> , (2004)	Ratio of demand fluctuation to order fluctuation	Soni (2010)
Information richness in carrying out deliveries	Gunasekarana <i>et al.</i> , (2004) Gunasekarana <i>et al.</i> , (2001)	Cost of information processing	Gunasekarana <i>et al.,</i> (2004) Stewart (1995)
Rate of delivery on time	Chia et al., (2009) Gunasekarana et al., (2004) Zhu et al., (2008) Ray et al., (2006) Gurumurthy Kodali (2008)	Release of Information	Sidiropoulos <i>et al.,</i> (2004)
resulting of delivery and system to meet a particular customer	Bigliard (2010) Christopher (1992)	Use of Facilities	
Delivery latency	Ray <i>et al.</i> , (2006) Gurumurthy and Kodali (2008) Rushton <i>et al.</i> , (2010) Gunasekarana <i>et al.</i> , (2001) Stewart (1995)	Effectiveness of cash flow	Gunasekarana <i>et al.,</i> (2004)
The number of error free deliveries	Gunasekarana <i>et al.,</i> (2004) Gunasekarana <i>et al.,</i> (2001)	Product service level	Soni and Kodali (2010)
Effectiveness of invoice delivery methods	Gunasekarana <i>et al.</i> , (2001)	Set up time/ idle time / waste time	Soni and Kodali (2010)
Order fulfilment delay	Bolstorff (2003) Soni and Kodali (2010) Christopher (1992) Bigliardi and Bottani (2010) Gunasekarana <i>et al.</i> , (2001)	Average size of product mix	Soni and Koladi
Order fulfilment	Shepherd and Gunter (2006)	Economies of scale	Christopher (1992) Bigliardi and Bottani (2010)
Flexibility	Schonsleben (2004) Chan (2003) Beamon (1999)	Total time of cash flow	Gunasekarana <i>et al.,</i> (2004) Stewart (1995)

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	Felix and Chan (2003) Lee and Billington (1993) Chan and Qi (2003) Mapes <i>et al.</i> , (1997) Slack <i>et al.</i> , (1995) Bigliardi, Bottani (2010)		Gunasekarana <i>et al.</i> , (2001)
Capacity flexibility	Sonic, Kodali (2010)	Net profit versus productivity ratio	Gunasekarana <i>et al.</i> , (2004) Gunasekarana <i>et al.</i> , (2001)
Range of products and services	Gunasekarana <i>et al.</i> , (2004) Soni and Kodali (2010) Bigliardi, Bottani (2010) Mapes <i>et al.</i> , (1997) Gunasekarana <i>et al.</i> , (2001)	Shortage cost per unit of volume	Soni and Kodali (2010)
Production flexibility	Beamon (1999) Soni and Kodali (2010)	Application of new technology	Soni, Kodali (2010)
Supply Flexibility	Cai et al., (2009)	Use of economic order quantity	Gunasekaranaa <i>et al.</i> , (2004)
Logistic flexibility	Cai et al., (2009)	Productivity index of Human resources	Gunasekaranaa <i>et al.</i> , (2004) Hubbard (2009)
Information system flexibility	Cai <i>et al.</i> , (2009)	Use of capacity	Zhu <i>et al.</i> , (2009) Gurumurthy and Kodali (2008) Soni and Kodali (2010) Bigliardi and Bottani (2010) Slack <i>et al.</i> , (1995) Gunasekaran <i>et al.</i> ,
Specifications flexibility	Fitzgerald <i>et al.</i> , (1991)	Efficiency	(2001) Ip <i>et al.</i> , (2011) Felix and Chan (2003)
Volume flexibility	Fitzgerald <i>et al.</i> , (1991) Soni and Kodali (2010)	Productivity	Hubbard (2009) Fitzgerald <i>et al.</i> , (1991)
Delivery speed Flexibility	Fitzgerald <i>et al.</i> , (1991)	Efficiency of timing methods	Bigliardi and Bottani (2010)
Flexibility of service	Gunasekaran et al.,	Effectiveness of primary	Gunasekaran et al.,

