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Faculty of Commerce

Accounting Department

BSC Model for Measuring a Firm's Progress in Implementing Lean Manufacturing with a Case Study

Prof. Dr.

Said Mahmoud El-Helbawy

Professor of Cost Accounting

Faculty of Commerce

Tanta University

Prof. Dr.

Mohamed Adel Elhamy

((in mercy of ALLAH))

Professor of Financial Accounting

Faculty of Commerce

Tanta University

Prepared By

Asmaa Mohamed Ebrahim Halloul

Demonstrator — Accounting Department

Faculty of Commerce

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Balanced Scorecard Model for Measuring a Firm's Progress in Implementing Lean Manufacturing: The Case of El-Araby Water Heater Factory

Abstract

Companies adopting lean manufacturing philosophy have recognized that relying mainly on performance measurement system raised only to support lean manufacturing philosophy is no longer adequate. The lean environment needs new kinds of performance measures, that reflect the strategic objectives of lean enterprises, which can be extracted by employing the concept of BSC and merging a BSC's strategy map with value stream map used in a lean company. Therefore, this paper aims at suggesting a new framework to measure performance in a strategic perspective, convenient to companies that adopt lean manufacturing philosophy, by constructing the most relevant lean performance measures that are stemmed from lean determinants. These measures must be developed to support lean enterprises' mission, vision and strategies at three different levels of the lean performance measurement framework which are SBUs level, value streams level, and cells level. This study was also applied in El-Araby water heater factory in Egypt, through constructing a case study to clarify the application of the proposed framework using the scoring model.

Key Words: Lean Manufacturing, Lean Performance Measurement system, Balanced Scorecard (BSC), Scoring Model.

1. Introduction

During the past few decades, the ultimate objective of manufacturing companies has become to increase its own productivity while achieving the highest quality. Currently, many manufacturing companies are facing different problems, such as high-quality rejects,

high inventories, long lead time of production, high costs of production, and inability to cope with customer orders (Wang, 2010). These challenges led the business firms to shift away from mass production strategies and adopt lean strategies.

For those companies decided to adopt such strategies, they must undergo radical changes in their performance measurement system. That is because relying mainly on lean performance measurement system is no longer suitable, rather new kinds of measures are needed to reflect the different aspects of lean environment.

Accordingly, the Balanced Scorecard (BSC) is considered as being one of the most significant performance measurement models in the management accounting. Taylor (2010) ensures a comprehensive measure of firm happenings. The study may recognize its main potential linked to its information processing, by considering the role of counterbalancing different perspectives (and different criteria/measures) of firm performance. It seems true, especially within very dynamic markets and environments that usually cause changes in organizational and operational structures- competitive, relational and product systems.

Therefore, this paper may serve as a reference point for the integration between the aspects of lean performance measurement system and BSC model, and examination the ability of the proposed framework to measure the firm's progress based on this integration.

In the following section we will develop a framework for lean performance measurement, see fig. 1, based on BSC. This framework shows a five stage (step) process. Each stage will be discussed.

2. Strategic Alignment

The Lean manufacturing Strategy is based on ‘‘perfection’’. This strategy operates on the principle that customer value must be maximized; defective products must be minimized; resources must be used by the necessary amounts; and endless diversity of products must be produced **(**Vienazindience & Ciarniene, 2013).

Lean practices related to setup time reduction, cellular manufacturing, and quality improvement initiatives have varied direct effects on profitability, whereas utilization of non-financial manufacturing performance measures has a significant direct effect on profitability (Fullerton& Wempe, 2009).

So, now the question is this: How an organization can show that it is moving toward lean manufacturing strategy? In this regard, the company must first define the mission under lean environment, then define the vision under lean environment, and finally identify the company's strategies for providing value to the customer.

2-1.Define the Company's Mission under Lean Manufacturing Environment:

Company's mission under lean manufacturing environment must reflect the overall goal of the company, which is maximizing customer's value and eliminating waste through continuous improvement programs.

2-2. Define the Company's Vision under Lean Manufacturing Environment:

Company's vision under lean manufacturing environment must reflect how the company will be valued from customer's point of view and also must include areas of competitive advantage or distinctive competences, such as higher quality and diversity.

2-3. Identify the Company's Strategies for Providing Value to Customer:

The core purpose of lean manufacturing company is to bring customer value into every perspective of their operations. Mirdad and Eseonu (2017) have considered that the BSC is an effective tool for translating strategy into high-level performance measures through four different perspectives for a full assessment of an organization as follows:

- **Financial:** strategies adopted by shareholders for profitability, higher income and improvement in financial measures (Kennerley & Neely ,2000).

- **Customer:** strategies adopted for being distinguished and valued by the customer (Tarus , 2021).
- **Internal businesses processes:** strategic priorities for certain process in conjunction with business progress, customer and shareholders satisfaction.
- **Learning and growth:** priorities for policies that support change, growth, and innovations within an organization (Dwivedi et..al, 2021).

