Supply chain value creation methodology under BSC approach

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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 scorecard • 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.

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 managers 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 measurement of supply chain evaluation

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 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).
| BSC perspective | Metrics (factors) | References |
|-----------------|-------------------|------------|
| Financial       | Cash to cash cycle time | Bolstorff (2003), Camerinelli and Cantu (2006) |
|                 | Financial benefits | Stewart (1991), Beamon (1999), Kleijn and Smits-Peformance (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 Bittici (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) |
| 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) |                                                                           |

| Internal business |                                                                 |                                                                 |
|-------------------|------------------------------------------------------------------|------------------------------------------------------------------|
| Achievmeent of defect free deliveries | Gunasekaran et al. (2001), Bhagwat and Sharma (2007)              |                                                                 |
| 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 | Kleijnpen and Smits-Peformance (2003)                            |                                                                 |
| Percentage of wrong products during production | Soni and Kodali (2010)                                            |                                                                 |

| Learning and innovation |                                                                 |                                                                 |
|--------------------------|------------------------------------------------------------------|------------------------------------------------------------------|
| 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 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 Vaas 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 experts’ 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 Varimix 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 Varimix 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
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 sales 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    |          |          |          |             |                           |                  |
| 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    |          |          |          |                 |                          |                  |
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.

Table 5 Correlations results

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

* Correlation is significant at the 0.01 level (2-tailed)

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 aims 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.

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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:                               |               |      |        |     |              |
| Incomimg stock level                                   |               |      |        |     |              |
| Work-in-progress                                       |               |      |        |     |              |
| Scrap value                                            |               |      |        |     |              |
| 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 |
|------------------------|----------------------|--------------------------------------|-----------------------------------------------|----------------------------------|-----------------------------|------------------------|-----------------------------|

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