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systems to fulfil customer's demands	(2004) Gunasekaran <i>e.</i> (2001)	t al.,	production time-scale	(2001)
Order flexibility	Soni and I (2010) Felix and Chan (Kodali 2003)	Use of facilities	Soni and Kodali (2010) Felix and Chan (2003) Chia <i>et al.</i> , (2009) Sidiropoulos <i>et al.</i> ,
Transport flexibility	Felix and Chan (2003)	Capital return ratio	(2004) Bhagwat and Sharma (2007) Xu <i>et al.</i> , (2009) Zhu <i>et al.</i> , (2008) Kainuma and Tawara (2006) Beamon (1999) Shepherd and Gunter (2006) Christopher (1992) Gunasekaran <i>et al.</i> , (2001)
Transportation			Product reliability	Ip <i>et al.</i> , (2011)
Effectiveness of institute's distribution schedule	Gunasekaran e. (2004)	t al.,	Effectiveness	Ip et al., (2011)
Effectiveness of order registration methods	Gunasekaran <i>e</i> . (2004)	t al.,	Asset turnover	Hubbard (2009) Brewer and Speh (2000) Gurumurthy and Kodali (2008) Kainuma and Tawrara (2006)
Transportation costs	Gurumurthy Kodali (2008) Ray <i>et al.</i> , (2006 Angerhofer Angelidies (2006 Bigliard and E (2010) Gunasekaran <i>et</i> (2001) Felix and Chan (Rushton <i>et al.</i> , (2	and) and 5) Bottani t al., 2003) 2010)	Cash-to-cash cycle	Brewer and Speh (2000) Bolstorff (2003)
Average inbound transportation cost	Soni and Kodali		Total cost of turnover	Shepherd and Gunter (2006)
Average inbound transportation cost per shipment	Soni and I (2010)	Kodali	Ability to offer facilities	Surendra and Satish (2007)
Average incoming	Soni and I	Kodali	Average flow/real-time cycle	Soni and Kodali

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shipment size Average outgoing shipment size	(2010) Soni and Kodali (2010)	Use of capacity as incoming inventory level	(2010) Soni and Kodali (2010)
Average outbound transportation cost	Soni and Kodali (2010)	Flow time efficiency	Soni and Kodali (2010)
Average outbound transportation cost per shipment	Soni and Kodali (2010)	Inventory turnover	Bigliardi and Bottani (2010)
Transportation error	Soni and Kodali (2010)	Asset turnover	Fitzgerald <i>et al.</i> , (1991)
Transport productivity	Felix and Chan (2003)	Return on equity	Hubbard (2009)
Storage costs	Felix and Chan (2003)	Operational efficiency	Xiaoping and Chen (2008)
Supply chain relationships		Cost	Chan (2003) Davis (1993) Newhart <i>et al.</i> , (1993)
Supplier desire to save cost	Soni and Kodali (2010)	Green supply chain	
Supplier mutual ability to respond to quality problems	Bhagwat and Sharma (2007) Gunasekaran <i>et al.</i> , (2001)	Pollution	Fitzgerald <i>et al.</i> , (1991)
supplier-customer relationship level	(1991) BigliardiBottani (2010) Toni <i>et al.</i> , (1994)	Air emission	Zhu <i>et al.</i> , (2008) Kainuma and Tawara (2006)
Extent of business relationship	Soni and Kodali (2010)	Energy consumption	Kainuma, Tawara (2006)
Supplier desire to promote cooperation	Gunasekaran <i>et al.</i> , (2001)	Solid wastes	Zhu <i>et al.</i> , (2008) Kainuma and Tawara (2006)
Supplier cooperation to solve technical problems	Bhagwat and Sharma (2007) Graham <i>et al.</i> , (1994) Maloni and Benton (1997)	Dangerous/toxic/damaging substances	Kainuma and Tawara (2006)
cooperation in problem-solving attempts	Soni and Kodali (2010)	Environmental costs	Zhu et al., (2008)
Extent of mutual cooperation in planning leading to quality	Graham et al., (1994)	Assistance (help)	Fitzgerald <i>et al.</i> , (1991)
Quality and frequency of supplier-customer information exchange	Soni and Kodali (2010)		

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MATERIALS AND METHODS

Methodology

In this section we bring three samples up for discussion which are research sample, first expert sample and second expert sample respectively.

A) Research Sample: It is used for identifying various aspects such as sustainability, enablers, sustainability obstacles, supply chain performance enablers, aspects of supply chain performance and its indices. It includes all studies carried out in this field. Publication of articles in credible academic journals, international conferences, and ISI and ISC databases were criteria used to verify the validity of papers.