Definition of right goals and their alignment with strategy become central to the success of an organization. Putting customer value at the heart of lean companies can result in the definition of the following objectives that are required to be achieved as shown in figure 2.

3. Implementing BSC in Extracting Lean Manufacturing Perspectives

After the organization states its lean strategy and pursues its mission. The BSC will provide the capability to translate the strategy into the relevant organization activities and lean concept will provide the vehicle for influencing these activities. In order to measure the activities of an organization with respect to lean manufacturing, three groups of activities must be examined as follows (Womack, 2006):

3-1. Business Goals

With respect to the business goals, two factors, which are customer and financial factors, must be taken into consideration. In other words, the company must not only seek those things that customers want and it did not provide them, but also must seek what will make the business sustain and durable (Parida and Chattopadhyay, 2007).

Accordingly, the company must first close the gap between where the company is and where it needs to be. So, precisely declaring the business goals will enable the organization to financially survive and achieve its targeted margins.

3-2. Processes

With a simple statement of business goals, the definition of ‘‘Process’’, in a company applying lean concept, deals with the value

stream which reflects all the activities valued by customers (from door to door), along with the information related to them.

As value is the end result of some processes and these processes can only produce what they are designed to produce never something better and often something worse.

Hence, the researcher believes that the value-stream maps of the current state are the most useful tool for evaluating the state of any process and its related activities. They show all of the steps in the process and wonder whether each step is valuable, capable, available, adequate, and flexible (Ward, & Sobek, 2014). . Finally, they show whether value flows smoothly from one step to the next at the pull of the customer after the appropriate leveling of demand.

3-3. Human Resources:

Every important process in an organization, in order to be continually assessed and improved, needs to have a person in charge of it, and that person is no one but one of the employees.

Accordingly, the ultimate result in using the scorecard system is that these three groups of lean company's activities are considered as respective to BSC perspectives and are restructured into final extracted lean perspectives as shown in table 1.

Table 1

Final Extracted Lean Perspectives

Primitive lean perspectives	Final extracted lean perspectives
Business goals	▪ **Financial Perspective** ▪ **Customer Perspective**
Processes	▪ **Process Perspective**
Human resources	▪ **Learning & Growth Perspective**

The **business goal** is broken down into two dimensions**: customer** and **long-term financial results**, to first cover the concept of business objective, second, to create a type of reconciliation between balanced scorecard methodology measurement and business goals.

The **customer perspective** will deal with the company's financial satisfaction and sustainability. **Learning & growth perspective** is also selected due to the critical role that human resources play in the success of the business, as it was mentioned earlier.

4. Customizing Balanced Scorecard Perspectives under Lean Manufacturing Environment and Its Corresponding Objectives:

At this stage, it is intended primarily to align the goals and indicators identified in the previous stages. Through using the BSC, it is possible to translate the four perspectives (learning and growth, processes, customer and financial) into those indicators that reflect the objectives to be achieved under lean manufacturing environment as shown in fig. 3. It is suggested that both, the perspectives and respective indicators, should be reviewed and updated periodically.

The BSC model depicted in fig. 3. allows the organization to customize the perspectives which enable managers to capture integrated information about

performance measurement activities (i.e. BSC) in the company, by reasoning from a lean standpoint. So, this figure tries to thread a relationship between BSC perspectives and lean manufacturing objectives as follows:

4-1. Learning and Growth Perspective:

The benefits of this perspective may be related to the concept of "continuous improvement". It may increase the learning curve for all employees, and also lead to an overall increase in labor productivity.

Thanks to the direct improvement of labor productivity, the firm may benefit from a decreasing in production throughput time and then, of increasing production volumes, with the aim at satisfying possible increases in demand for goods, in general.

Furthermore, the firm will be able to determine employee capabilities and the reliability of information systems, which will help in improving internal processes and in implementing strategies at any

organizational level; relationships may be strengthened with customers and, in general, with stakeholders.

4-2. Processes Perspective:

The benefits of this perspective may be related to both the concepts of "eliminating waste" and "continuous improvement". By applying them, the production time for internal processes (throughput time) should be lowered by removing wasted time and the excess capacity in all the processes of production, even lowering inventories.

Moreover, according to the internal process perspective, the employing of the BSC in a lean manufacturing company may highlight internal processes that should be enhanced for satisfying not only customers, but also shareholders according to the strategic decisions stated by the governance. The previous benefits also imply that the company should sustain a continuous improvement for internal processes and further improved by a strong tool coming from company's culture and scattered all over its organization. This is lean manufacturing.

