J Ind Eng Int (2014) 10:67
DOI 10.1007/s40092-014-0067-5

ORIGINAL RESEARCH

Supply chain value creation methodology under BSC approach

Seyedehfatemeh Golrizgashti

Received: 13 April 2013 / Accepted: 24 May 2014 / Published online: 14 June 2014

Abstract The objective of this paper is proposing a developed balanced scorecard approach to measure supply chain performance with the aim of creating more value in manufacturing and business operations. The most important metrics have been selected based on experts' opinion acquired by in-depth interviews focused on creating more value for stakeholders. Using factor analysis method, a survey research has been used to categorize selected metrics into balanced scorecard perspectives. The result identifies the intensity of correlation between perspectives and cause-and-effect chains among them using statistical method based on a real case study in home appliance manufacturing industries.

Keywords Supply chain · Balanced scored · Performance measurement · Stakeholders · Value

Introduction

Successful engineering managers require experience in business and engineering by applying engineering principles to business practice. Engineering managers usually focused on production process to improve product quality and to decrease cost of production. They monitor many metrics to evaluate process during supply chain without focusing on value creation for supply chain stakeholders. Balanced scorecard (BSC) is an effective approach that managers use to evaluate supply chain performance.

S. Golrizgashti (✉)
Department of Industrial Engineering, South Tehran Branch, Islamic Azad University, Tehran, Iran
e-mail: Sf_golrizgashti@Azad.ac.ir

There are many researches about applying BSC approach in the literature, but there is no research focusing on using this approach to create more value during supply chain in competitive market. Identifying key value metrics and defining their effects on other metrics can help engineering managers to improve the most important metrics instead of monitoring all of them. In this paper, correlation between BSC perspectives and cause-and-effect chains among them has been identified. Therefore, this paper considers how production and operations management can respond to the pressures of the competitive global marketplace by focusing more on value metrics in the supply chain. Applying proposed framework in this research by engineering mangers causes adding flexibility to the system, reducing production cost and increasing stakeholder's satisfaction via creating more value in supply chain.

Supply chain, emerging in the 1980s, is an internationally used term that encompasses every effort engaged in production and delivering of final products and services, from the suppliers' suppliers to the customers' customers (Khalifa 2004). Supply chain management is a strategic implication for any business activity and any company. Performance measurement is essential and should be a main part of any business strategy (Bhagwat and Sharma 2007). Therefore, the effective collaboration of partners and coordination of all activities within the supply chain are prerequisites in competitive and dynamic market conditions (Bahri and Tarokh 2012). Shepherd and Günter (2006) mentioned that performance measurement is a critical issue to improve supply chains' effectiveness and efficiency of companies (Beamon 1999; Shepherd and Günter 2006). According to Beamon (1999) and Gunasekaran et al. (2004) decision makers in supply chains should focus on developing measurement metrics for evaluating the performance. Many methods have been

suggested for evaluation of SCM in organizations. Traditional methods in their literature focus only on well-known financial measures. These methods are not necessarily suitable for evaluating supply chain performance in today's market. Due to the fierce competition among supply chains in today's market, creating more value in supply chain determines competitive advantage of a firm over its competitors. Newer generations of supply chains have to provide tangible and intangible benefits for their stakeholders. Therefore, it is an appropriate idea to use a balanced approach to measure and evaluate supply chain performance comprehensively. According to the past literatures, there is a lack of effective performance metrics and their integration at strategic, tactical, and operational levels (Gunasekaran et al. 2001; Hudson et al. 2001). According to Taghizadeh and Hafezi (2012), determining the quantitative criteria and parameters through which the most suitable partner could be chosen seems to be useful.

There are many metrics suggested in several literatures to evaluate supply chain performance. These metrics focused mostly on financial benefits and customer satisfaction criteria. Some of these metrics have been repeated in different perspectives of performance measurement without identifying vital correlations. Hence, there is a lack of enough attention to other supply chain stakeholders, improving value creation and, defining correlation between metrics and performance measuring perspectives. Having an overview on most of theoretical and empirical studies which focused on BSC approach for improving SCM performance measurement, a new balanced SCM scorecard has been developed in this study to evaluate SCM performance with respect to all its dimensions. A balanced performance measurement of SCM helps organizations to improve their internal and external functions of business and create more value for their stakeholders. The proposed developed BSC approach is the result of investigating more than 300 existing metrics in several literatures and having them confirmed using factor analysis method considering their highest correlation with each of BSC perspectives.

Literature review

Supply chain management and value creation

According to Chopra and Meindl (2001), the objective of supply chain is to maximize the overall value generated. The value a supply chain generates is the difference between what the final product is worth and the customer's request, and according to Satapathy and Mishra (2013) the customer is satisfied when he/she feels that the service performance fits well with his/her personal framework (confirming). If it remains below expectations, then the customer will be dissatisfied (disconfirming). In most commercial supply chains, value is correlated with profitability. Estampe et al. (2010) state that supply chain management creates value for companies, customers and stakeholders who are interacting along the supply chain. Bhagwat and Sharma (2007) mentioned that companies can continue to improve and create value in their supply chain by applying balanced scorecard approach and continuous evaluation.

Due to the fierce competition among supply chains in today's market, creating more value via improving supply chain performance determines competitive advantage for a firm over its competitors. Hence, evaluating supply chain performance with focus on creation of more value is an essential issue in supply chain management. Some authors mentioned that companies can use balanced scorecard approach, including customer, financial, internal business and, learning and innovation perspectives, to evaluate supply chain performance and to consequently obtain value-adding products and services (Martinsons et al. 1999). Components of BSC approach can help companies to create more value to their stakeholders. For an instance, customer perspective is external clients and affects on society. Internal business perspective consists of processes, which enable the organization to create value for its customer and to reach its financial goals (Hongxia and Zhipeng 2007). The proposed framework develops BSC approach with focus on effective metrics to evaluate supply chain performance comprehensively for gaining more value.