B) **First Expert Sample:** Members of this sample were selected from academic board or PhD students in field of industrial management who were administrative professionals in the field of supply chain and knowledge management or having conducted researches in those fields.

C) Second Expert Sample: It involves active companies in Iran's machine-woven carpet industry and pundits in their supply chain.

Appropriate sampling method would be adapted for each above mentioned samples.

A) Research Sample: Data collected through available, trustworthy scientific sites.

B) First Expert Sample: A handful available member of this sample were as follow; 1. Supervisors and consultants (3 persons)

2. Industry experts who hold Postgraduate Certificate and serve more than 5-year in the industry (6 persons).

3. A PhD student in production and operation management who has administrative or research background in this field.

C) Second Expert Sample: In this part companies which had more than 40 employees were the subjects of the study. Questionnaire distributed among those possessing necessary qualifications.

The first expert sample comprised 10 individuals, who selected following indices to measure supply chain performance through Delphi method:

Code	Index	Code	Index					
P1	Order quantity	P17	Products/services variety					
P2	Customer satisfaction level	P18	Supplier cooperation to solve technical problems					
P3	Number of new customers	P19	Turnover					
P4	Total inventory holding cost in supply chain	P20	Annual investment in employee training					
P5	New products and services	P21	Operation and production cost per hour					
P6	Manpower efficiency	P22	Identifying the future demands of customers					
P7	Rate of delivery on time	P23	The number of retained customers					
P8	Customer-supplier relationship level	P24	Total supply chain cost					
P9	Market share and market status	P25	Supply chain response					
P10	Employee morale and satisfaction	P26	Product quality					
P11	Supplier innovation to reduce costs	P27	Delivery flexibility					
P12	Cost of collecting and processing information	P28	Transportation cost					
P13	Use of capacity	P29	Pollution level					
P14	Order answer time	P30	Delivery time set by supplier proportionate to type of industry					
P15	Finished goods/raw material/work-in- process inventory level	P31	Total time of cash flow					
P16	Product development cycle time							

Table 3: Indices selected to measure supply chain performance

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RESULTS AND DISCUSSION

Findings

Results of KMO and Bartlett's test were manifested in table below. As the table shows KMO measure of sampling adequacy 0.887 which was over 0.7, indicates the meritorious inter-correlations pattern among attributes.

Table 4: Results of KMO and Bartlett's test for supply chain performance indicators

	Kaiser-Meyer-Ol	kin Measure of Sampling	.887
Adequacy.			
Bartlett's	Test	of Approx. Chi-Square	3255.982
Sphericity		df	465
		Sig.	.000

Table 4: Explanatory factor analysis of supply chain performance indicators					
Factor	Factor name	Variable name	Question number		
		Order quantity	P1		
		Customer satisfaction level	P2		
		Number of new customers	P3		
	Customer	Rate of delivery on time	P7		
1	Customer	Order answer time	P14		
		Identifying the future demands of customers	P22		
		Number of retained customers	P23		
		Delivery flexibility	P27		
		Total inventory holding cost in supply chain	P4		
		Cost of collecting and processing information	P12		
2	Cost	Operation and production cost per hour	P21		
		Total supply chain cost	P24		
		Transportation costs	P28		
		New products and services	P5		
3	Droduct	Product development cycle time	P16		
3	Product	Products and services variety	P17		
		Product quality	P26		
		Market share and market status	P9		
4	Financial	Use of capacity	P13		
4	Fillanciai	Turnover	P19		
		Total time of cash flow	P31		
		Customer-supplier relationship level	P8		
		Supplier innovation to reduce costs	P11		
5	Supplier	Supplier cooperation to solve technical problems	P18		
		Delivery time set by supplier proportionate to type	D 20		
		of industry	F 50		
6		Manpower efficiency	P6		
	Employee	Employee' morale and satisfaction	P10		
		Annual investment in training employee	P20		
7		Finished product/raw material/work-in-process	P 20		
	Supply chain	inventory level	1 20		
	Suppry chain	Supply chain response	P25		
		Pollution level	P29		

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The Bartlett test of sphericity revealed statistical significance below 0.5. Thus, the exploratory factor analysis processed with confidence.

Results of the explanatory factor analysis are as follow; 31 variables were classified into 7 factor groups. Each those factors were given a name:

Now it is time to do confirmatory factor analysis. All indices have factor loading more than 0.5 so that none of which would be excluded from further analysis.Goodness-of-fit indices indicated that the fit model is plausible.