4-3. Customer Perspective:

The benefits of this perspective may be related to the concept of "creating value" for customers. It implies an increase in customer satisfaction by providing customers with exactly what they need. Then, if errors and scraps in the production processes are minimized, a value adding activity could be reached, referring to the value transferred to customers and directly coming from the output sold by the firm(Martynenko et al .,2020).

4-4. Financial Perspective:

The core emphasis for financial perspective may be related to the concept of "eliminating waste", i.e., decreasing costs (waste is certainly synonymous of cost) – in particular variable costs – in all the processes of product manufacturing and also in their support activities. This would lead to a subsequent increase in financial returns; if necessary, an increase in the level of sales that should lead to higher profit; a decrease in inventory size; higher return on sales, higher capital turnover and higher return on investments.

Also, when considering investments from this perspective's point of view, eliminating waste would also mean that the amount of the capital required for implementing a lean manufacturing system should definitely be considered, along with self-financing activities led by the firm itself and coming from not shared or re-invested earnings within the whole firm's processes.

5. Extracting Measures for a Lean Company's Performance Measurement Customized by BSC Perspectives

This stage is where the real framework development work begins. There are several steps in this stage. First, objectives must be identified. Second, CSFs should be determined. Third, relevant performance measures should be developed. The steps for conducting this stage are divided into three sets as follows:

First, SBUs level:

1- Identify Strategic Objectives:

Here, the main strategy of the firm is analyzed and translated into strategic objectives, which lead to achieving the connection in the strategic performance measurement system components through deriving the objectives from the strategy at one hand, and the cooperation and interaction of objectives together to achieve the strategy at the other hand.

These objectives represent the desired outcomes that firm seeks to achieve, and the progress toward achieving the objective is measured through one or more performance measure(s).

2- Identify the CSFs for the Company:

Lean company must determine what set of product characteristics will create the optimal value for customers, and what employee capabilities, information system, and organizational climate are needed to continually improve processes and customer relationships.

3- Develop the Relevant Strategic Performance Measures:

Strategic measures are matched with the identified strategic objectives and they are designed to measure the achievement of business as planned and modified (Maskell & Baggaley ,2017).

Table 2
SBU'S Objectives, CSFs, and Performance Measures

Strategic Objectives	BSC Perspectives	CSFs	Strategic Performance Measures	Practices
➢ Empowerment ➢ Human capital management	Learning& growth perspective	▪ Flexibility ▪ Employee Skill Development ▪ Productivity	○ No. of suggestions per employee in a year ○ No. of design changes ○ No. of training hours for each employee	▪ Employee training and growth ▪ Employee involvement ▪ pay for skill and performance
➢ Creating Continuous Improvement Culture ➢ Zero Defects / Waste Elimination ➢ Flow & Pull	Internal business process perspective	▪ Flexibility ▪ Productivity	○ Ratio of process time to cycle time ○ Customer response time ○ First-time through (Producing good units from first time) ○ Overall Equipment Effectiveness (OEE)	▪ Total productive maintenance ▪ Value stream mapping ▪ New process or equipment technologies
➢ Maximizing customer satisfaction	Customer perspective	▪ Quality ▪ Timeliness	○ On-time delivery = the orders delivered on time / the total no. of orders delivered	▪ Customer relations management
			○ Number of customers complaints ○ Percentage of resale	
➢ Profitability & Satisfied Shareholders	Financial perspective	▪ Productivity ▪ Cost Reduction	○ Sales revenues of present product/new product ○ capital utilization percentage in creating value ○ ROI %	▪ Value stream costing (VSIS) ▪ Value Stream Box Score (VSBS). ▪ Value Stream Income Statement (VSIS)

Second, Value Stream Level:

1- Identify Value Stream's Objectives:

The main objective of the value stream team is to achieve continuous improvement, from the point of view of making lean progress, and to design future improvement initiatives within value stream (Mahidhar, 2005).

2- Identify Value Stream's CSFs:

The value stream's CSFs are those things that the value stream people must do extremely good in order to achieve value stream's objectives. These CSFs should be in a positive direction in which they always include means to reduce time, reduce cost, increase quality and increase flexibility.

3- Develop Value Stream's Performance Measures:

Value stream measures calibrate how well the value stream is doing in proceeding towards the performance targets designed into the future state map. They are collected and analyzed weekly by the continuous improvement team as "result" measures from the point of view of making lean progress (Baggaley, 2006).