The balanced scorecard

There are different methods to evaluate supply chain performance (Bititici et al. 2005; Chan and Qi 2003a, b; Chan and Chan 2006; Sharma et al. 2005). Some researchers have used BSC and Activity Based Costing (ABC) methods for such evaluation (Liberatore and Miller 1998). The balanced frameworks such as performance measurement metrics, results-determinants framework, performance pyramid, etc., have been proposed by some other researchers on the other hand (Neely 2005).

The Supply Chain Operations Reference (SCOR) model has been developed as a systematic supply chain performance measurement to improve supply chain construction by identifying, evaluating and monitoring supply chain performance (Lockamy and McCormack 2004). In this paper, BSC approach is used to propose a developed framework to help companies to create more value for their customers, employees and shareholders as stakeholders of supply chain. According to Bititici et al. (2005), performance measurement systems are needed at different

levels of decision making in the industry or service contexts.

The BSC approach has been proposed by Kaplan and Norton (1992) as a tool to evaluate corporate performance from four different perspectives: the financial, the internal business process, the customer, and the learning and growth. They have suggested the hypothesis that some relationships exist among the metrics of the evaluation system. They expressed that there is cause-and-effect relation between the perspectives of the BSC. Some studies have tried to prove the existence of the cause-and-effect chain among different perspectives of BSC (Wang et al. 2010). The BSC approach helps managers to evaluate financial measures of past performance with their measures of the drivers of future performance (Bhagwat and Sharma 2007).

BSC have been used for many areas. According to Youngblood Alisha and Terry (2003), balanced scorecard provides valuable feedback on a variety of performance metrics. They introduced BSC as a better way to evaluate investment alternatives. BSC approach creates a balance between short-term and long-term objectives, between financial and non-financial measures, between lagging and leading indicators, and between internal and external performance perspectives. Malmi (2001) mentioned that the BSC can be applied as a control panel, pedals and steering wheel. Martinsons et al. (1999) believed that many companies apply BSC as the foundation for their strategic management system. Some managers have used it to align their businesses to new strategies, aiming to move away from cost reduction and shift toward growth opportunities based on more customized, value-adding products and services. Many methods of performance measurement have been reported in the past literatures, but in this paper we presented a developed BSC approach based on the BSC framework proposed by Kaplan and Norton (Table 1).

Table 1 The four perspectives in a balanced scorecard (Kaplan and Norton 1992)

Customer perspective (value-adding view)	Financial perspective (shareholders' view)
Mission: to achieve our vision by delivering value to our customer	Mission: to succeed financially, by delivering value to our shareholders
Internal perspective (process-based view)	Learning and growth perspective (future view)
Mission: to promote efficiency and effectiveness in our business processes	Mission: to achieve our vision, by sustaining innovation and change capabilities, through continuous improvement and preparation for future challenges

Performance and measurement of supply chain

Performance measurement is the feedback or information on activities with respect to meeting customers' expectations and strategic objectives (Chan 2003). Butler Renee et al. (2006) mentioned that planning a supply chain for a new product requires analysis demand and cost uncertainty in market conditions over time. Therefore, an effective approach is essential to obtain customer demand during supply chain. Performance measurement can improve all areas in supply chain such as quality, price, delivery, and so on. In this paper, we offer some of the most appropriate performance metrics and measures for SCM with special focus on value creation. Most traditional methods focus on well-known financial measures, such as the return on investment (ROI), net present value (NPV), the internal rate of return (IRR), and the payback period. These methods could best suit to measure created value in simple SCM applications (Bhagwat and Sharma 2007). Evaluation methods and metrics that rely on financial measures are not proper enough for newer generation of SCM applications, which strive for more value. Therefore, there has not been any well-designed model to measure supply chain performance with strong focus on value creation.

It is needed to study the measures and metrics for evaluating supply chain performance comprehensively because there is lack of a balanced approach, which includes both financial and non-financial measures (Gunasekaran et al. 2001; Hudson et al. 2001). They also identified the problem of lack of enough knowledge for deciding on number of metrics to be used by firms for supply chain performance evaluation. Companies use a large number of performance metrics while they can use only a few suitable metrics. Finally, there is an important distinction between metrics at strategic, tactical, and operational levels. Each metric has to be classified into these three levels, where it would be most appropriate. Therefore, literatures on supply chain management lack a study proposing a framework as a comprehensive set of effective metrics for performance measurement. New generation of supply chains needs to be well investigated and evaluated by a wide range of tangible and intangible metrics to survive in competitive market.

Balanced scorecard for supply chain evaluation

The BSC for SCM framework presented in this study is structurally similar to the BSC framework at the corporate management level proposed by Kaplan and Norton. We have identified supply chain performance metrics from the past literature reviews, with focus on value creation in supply chain and hereby propose a framework for SCM performance evaluation. In this paper, the BSC is applied to these metrics with the intention of assessing SCM performance

comprehensively. The four perspectives of the BSC are considered and these metrics are fitted into them as shown in exhibit 2. The table indicates the high performance metrics that target broader functional areas of supply chain with respect to value creation. Bhagwat and Sharma (2007) mentioned that the perspectives should be reviewed periodically and updated as necessary. The measures included in the given BSC should be traced over time, and integrated explicitly into the strategic SCM process.