Figure 1: First order factor analysis for supply chain performance indicators

Table 6: Fit indices for supply chain performance indicators								
CFI	NNFI	NFI	RMSEA	AGFI	GFI	RMR	X ² /df	
0.97	0.97	0.93	0.064	0.72	0.76	0.074	1.69	
Optimal	value: $X^2/df \leq$	3 GFI, NFI,	NNFI, CFI ≥	≥ 0.90, AG	$FI \ge 0.80,$	$RSMEA \leq 0.$	08 and RM	1R
closer to zero indicates a better fit								

Next the supply chain performance indicators would be investigated in second order factor analysis. Given the results in figure 2 and3, key indices in supply chain performance would be recognized. According to figure 2 all indices have factor loading more than 0.5, meanwhile t-values of all indices are

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not in range between (-2 & 2) According to figure 3, so that it could be claimed that all said indices are key ones in supply chain performance.







Figure 3: t-Value for supply chain performance indicators

Table 8 also shows the fit model. It verifies the goodness of fit for the model of supply chain performance indicators as well as validity of the model.

Table 7: Fit indices for supply chain performance indicators in second order factor analysis								
CFI	NNFI	NFI	RMSEA	AGFI	GFI	RMR	X^2/df	f
0.97	0.97	0.93	0.065	0.72	0.76	0.081	1.67	
Optimal	value: $X^2/df \leq$	3 GFI, NFI,	NNFI,CFI≥	: 0.90 , A	$AGFI \geq 0.80,$	$RSMEA \leq 0.0$)8 and	RMR
closer to zero indicates a better fit								

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Now that all items were verified, the important of each factors and indicators relative to them would be investigated through AHP method.

Conclusion						
Factor	Significance	Variable	Significance			
		Order quantity	0.07			
		Customer satisfaction level	0.2			
		Number of new customers	0.1			
Customan	0.28	Rate of delivery on time	0.1			
Customer		Order answer time	0.1			
		Identifying the future demands of customers	0.08			
		Number of retained customers	0.1			
		Delivery flexibility	0.15			
		Total inventory holding cost in supply chain				
		Cost of collecting and processing information				
Cost	0.9	Operation and production cost per hour				
		Total supply chain cost				
		Transportation cost				
		Finished product/raw material/work-in-process inventory				
Supply	0.10	level				
chain		Supply chain response				
		Pollution level				
		New products and services	0.3			
Product	0.11	Product development cycle time	0.28			
Tiouuci		Products and services variety	0.27			
		Product quality	0.15			
		Market share and market status	0.39			
		Use of capacity	0.11			
Financial	0.12	Turnover	0.25			
		Total time of cash flow	0.25			
Supplier	0.22	Customer-supplier relationship level	0.1			
		Supplier innovation to reduce costs	0.4			
		Supplier cooperation to solve technical problems	0.3			
		Manpower efficiency	0.31			
Employee	0.8	Employee' morale and satisfaction				
		Annual investment in employee training				

Several modes and indicators were recognized through review of literature. And Among those key indicators were determined, namely: order quantity, customer satisfaction level, number of new customers, total inventory holding cost in supply chain, new products and services, manpower efficiency, rate of delivery on time, customer-supplier relationship level, market share and marker status, employee's morale and satisfaction, supplier innovation to reduce costs, cost of collecting and processing information, use of capacity, order answer time, finished product/raw material/work-in-process inventory level, product development cycle time, products and services variety, supplier cooperation to solve technical problems, turnover, annual investment in employee training, operation and production cost per hour, identifying the future demands of customers, number of retained customers, total supply chain cost, supply chain response, product quality, delivery flexibility, transportation cost, pollution level, delivery time set by supplier proportionate to type of industry and total time of cash flow. They were divided into 7 groups through explanatory factor analysis, namely; customer, cost, product, financial, supplier, employee and chain supply. All of preceding factors and indicators were verified through confirmatory

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factor analysis. According to significance achieved through AHP method, it was revealed that customer service needs to be given more attention than other aspects, though it is obvious, given the present competitive situation in carpet industry. Customer and supplier are of great importance among all abovementioned aspects, this importance is also perceived in current situation of this industry. Substantial percentage of fluctuations in price and production of machine-woven industry is caused by inadequate supply of raw material which demands urgent attention to supplier.Rest of indicators relatively has the same importance.

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