Table 3
Value Stream's Objectives, CSFs, and Performance Measures

Value Stream Objectives	BSC Perspectives	CSFs	Value stream Performance measures	practices
➢ Increasing lean culture and motivation ➢ Empowerment ➢ Involvement in improvement programs	Learning & growth perspective	▪ Innovation ▪ Productivity ▪ Flexibility	○ Percentage of implemented suggestions per employee ○ Amount (in hours) of training given to employee ○ No. of new technology development per year/month	▪ Employee training and growth ▪ Employee improvement ▪ Multifunctional teams ▪ Self-directed teams
➢ Creating perfect link between processes ➢ Value creating processes	Internal business process perspective	▪ Flexibility ▪ Waste elimination	○ Batch size ○ No. Of mixed models in a line ○ Throughput time or manufacturing lead time ○ Percentage of value added activities to overall activities	▪ Small lot sizes ▪ Value stream mapping

➢ Capable & reliable processes	Internal business process perspective	▪ Eliminating obstacles on flow ▪ Productivity	○ Dock-to-dock time ○ Average inventory level ○ Overall Equipment Effectiveness (OEE)	▪ Standard work ▪ Concurrent engineering ▪ Total productive maintenance
➢ Flexible and adequate processes	Internal business process perspective		○ Setup time ○ Degree of pull ○ Percentage of waste elimination ○ Scrap or rework cost	▪ Complementary quality and productivity program ▪ Visual management system ▪ Quality circles ▪ Lead time reduction
➢ More satisfied customer ➢ Higher quality & lower price	Customer perspective	▪ Quality ▪ Eliminating constraints on flow	○ Rate of customer returns ○ Active customer involvement ○ Frequency of contact with customers	▪ Quality function deployment (QFD) ▪ Supplier integration

Third, Cell Level:

1- Identify cell's objectives:

The cell team's job is to make to takt time using prescribed standard work methods while adhering to the kanban signals that direct work to be performed and work time-lines.

Takt time = net available manufacturing time per day / customer demand time per day

2- Identify cell's CSFs:

Cell's CSFs can be defined as what cell's people must do well at the cell level in order to achieve cell's objectives.

3- Develop cell measures:

Cell performance measures are matched with cell's objectives and should help the cell team to calibrate their work and finish what needs to be done during the course of the shift.

Table 4
Cell's Objectives, C

Cell's Objectives	BSC Perspectives	CSFs	Cell's Performance Measures	Practices
➢ Providing desirable place to work ➢ Secured and safe environment ➢ Suitable work hours for employees	Learning& growth perspective	▪ Workplace	o Employee satisfaction survey o No. of employees who leave the work o No. of employees who have injured during work o No. of working hours o Employee satisfaction rating of working hours	▪ Safety improvement
➢ Expert employees	Learning &growth perspective	▪ Training and education	o Cross training chart	▪ Employee training and growth
➢ Decreasing process time ➢ Increasing process quality ➢ Increasing process effectiveness	Internal business process perspective	▪ Flexibility ▪ Productivity	o Day-by-the-Hour o First-time-through (FTT) o Work-in process (WIP) to standard work-in-process (SWIP) o Operational Equipment Effectiveness (OEE)	▪ Automation ▪ Line balancing ▪ Focused factory cellular manufacturing ▪ U-shaped cells

SFs, and Performance Measures

➢ Value identification/ customer satisfaction	Customer perspective	▪ Timeliness ▪ Quality	o Customer satisfaction index o Percentage (or number) of defective products shipped to customer	▪ Customer requirements analysis

5-1. Integrating the BSC's Strategy Map with Value Stream Mapping

Lean accounting is looking for a mapping bridge between the "hearts" of both lean operational measures and "balanced" measurement system provided by the BSC model with its financial and non- financial perspectives.

It was found that lean accounting provides an extension to this integration through merging a BSC's strategy map with value steam map used in a lean company (Johnson, 2006).

The strategy map can, in general, be assumes to be the blueprint from which the whole architecture of BSC emerges. Then, thanks to the strategy map and its cause and effect diagram, the emerging characteristics of lean manufacturing may be transferred within each perspective considered; this could simplify management activities in order to understand what kind of strategic actions the company will take for giving a lean imprint to its business, and how it will infuse the control of those actions within the BSC itself.

Moreover, nowadays, it is known that accounting practices related to "lean accounting" are mostly based on the value stream map, a technique used to analyze and design how value flows through a manufacturing system (Stephen and Louay, 2010).

By scanning – from a value standpoint – the production process within the firm, lean accounting aims to provide managers with the timely and exact information that gives a clear insight into the firm's performance. Tensions among this kind of information and the strategic volitions pictured inside the strategy map might meet each other, to draw and to test the primitive source of Information, by which everything unfolds within the firm **(**Woehrle & Abo-Shady, 2010).

Hence, **operational** decision-making process activities should be related to **strategic** decision-making process activities, with the aim at understanding the contribution given by the value stream map as one of the possible sources of information for the strategy map (Mirdad, 2014).

5-2. Interrelationships among Performance Measures within Three Business Levels of Lean Performance Measurement Framework:

Leading and lagging indicators can be illustrated by the three different levels of performance measurement framework under lean manufacturing environment. Cells level measures are considered as leading indicators to value stream level measures, which in turn are considered as leading indicators for SBUs level measures. At the same time, they are considered lagging indicators for the cells level measures, while the SBUs level measures are inherently lagging indicators. This can be illustrated in figure 5.