Materials and methods

Developed balanced scorecard

Investigating the proposed models, this study has endeavored to discover every possible metrics regarding evaluation of value creation process along supply chains. It should be noted that although all of the offered metrics within selected articles are suitable, they lack a holistic view of evaluating supply chain for value creation and comprehensive assessment. Thus, it is strived in this study to establish a technical review of supply chain performance metrics with focus on value creation for stakeholders. By the review of literature on SCM performance measures, more than 300 metrics were identified. These metrics are too many for managers to monitor supply chain performance. Measuring all these metrics is difficult and some of them may not have important affect on improving supply chain areas. Thus, it needed to develop an effective approach by effective metrics and align it to value metrics in supply chain.

Research method and data

In this article, the BSC approach is applied to performance metrics with the intention of evaluating SCM performance comprehensively. Different metrics have to been fitted into four different perspectives of BSC. Firstly, the qualitative in-depth interview method was applied to select performance metrics. After selecting effective metrics, the factor analysis method was applied to confirm metrics. Qualitative in-depth interview is an exploratory research technique with the ability of giving well-grounded, rich descriptive explanations (Sage Gordon and Langmaid 1998; Arksey and Knight 1999). Indeed, these methods permit concepts and meanings to be explored with better understanding than questionnaires.

Case study

The balanced SCM scorecard has been recently implemented in Parstoushe holding. It contains ten Iranian home appliance industries that apply BSC approach to evaluate supply chain management. Five are medium-sized companies and five are small-scale enterprise. The biggest company is a leading assembly manufacturer and operates in a multi-plant environment. It has been established in 1968 and situated in a major industrial town of north. It was the first company to launch the production of home appliances in Iran. The number of employees in the firm is 350. Distribution to dealer network and developing big after-sale services networks are the two important activities applied by this company. Four other case companies are manufacturers of home appliances too. They are medium-scale companies with manpower of nearly 300. The five other case companies are small scale with manpower of 100. The companies have applied some ISO certificates such as 9001 and 10002 to improve their performances.

The main purpose of this study is identifying the intensity of correlation between perspectives of BSC applying in these companies. The managers' experiences emphasis performance improving via applying balanced scorecard.

The case companies use four perspectives in their scorecards suggested by Kaplan and Norton (Kaplan and Norton 1992). Applying BSC has been cause that the companies use most important metrics. Balanced scorecard is applied at several levels in companies such as production, marketing, financial, top manager level and esc. Therefore, managers have good experiences to select important metrics. They mentioned that selected metrics in their companies were related to strategic, tactical, and operational levels.

There are targets for each metric to improve supply chain performance in case companies. All employees try to achieve identified targets. All financial and non-financial metrics are important for companies to improve their performance. Key information has been imported to companies via BSCs metrics. To evaluate metrics, data collected from several tools included portal and total software via production and sales process. Information availability levels have been defined for CEO, managers and key employees in companies to collect data and observe reports to evaluate metrics in their areas and to analysis their results. Managers have used results to review current strategies and applied new strategies to improve performance. Applying BSC approach affects the performance positively such as decreasing lead time and decreasing cost order. Managers can evaluate customer satisfaction by monitoring metrics related to customer perspective via BSC approach. They believe that monitoring financial metrics included assets cost, return on investment, and total inventory cost is not enough to improve supply chain performance; therefore, they measure non-financial metrics, for example, range of product and services, capacity utilization, the delivery channel, vehicle scheduling and so on too. Managers mentioned that evaluating metrics via BSC approach affects the cost performance, customer service, lead time, ROI and so on in these companies. Therefore, selecting effective metrics is very important to applying BSC approach (Table 2).

Table 2 Key performance metrics

BSC perspective	Metrics (factors)	References
Financial	Cash to cash cycle time	Bolstorff (2003), Camerinelli and Cantu (2006)
	Financial benefits	Stewart(1991), Beamon (1999), Kleijnen and Smits-Pefformance (2003) and Hongxia and Zhipeng (2007)
	Final net profit	Stewart (1991) and Gunasekaran et al. (2001)
	Value of stock	Mondragon et al. (2011)
	Sale rate new product sale ratio	Hongxia and Zhipeng (2007), Cai et al. (2009) and Yang (2008)
	Reverse logistics costs	Bolstorff (2003), Hongxia and Zhipeng (2007) and Mondragon et al. (2011)
	Logistics cost	Identified during interviews
	Productivity on time	Hongxia and Zhipeng (2007)
	Waste reduction	Stewart (1991)
	Security costs	Hongxia and Zhipeng (2007)
	Cost of manpower resources	Hongxia and Zhipeng (2007)
	Purchase costs	Li et al. 2009)
	Rate of return on investment	Christopher (1992), Dobler and Burt (1996), Beamon (1999), Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Variations against budget	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Supplier cost saving initiatives	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Cost per operation hour	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Total inventory cost as: incoming stock level	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Total inventory cost as: work in progress	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Total inventory cost as: scrap value	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Total inventory cost as: finished goods in transit	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Cost reduction project	Identified during interviews
	Information carrying cost	Levy (1997), Lee and Billington (1992), Gunasekaran et al. (2001), Bolstorff (2003) and Bhagwat and Sharma (2007)
Customer	Customer query time	Mason-Jones and Towill (1997), Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Level of customer perceived value of product	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Range of products and services	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Order lead time	Gunasekaran et al. (2001), Bolstorff (2003) and Bhagwat and Sharma (2007)
	Flexibility of service system to meet particular customer needs	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Delivery lead time	Rushton and Oxley (1991), Christopher (1992) Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Percentage of on-time deliveries	Beamon (1999) and Soni and Kodali (2010)
	Effectiveness of delivery invoice methods	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Client retaining	Yang (2008)
	Accuracy of forecasting techniques	Gunasekaran et al. (2001), Bhagwat and Sharma (2007), Yilmaz and Bititci (2006) and Mondragon et al. (2011)
	Market share	Identified during interviews
	Answer time of complaint	Hongxia and Zhipeng (2007)
	After-sale service quality level	Hongxia and Zhipeng (2007)
	Price	Donnet et al. (2009) and Soni and Kodali (2010)
	Rate of credit	Hongxia and Zhipeng (2007)
	Wasting degree of energy sourcing	Hongxia and Zhipeng (2007)
	Number of distribution channels	Identified during interviews
	Time required to produce new product	Soni and Kodali (2010)
	Average units returned	Mondragon et al. (2011)
	Environment protection efficiency	Yang (2008)

Table 2 continued

BSC perspective	Metrics (factors)	References
	Production flexibility	Cai et al. (2009) and Soni and Kodali (2010)
	Delivery reliability	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Responsiveness to urgent deliveries	Gunasekaran et al. (2001), Bhagwat and Sharma (2007) and Soni and Kodali (2010)
	Effectiveness of distribution planning schedule	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Quality of delivery documentation	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Driver reliability for performance	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Quality of delivered goods	Donnet et al. (2009), Gunasekaran et al. (2001), Bhagwat and Sharma (2007) and Soni and Kodali (2010)
	Achievement of defect free deliveries	Gunasekaran et al. (2001), Bhagwat and Sharma (2007)
Internal business	Buyer–supplier partnership level	Toni et al. (1994), Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Information share	Angerhofer and Angelides (2006) and Hongxia and Zhipeng (2007)
	Group participation	Yang (2008)
	Expansion capability	Soni and Kodali (2010)
	Planning and ERP execution systems	Yilmaz and Bititci (2006)
	Supplier collaborative planning systems	Yilmaz and Bititci (2006)
	Raw material and resource usage rate	Yang (2008)
	Internal process efficiency	Kleijnen and Smits-Pefformance (2003)
	Percentage of wrong products during production	Soni and Kodali (2010)
	Supplier rejection rate	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Total supply chain cycle time	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Supplier lead time against industry norms	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Level of supplier's defect free deliveries	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Purchase order cycle time	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Planned process cycle time	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Effectiveness of master production schedule	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Capacity utilization	Stewart (1995), Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Efficiency of purchase order cycle time	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Frequency of delivery	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
Learning and innovation	Learning abilities	Stewart (1991)
	Innovation abilities	Stewart (1991)
	Product recycle interest	Yang (2008)
	Use of new technology	Soni and Kodali (2010)
	Supplier assistance in solving technical problems	Soni and Kodali (2010), Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Supplier ability to respond to quality problems	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Supplier's booking in procedures	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Order entry methods	Gunasekaran et al. (2001) and Bhagwat and Sharma (2007)
	Social programs investments	Identified during interviews
	Employee turnover	Identified during interviews
	Motivation plan	Identified during interviews
	Employee training program	Identified during interviews

The main purpose of interviews and the key question was to find out the effective metrics to evaluate supply chain performance in case companies. Eighty-one metrics were resulted from interviews (shown in Table 2). As mention during interviews, some managers believed that it is needed to add some new metrics to their scorecards, to create more value for stakeholders. Hence, some new metrics were added according to experts' ideas mentioned in Table 2. In practice, most of the metrics correlate with each other and have tangled cause-and-effect interplays and can be fitted into more than one perspective (Norrekilt 2000). But some metrics have higher correlations with each other and with BSC perspectives. As an example, higher level of customer expectations (customer perspective) will lead companies to use new technology (learning and growth perspective) and this in turn will increase the market share and profitability (financial perspective) (Bhagwat and Sharma 2007). In most studies, performance metrics are classified into four perspectives and directly in quantitative terms. Therefore, metrics with high correlations with each other and BSC perspectives have to be identified and classified into four BSC categories. In this study, a statistical method is applied to identify high correlation between metrics and BSC perspectives.

Confirmatory factor analysis has been employed to confirm suitability of the metrics in the designed framework. Using factor analysis to generate the correlation metrics, the variables are collected in clusters so that the variables in the same cluster are more correlated than the variables belonging to different clusters (De Vaus 2002).

In order to empirically confirm the correlation between metrics and BSC perspectives, a questionnaire was developed and a survey was conducted. The sample is ten Iranian home appliance industrial, which has implemented BSC approach to evaluate their supply chain performance. The respondents are mainly experts or core members in the management team who have good understanding of the company's performance. The structured questionnaire consists of two sections: section A elicits general information, which includes name of their companies, age, current position, education and number of years they have been in service; Section B included assessments of balanced scorecard metrics in their companies. Respondents were asked to indicate their assessments of the company's current performance. Five-point Likert scale that ranged from "1 = strongly bad" to "5 = strongly good" was used.

While the respondents of questionnaire were selected by simple random sampling, 30 copies of questionnaire were given out to experts in a pilot test. After revising or removing unsuitable items as per exerts' advice, author sent out 320 copies of questionnaire and received 301 validly completed copies for a 94 % response rate. After collecting data from questionnaires, confirmatory analysis was run to confirm the relationship between metrics and BSC perspectives. Kaiser–Meyer–Olkin measure of sampling adequacy for this study is 0.717, which proves the existing correlation is appropriate for factor analysis (Table 3).

Since the KMO value is in the acceptable range, the second phase can be started. Principal component analysis has been employed to extract the factors, and Varimax rotation has been used to clean up these factors in this study Table 4.

Result

The result of descriptive statistics is specified in Table 4. Every single metrics is fitted into the BSC perspective, which has higher correlations with the metrics. The values of skewness and kurtosis for all metrics are in the acceptable range.