It is clear from fig. 5 that there are cause-and-effect relationships between performance measures through different business levels of lean performance measurement framework as follows:

Cells Level:

- Increased attention toward day-by-the hour and cross training chart leads to an increase in productivity per employee and a decrease in setup time; also it leads to an increase in first-time-through (FTT) without scrap or rework.
- An increase in first-time-through would lead to improve production according to takt time; customer response time; average inventory level and ultimately leads to an increase in the ratio of process time to cycle time.
- Focusing on operational equipment effectiveness leads to an increase in the ratio of process time to cycle time and improving first-time-through (FTT) of processes and products.
- Focusing on five S Audits would lead to an increase in productivity per employee and improving production according to takt time.

Value streams level

- An increase in productivity per employee would lead to an increase in sales revenues of present / new product; an increase in profitability and ROI.
- An increase in customer response time leads to an increase in profitability and an increase in market share.
- An increase in the ratio of process time to cycle time leads to an increase in both profitability per product and an increase in customer returns.
- An increase in first-time-through (FTT) leads to an increase in customer satisfaction which in turn leads to an increase in customer returns and therefore leads to an increase in company's profitability.

SBUs level

- An increase in company's market share leads to an increase in sales revenues and an increase in ROI which ultimately leads to an increase in profitability.
- An increase in product profitability and customer returns leads to an increase in sales revenues and ROI.
- The company's profitability as a whole is the ultimate result of an increase in the effectiveness of performance measures in value streams and cells levels.

6. Identifying Performance Measures' Relative Importance in the Decision-Making Process (Scoring Model)

In this stage, the most important measures of performance measurement will be identified . The identification of measures should follow the principle of minimizing the same for the measurement of performance to be effective, easy to use and analyze.

This suggests that the process is conducted based on a system like scoring model, as determining the weight of each measure will be instrumental in the selection stage. Initially, the most important measures in each perspective of BSC should be identified. It should be noted that the method under discussion is not sealed and could differ depending on factors such as the type of organization and its structure,

objectives to be achieved. So it is possible to identify measures giving more relevance to one or several BSC perspectives in detriment of another(s).

In the second phase, it is proposed that the weights of the measures, which reflect their relatively importance, identified in the first phase would be based on five main determinants: providing value to customer; managing by value stream; flow and pull; seeking perfection; empowerment and finally with regard to the goals.

Using the scoring model the comparisons will be made between the importance of each determinant and the main objective; then with regard to the weighting of each measure in each determinant and finally to the weighting of each measure for the goals.

Having chosen measures, or metrics, for each of the BSC perspective and the weighting related to the lean performance measurement determinants, the process can be layer out as follows fig. 6:

In this study, attempt has been made to not only determining the cause and effect relationship between performance measures, but also to determine their Relative Importance in the Decision-Making Process. So, they can be employed to improve week points in a manufacturing system. Hence, to this end scoring model decision making technique along with summary of experts' opinions, on basis multicriteria decision making were used. Clearly, in view of the fact that measures that were selected on basis of determinants were final. The cause and effect relationship between Indicators within three business levels of lean performance measurement framework, by considering the dependency of criteria to each other, will be obtained and experts will consider this when setting values in scoring model method. In this section, the study alludes and summarizes the use of scoring model.

6-1. Scoring Model

Scoring model is a way to identify the best decision alternative for a multicriteria decision problem. This model uses a common set of values for all of the observations. Each value has a weight: assigned values of high importance have a high weight, while values of lower importance have a lower weight. The observations are measured

against these values and assigned scores according to how well they match the predefined values. (Anderson et al., 2015)

This model can be summarized as following steps:

Step 1. Develop a list of the criteria to be considered. The criteria are the factors that the decision maker considers relevant for evaluating each decision alternative.

Step 2. Assign a weight to each criterion that describes the criterion's relative importance. Let

W_i = *the weight for criterion i*

Step 3. Assign a rating for each criterion that shows how well each decision alternative satisfies the criterion. Let

R_{ij} = *the rating for criterion i and decision alternative j*

Step 4. Compute the score for each decision alternative. Let

S_j = *Score for decision alternative j*

The equation used to compute S_j is as follows:

$$S_j = \sum_{i}^{m} W_i \, R_{ij}$$

Step 5. Order the decision alternatives from the highest score to the lowest score to provide the scoring model's ranking of the decision alternatives. The decision alternative with the highest score is the recommended decision alternative.

Table 5

Final Matrix (after getting a consensus opinion of the experts) for El-Araby Water Heater Factory

criteria		No. of design changes		No. of training hours for each employee		First-time through		Customer response time		Ratio of process time to cycle time		On-time delivery		Number of customers complaints		Product cost per unit		Sales revenues of present product / new product		Return on investment (ROI)%	
	Weight (W_i)	Rating R_{i1}	Score W_iR_{i1}	Rating R_{i2}	Score W_iR_{i2}	Rating R_{i3}	Score W_iR_{i3}	Rating R_{i4}	Score W_iR_{i3}	Rating R_{i5}	Score W_iR_{i5}	Rating R_{i6}	Score W_iR_{i6}	Rating R_{i7}	Score W_iR_{i7}	Rating R_{i8}	Score W_iR_{i8}	Rating R_{i9}	Score W_iR_{i9}	Rating R_{i10}	Score W_iR_{i10}
providing value to customer	3.58	2.88	10.31	2.69	9.63	3.8	13.6	3.6	13.1	3.3	9.5	4	14.3	3	10.74	3.7	13.21	3.2	11.42	3.2	11.56
managing by value stream	3.19	3.38	10.78	3.69	11.77	3.6	11.7	3.8	12.1	4	13.5	3.8	12.26	3.03	9.66	3.5	11.16	3.4	10.78	3.4	10.90
flow and pull	3.53	3.5	12.36	3.96	13.98	3.6	12.8	3.3	11.6	3.8	13.3	3.2	11.40	3.3	11.64	3.3	11.79	3.4	12.07	3.2	11.50
seeking perfection	3.65	3.57	13.03	3.65	13.32	3.4	12.4	3.1	11.2	3.3	11.9	3.5	12.88	3.3	12	3.7	13.46	4	14.6	4.6	16.82
empowerment	2.76	3.53	9.74	3.88	10.71	3.4	9.54	3.5	9.6	3.1	11.3	3.3	9.21	3.38	9.32	3.5	9.74	3.1	8.58	4.5	12.42
			56.22		59.41		60.2		57.7		59.50		60.07		53.42		59.37		57.45		63.23

In this research, we have used scoring model for identifying the criterion's relative importance and to determine the recommended decision alternative for the factory's performance measurement framework.in the first part, Further analysis of the results related to the weights of the five determinants selection criteria indicated that 'seeking perfection' is the most important criterion for El-Araby water heater factory followed by 'providing value to customer', which is considered somewhat important, as each received an average of 3.65, 3.58 respectively.

The 'flow & pull' criterion is considered as averagely important, with an average of 3.53. While 'managing by value stream' is considered somewhat unimportant, as it received an average of 3.19. Finally, because 'empowerment' is considered to be somewhat unimportant, it received the lowest average with an average of 2.76.

According to the above results, it is observed that EL-Araby water heater factory pays more attention to the 'seeking perfection' determinant which is fundamental to lean thinking. Anything that interrupts the flow of value at the pull of the customer would result in less than perfection. This requires that performance measures should focus on measuring all cases of "non-value" and "non-flow".

The weights shown in table 5 are subjective values provided by the EL-Araby water heater factory's experts. Different experts would most likely choose to weight the criteria differently. One of the key advantages of the scoring model is that it uses the subjective weights that most closely reflect the preferences of the individual decision maker. In the next part, we embarked on determine the degree of relative importance for each performance measure in water heater factory, as well as to determine the relationship between such measures and the adopted BSC perspectives. According to the above

results shown in table 5, the tested decision alternatives are ranked as follows:

1. Return on Investment (ROI), with the highest score of 63.22,
2. First-time through, with a score of 60.22,
3. On-time delivery, with a score of 60.07,
4. Ratio of process time to cycle time, with a score of 59.50,
5. No. of training hours for each employee, with a score of 59.41,
6. Product cost per unit, with a score of 59.37,
7. Customer response time, with a score of 57.70,
8. Sales revenues of present product / new product, with a score of 57.45,
9. No. of design changes, with a score of 56.22,

Number of customers complaints, with a score of 53.42.

Thus, ROI is the recommended decision alternative.

As the operational measures are holistically reflected in the financial progress of the factory, this is considered as a good sign for the ability of such factory to transfer from its current performance measurement system to the ultimate strategic performance measurement system (BSC approach).

However, The results also revealed that El-Araby water heater factory pays the most attention to the financial measures (financial perspective), as ROI % is the recommended decision alternative, and pays the least attention to customer satisfaction measures, as no. of customer complaints is the least recommended alternative. Thus, EL-Araby water heater factory has to devote more attention to the after sale services of its products to respond to customer complaints.