The result of principal component analysis that has been employed to confirm the factors and Varimax rotation that has been used to clean up the factors is shown in Table 4. The correlation analysis indicates a strong positive association between metrics and the four BSC perspectives. To identify correlation between four BSC perspectives, a correlation test has been applied. The result of the test is presented in the Table 5.

According to the literature, there is a cause-and-effect relation between the perspectives of BSC approach. In this study, the relationship has been confirmed using a statistical method based on a real case study. The correlation between four perspectives of BSC can be different in different industries. According to the results, all perspectives have acceptable correlation to each other with different amounts. The customer perspective has strong relation with other perspectives. For instance, in the Iranian home appliance industries, customer and financial perspectives have the highest correlation with each other. Thus, improving a perspective of supply chain performance affects the other perspectives positively. Managers can improve their supply chain performance by applying this proposed framework as a balanced way. Automation of data collection, electronic processing of information and improvement in reporting techniques can help companies to evaluate supply chain performance continuously (Fig. 1).

The value of correlation between all perspectives is in the interval 0.743–0.791, which indicates a strong positive correlation. Therefore, all perspectives have strong correlation with each others. The value of correlation between

Table 3 KMO statistic and Bartlett's test

Kaiser–Meyer–Olkin measure of sampling adequacy		0.717
Bartlett's test of sphericity	Approx. Chi square	78.125
	df	10
	Sig.	0.000

customer and financial perspectives is high. It shows that higher level of customer satisfaction and expectations will lead companies to more market share and will increase the profitability. Bhagwat and Sharma (2007) mentioned this result in their research too.

The value of correlations between business and financial perspective is more than others. It shows that the business process has the greatest impact on financial metrics and vice versa. When the business metrics, for example, purchase order cycle time and level of supplier's defect decrease, it strongly affect on cost reduction in financial perspective. Therefore, improving internal business metrics affects financial metrics strongly. According to the result, the value of correlation between all perspectives shows strong cause-and-effect relationships. Therefore, managers can improve their supply chain performance by monitoring metrics respect to four essential BSC perspectives. The value of correlations had been calculated according to the expert's opinion with respect to their firm's performance via a survey in selected case companies that apply BSC approach. The result is a validation on past researches.

Table 4 Explorative factor analysis on BSC

Measurement items	Factor 1	Factor 2	Factor 3	Factor 4	Eigen value	Cum. % variance explained	Cronbach's alpha
F1: Cash to cash cycle time	0.833				22.719	28.048	0.974
F2: Financial benefits	0.969						
F3: Final net profit	0.961						
F4: Value of stock	0.754						
F5: Sale rate new product sale ratio	0.743						
F6: Reverse logistics costs	0.859						
F7: Logistics cost	0.691						
F8: Productivity on time	0.833						
F9: Waste reduction	0.610						
F10: Security costs	0.862						
F11: Cost of manpower resources	0.964						
F12: Purchase costs	0.848						
F13: Rate of return on investment	0.967						
F14: Variations against budget	0.965						
F15: Supplier cost saving initiatives	0.698						
F16: Cost per operation hour	0.967						
F17: Total inventory cost as: Incoming stock level	0.951						
F18: Total inventory cost as: work in progress	0.947						
F19: Total inventory cost as: Scrap value	0.835						
F20: Total inventory cost as: finished goods in transit	0.874						
F21: Cost reduction project	0.694						
F22: Information carrying cost	0.848						
L1: Learning abilities		0.806			21.760	54.912	0.839
L2: Innovation abilities		0.977					
L3: Product recycle interest		0.964					
L4: Use of new technology		0.958					
L5: Supplier assistance in solving technical problems		0.971					
L6: Supplier ability to respond to quality problems		0.968					
L7: Supplier's booking in procedures		0.970					
L8: Order entry methods		0.975					
L9: Social programs investments		0.968					
L10: Employee turnover		0.971					
L11: Motivation plan		0.769					
L12: Employee training program		0.866					

Table 4 continued

Measurement items	Factor 1	Factor 2	Factor 3	Factor 4	Eigen value	Cum. % variance explained	Cronbach's alpha
B1: Buyer–supplier partnership level			0.784		17.741	76.815	0.985
B2: Information share			0.892				
B3: Group participation			0.782				
B4: Expansion capability			0.990				
B5: Planning and ERP execution systems			0.628				
B6: Supplier collaborative planning systems			0.892				
B7: Raw material and resource usage rate			0.910				
B8: Internal process efficiency			0.902				
B9: Percentage of wrong products during production			0.428				
B10: Supplier rejection rate			0.991				
B11: Total supply chain cycle time			0.730				
B12: Supplier lead time against industry norms			0.729				
B13: Level of supplier's defect free deliveries			0.986				
B14: Purchase order cycle time			0.781				
B15: Planned process cycle time			0.908				
B16: Effectiveness of master production schedule			0.679				
B17: Capacity utilization			0.679				
B18: Efficiency of purchase order cycle time			0.921				
B19: Frequency of delivery			0.981				
C1: Customer query time				0.746	12.184	91.857	0.911
C2: Level of customer perceived value of product				0.820			
C3: Range of products and services				0.948			
C4: Order lead time				0.819			
C5: Flexibility of service system to meet particular customer needs				0.938			
C6: Delivery lead time				0.619			
C7: Percentage of on-time deliveries				0.906			
C8: Effectiveness of delivery invoice methods				0.811			
C9: Client retaining				0.928			
C10: Accuracy of forecasting techniques				0.614			
C11: Market share				0.938			
C12: Answer time of complaint				0.829			
C13: After-sale service quality level				0.918			
C14: Price				0.619			
C15: Rate of credit				0.946			
C16: Wasting degree of energy sourcing				0.820			
C17: Number of distribution channels				0.668			
C18: Time required to produce new product				0.748			
C19: Average units returned				0.939			
C20: Environment protection efficiency				0.819			
C21: Production flexibility				0.948			
C22: Delivery reliability				0.619			
C23: Responsiveness to urgent deliveries				0.921			
C24: Effectiveness of distribution planning schedule				0.843			
C25: Quality of delivery documentation				0.819			
C26: Driver reliability for performance				0.941			
C27: Quality of delivered goods				0.948			
C28: Achievement of defect free deliveries				0.819			

Table 5 Correlations results

		Finance	Customer	Learning	Business
Finance	Pearson correlation	1	0.809[a]	0.757[a]	0.866[a]
	Sig. (2-tailed)		0	0	0
	N	301	301	301	301
Customer	Pearson correlation	0.809[a]	1	0.743[a]	0.791[a]
	Sig. (2-tailed)	0		0.013	0
	N	301	301	301	301
Learning	Pearson correlation	0.757[a]	0.743[a]	1	0.791[a]
	Sig. (2-tailed)	0	0.013		0.114
	N	301	301	301	301
Business	Pearson correlation	0.866[a]	0.791[a]	0.791[a]	1
	Sig. (2-tailed)	0	0	0.114	
	N	301	301	301	301

[a] Correlation is significant at the 0.01 level (2-tailed)

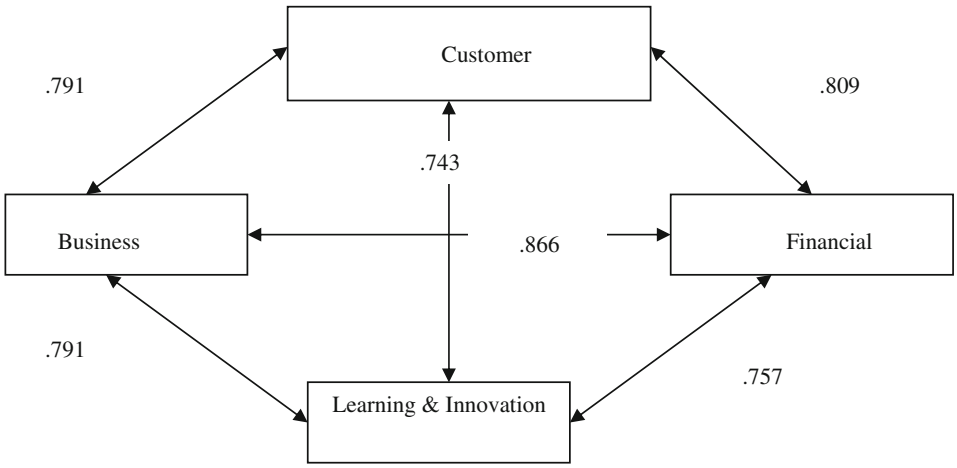

Fig. 1 BSC perspective correlation

Discussion

Continuous improvement has to be applied across the supply chain. Most of companies use lean enterprise, six sigma and other productivity improvement techniques for continuous improvement (Huehn-Brown and Murray 2010). The proposed developed approach helps managers to apply such techniques more effectively by introducing effective metrics. Supply chain management should be more noted by engineering managers, due to the fact that value creation through supply chain activities plays an important role in the competitive market. In contrast to the traditional supply chain management, nowadays there is a fierce competition among supply chains rather than among firms. In addition, it should be noted that satisfaction of all categories of stakeholders leads to the total value of supply chain.

There are many supply chain performance metrics in the literature that some of them focused on value creation. It is difficult to monitor all the supply chain performance metric for managers in supply chain. It is necessary to identify actual value metric for all supply chain stakeholders and define correlation between them. There is a lack of definition for supply chain value metrics to create value for all stakeholders. Managers usually continue to pursue supply chain metrics as a means to increase value without attention on what really mean value in supply chain. We defined actual supply chain value metrics according to proposed framework. According to the results, engineering managers can identify the most important metrics and their effects on other BSC perspectives for applying lean manufacturing, line balancing, and dynamic facilities layout approaches to improve supply chain performance. High quality, low price, product development and, etc., are the competitive

metrics in turbulent market place to survive, therefore business practices are essential fields for engineering function. Applying a proposed framework can guide engineering managers to redesign supply chain process according to value metrics. The reminder of this research is that the value concept has to be established between engineering managers as a practicing issue and applying for supply chain process design.

Conclusion

Creating more value via business and manufacturing process is a competitive advantage for engineering managers in today's market. There are many metrics, suggested in the past literatures, to evaluate supply chain performance. Evaluating all these metrics is difficult for engineering managers and they miss the monitoring of effective metrics as they are engaged with all metrics. Some of metrics proposed in the literature were fitted into more than one perspective of BSC. Some of them contradict other metrics and some of them may compromise others. This study proposes the use of a developed BSC framework using effective metrics to align companies' strategies and supply chain performance for creating more value.

Identifying key value metrics and defining their effects on other metrics can help engineering managers to improve the most important metrics instead of monitoring all of them. The proposed framework provides comprehensive metrics to evaluate supply chain performance with a focus on creating more value. The proposed metrics are concluded by reviewing literatures and they are selected with respect to interviews with experts in home appliance manufacturing industries. During interviews some new useful metrics were also identified. These metrics co-help managers to evaluate supply chain performance with respect to create more value for stakeholders such as employees who affect on total value creation in supply chain. This paper proves that every metric is more correlated with one of the perspective in BSC approach. Applying a quantitative method, the metrics are categorized into four main BSC perspectives. Survey research and factor analysis method were applied to identify the correlation between each metric and BSC perspective. The main objective of using factor analysis is to confirm effective selection of metrics for evaluating supply chain performance as it creates more value. Other studies in the past used qualified approaches to categorize metrics.