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Fig. 1. Framework of the research approach

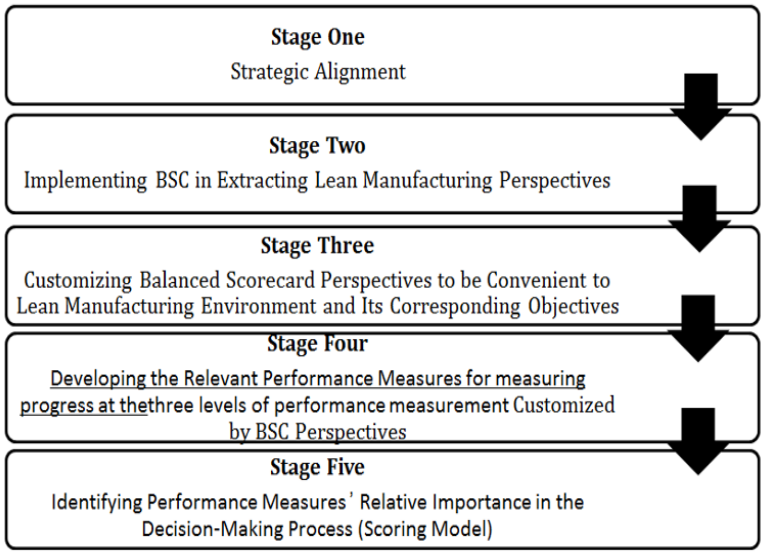


Figure 2. Alignment between Lean Manufacturing Objectives and BSC Perspectives

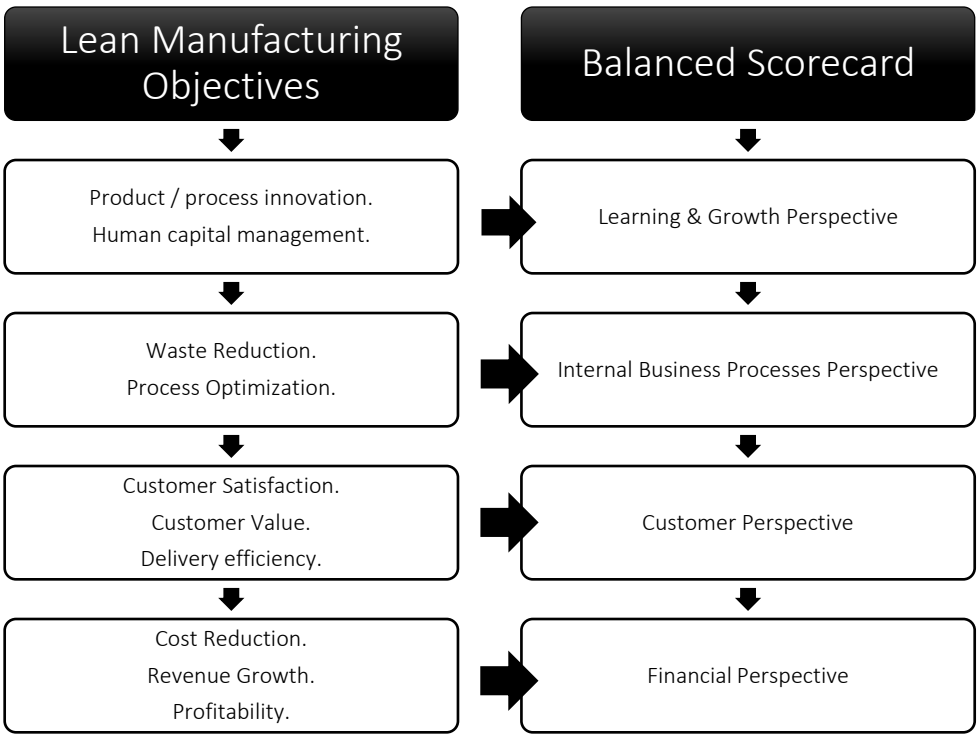
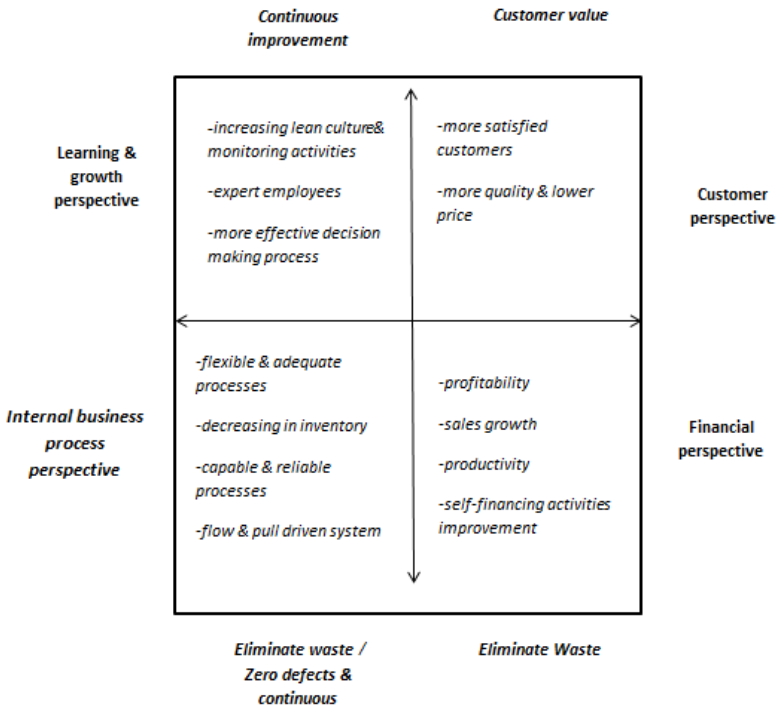