According to the past literatures, there is a cause-and-effect relationship between perspectives of the BSC and some studies tried to prove these relationships. This paper identifies the intensity of correlation between perspectives of BSC using a statistical method based on a real case study in home appliance manufacturing industries. Therefore, correlations between the perspectives of BSC were identified. Using the proposed framework, managers can improve their supply chain performance in a balanced way. This proposed framework would help managers of supply chains to better grasp the main facets of supply chain performance evaluation and aids them to take the right actions to enhance the overall performance and to speed up supply chain improvements. Developing a dynamic model based on knowledge management, performance metrics can be generated in the proposed framework. Generating metrics, continuous evaluation and result analysis are the most essential keys to the successful implementation of proposed framework using accurate information and information sharing in supply chain management.

Questionnaire

SECTION A: GENERAL ORGANISATIONAL INFORMATION

A1. Name of your company: .....

A2. Age: .....

A3. Your current position: .....

A4. Education: .....

A5: Number of years you have been in service: .....

SECTION B: ASSESSMENT OF COMPANY'S CURRENT PERFORMANCE

There are different metrics for each of the five scales on this section. In your opinion, tick on a level of each continuum that represents your assessment regarding the metrics about your company's performance.

"How do you assessment your company's performance regarding each of these metrics?"

Measurement Items	Strongly good	good	middle	bad	Strongly bad
Cash to cash cycle time					
Financial benefits					
Final net profit					
Value of stock					
Sale rate new product sale ratio					
Reverse logistics costs					
Logistics cost					
productivity on time					
waste reduction					
security costs					
cost of manpower resources					
Purchase costs					
Rate of return on investment					
Variations against budget					
Supplier cost saving initiatives					
Cost per operation hour					
Total inventory cost as: Incoming stock level					
Total inventory cost as: Work-in-progress					
Total inventory cost as: Scrap value					
Total inventory cost as: Finished goods in transit					
Cost reduction project					
Information carrying cost					
learning abilities					
innovation abilities					
product recycle interest					
Use of new technology					
Supplier assistance in solving technical problems					
Supplier ability to respond to quality problems					
Supplier's booking in procedures					

Order entry methods					
Social programs investments					
Employee turnover					
Motivation plan					
employee training program					
Buyer-supplier partnership level					
information share					
group participation					
Expansion capability					
planning and ERP execution systems					
Supplier collaborative planning systems					
raw material and resource usage rate					
internal process efficiency					
percentage of wrong products during production					
Supplier rejection rate					
Total supply chain cycle time					
Supplier lead time against industry norms					
Level of supplier's defect free deliveries					
Purchase order cycle time					
Planned process cycle time					
Effectiveness of master production schedule					
Capacity utilization					
Efficiency of purchase order cycle time					
Frequency of delivery					
Customer query time					
Level of customer perceived value of product					
Range of products and services					
Order lead time					
Flexibility of service system to meet particular customer needs					
Delivery lead time					
Percentage of on-time deliveries					
Effectiveness of delivery invoice methods					
client retaining					
Accuracy of forecasting techniques					
Market share					
answer time of complaint					
After sale service quality level					
Price					
Rate of credit					
Wasting degree of energy sourcing					
Number of distribution channels					
Time required to produce new product					
Average units returned					
Environment protection efficiency					

Production flexibility					
Delivery reliability					
Responsiveness to urgent deliveries					
Effectiveness of distribution planning schedule					
Quality of delivery documentation					
Driver reliability for performance					
Quality of delivered goods					
Achievement of defect free deliveries					

References

Angerhofer BJ, Angelides MC (2006) A model and a performance measurement system for collaborative supply chains. Decis Support Syst 42(1):283–301

Arksey H, Knight P (1999) Interviewing for social scientists: an introductory resource with examples. Sage Publications, London

Bahri M, Tarokh MJ (2012) A seller-buyer supply chain model with exponential distribution lead time. J Ind Eng Int 8:13

Beamon BM (1999) Measuring supply chain performance. Int J Oper Prod Manag 19(3):275–292

Bhagwat R, Sharma MK (2007) Performance measurement of supply chain management: a balanced scorecard approach. Comput Ind Eng 53(1):43–62

Bititici US, Cavalieri S, Cieminski G (2005) Implementation of performance measurement systems: private and public sectors. Editor Prod Plan Control 16(2):99–100

Bolstorff P (2003) Measuring the impact of supply chain performance. CLO Chief Logist Off 12:5–11

Butler Renee J, Ammons Jane C, Joel Sokol (2006) Planning the supply chain network for new products: a case study. Eng Manag J 18(1):35–43

Cai J, Liu X, Xiao Z, Liu J (2009) Improving supply chain performance management: a systematic approach to analyzing iterative KPI accomplishment. Decis Support Syst 46:512–521

Camerinelli E, Cantu A (2006) Measuring the value of supply chain. Supply Chain Pract 8(2):40–59

Chan FTS (2003) Performance measurement in a supply chain. Int J Adv Manuf Technol 21(7):534–548

Chan FTS, Qi HJ (2003a) An innovative performance measurement method for supply chain management. Supply Chain Manag Int J 8(3):209–223

Chan FTS, Qi HJ (2003b) Feasibility of performance measurement system for supply chain: a process-based approach and measures. Integr Manuf Syst 14(3):179–190

Chan FTS, Chan HK, Qi HJ (2006) A review of performance measurement systems for supply chain management. Int J Bus Perform Manag 8(2/3):110–131

Chopra S, Meindl P (2001) Supply chain management: strategy, planning, and operation. Prentice Hall, New Jersey

Christopher M (1992) Logistics and supply chain management. Pitman Publishing, London

De Vaus D (2002) Surveys in Social Research. 5th edition, Routledge

Dobler DW, Burt DN (1996) Purchasing and Supply Management. The McGraw-Hill Companies, New York

Donnet ML, Weatherspoon DD, Charles BM (2009) Measuring food product differentiation by quality ratings: a cross-entropy analysis of specialty coffee e-auctions. J Agric Econ 61(1):122–137

Estampe D, Lamouri S, Paris JL, Brahim-Djelloul S (2010) A framework for analysing supply chain performance evaluation models. Int J Prod Econ 128(1), (in press)

Gunasekaran A, Patel C, Tirtiroglu E (2001) Performance measures and Metrics in a supply chain environment. Int J Prod Oper Manag 21(1/2):71–87

Gunasekaran A, Patel C, McGaughey RE (2004) A framework for supply chain performance measurement". Int J Prod Econ 87(3):333–347

Hongxia J, Zhipeng C (2007) Performance Appraisal on Supply Chain Based on Value Engineering and Multistage Fuzzy Comprehensive Evaluation. In: Proceeding of International conference in Wireless Communications, Networking and Mobile, Shanghai, pp 21–25

Hudson M, Lean J, Smart PA (2001) Improving control through effective performance measurement in SMEs. Prod Plan Control 12(8):804–813

Huehn-Brown WL, Murray S (2010) Are companies continuously improving the supply chain? Eng Manag J 22(4):3–10

Kaplan R, Norton D (1992) The balanced scorecard: measures that drive performance. Harv Bus Rev 70(1):71–99

Khalifa AS (2004) Customer value: a review of recent literature and an integrative configuration. J Manag Decis 42(5):645–666

Kleijnen JPC, Smits-Pefformance MT (2003) Performance metrics in supply chain management. Oper Res Soc Ltd 54(1):507–514

Lee HL, Billington C (1992) Managing supply chain inventory: Pitfalls and opportunities. Sloan Manag Rev 1:65–73

Levy DL (1997) Lean production in an international supply chain. Sloan Manag Rev 38(2):94–102

Li X, Jian GuX, Gang Liu Z (2009) A strategic performance measurement system for firms across supply and demand chains on the analogy of ecological succession. J Ecol Econ 68(12):2918–2929

Liberatore MJ, Miller T (1998) A framework for integrating activity-based costing and the balanced scorecard into the logistics strategy development and monitoring process. J Bus Logist 19(2):131–154

Lockamy A III, McCormack K (2004) Linking SCOR planning practices to supply chain performance: an exploratory study. Int J Oper Prod Manag 24(11/12):1192–1218

Malmi T (2001) Balanced scorecards in Finnish companies: a research note. Manag Account Res 12(1):207–220

Martinsons M, Davison R, Tse D (1999) The balanced scorecard: a foundation for the strategic management of information systems. Decis Support Syst 25(1):71–88

Mason-Jones R, Towill DR (1997) Enlightening supplies. Manuf Eng 76(4):156–160

Mondragon AEC, Lalwani C, Mondragon CEC (2011) Measures for auditing performance and integration in closed-loop supply chains. J Supply Chain Manag 16(1):43–56

Neely A (2005) The evolution of performance measurement research: developments in the last decade and a research agenda for the next". Int J Oper Prod Manag 25(12):1264–1277

Norrekilt H (2000) The balance on the balanced scorecard—a critical analysis of some of its assumptions. Manag Account Res 11(1):65–68

Rushton A, Oxley J (1991) Handbook of logistics and distribution management. Kogan Page, London

Sage Gordon W, Langmaid R (1998) Qualitative marketer research. Gower, Aldershot

Satapathy S, Mishra P (2013) A customer oriented systematic framework to extract business strategy in Indian electricity services. J Ind Eng Int 9:33

Sharma MK, Bhagwat R, Dangayach GS (2005) Practice of performance measurement: experience from Indian SMEs. Int J Glob Small Bus 1(2):183–213

Shepherd C, Günter H (2006) Measuring supply chain performance: current research and future directions. Int J Prod Perform Manag 55(3/4):242–258

Soni G, Kodali R (2010) Internal benchmarking for assessment of supply chain performance. Int J Benchmarking 17(1):44–76

Stewart GB (1991) The quest for value: a gide for senior managers. Harper Business, New York

Stewart G (1995) Supply chain performance benchmarking study reveals keys to supply chain excellence. Logist Inf Manag 8(2):38–44

Taghizadeh H, Hafezi E (2012) The investigation of supply chain's reliability measure: a case study. J Ind Eng Int 8:22

Toni AD, Nissimbeni G, Tonchia S (1994) New trends in supply environment. Logist Inf Manag 7(4):41–50

Wang C-H, Lu I-Y, Chen Chin B (2010) Integrating hierarchical balanced scorecard with non-additive fuzzy integral for evaluating high technology firm performance. Int J Prod Econ 128(1):413–426

Yang J (2008) Integrative performance evaluation for supply chain system based on logarithm triangular fuzzy number-AHP method. Emerald Group Publ Ltd Kybern 38(10):1760–1770

Yilmaz Y, Bititci U (2006) Performance measurement in the value chain: manufacturing vs. Tourism. Int J Prod Perform Manag 55(5):371–389

Youngblood Alisha D, Terry R (2003) Addressing balanced scorecard trade-off issues between performance metrics using multi-attribute utility theory. Eng Manag J 15(1):11–17