Figure 3. Customized BSC Model



Source: Baroma et. al., 2013 (Some Modification Added)

Fig. 4. a BSC's Strategy Map and Value Stream Map Integration

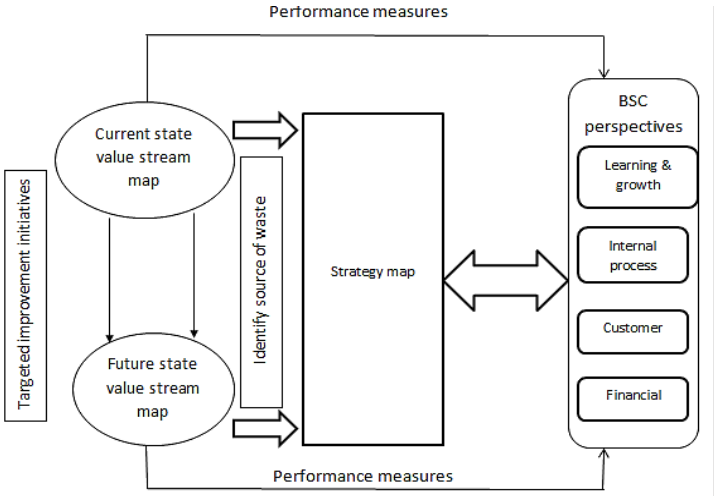


Fig. 5. Leading and Lagging Indicators within Three Business Levels of Lean Performance Measurement Framework

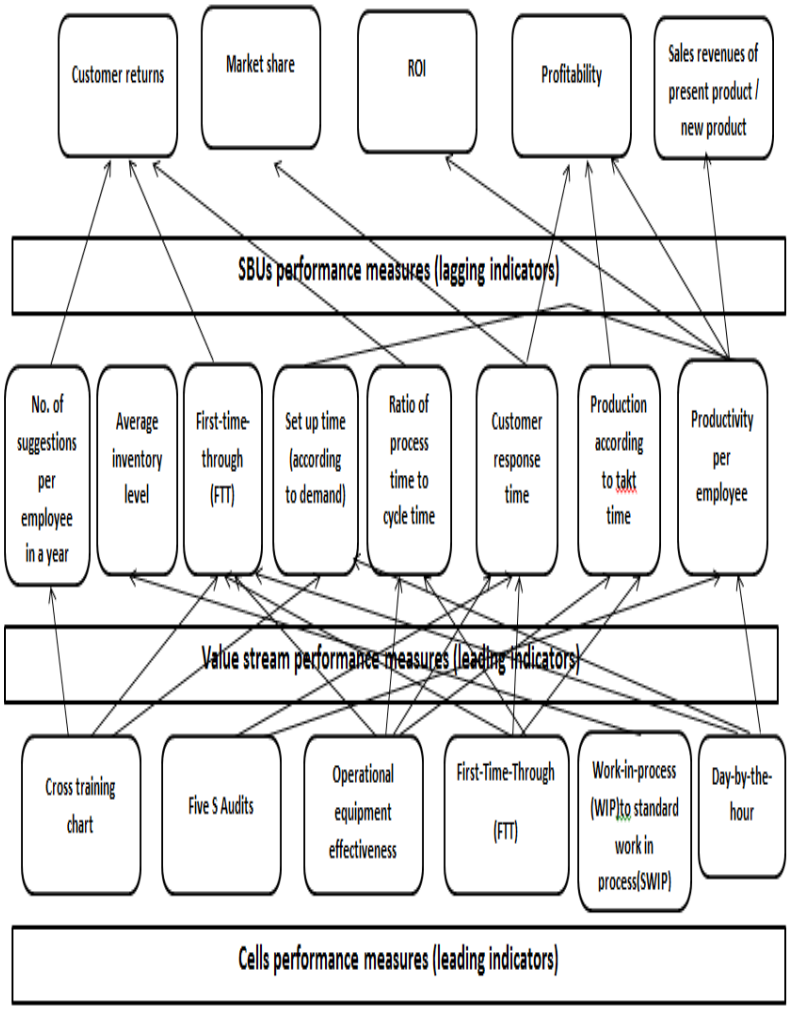


Fig. 6. Relationship Matrix